School of Environmental Technology
Federal University of Technology
Minna, Niger State, Nigeria.

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PROCEEDINGS OF 5th SETIC 2024

Editors-in-Chief
Assoc. Prof. Dr Ogunbode, Ezekiel Babatunde
Dr Ajayi, Oluibukun Gbenga
Prof. Dr Kemiki, Olurotimi Adebowale

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Proceedings of SCHOOL OF ENVIRONMENTAL TECHNOLOGY INTERNATIONAL CONFERENCE 2024 (SETIC 2024)

22nd – 24th October, 2024

Federal University of Technology, Minna, Niger State, Nigeria

EDITORS IN CHIEF

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PREFACE

The School of Environmental Technology International Conference (SETIC 2024), organized by the School of Environmental Technology, Federal University of Technology Minna, Nigeria, is a prestigious platform that brings together experts from diverse fields to exchange knowledge and drive innovation. This year, the conference is held in collaboration with notable institutions, including the School of Architecture and Design, Lovely Professional University, New Delhi, India; Abubakar Tafawa Balewa University (ATBU), Bauchi State, Nigeria; the Architectural Engineering Department, Najran University, Najran, Saudi Arabia; Perch Inc Development Consultancy Services, Zimbabwe; Faculty of Health Sciences, Graduate Education Institute, Istanbul Gelişim University, Istanbul, Turkey; Robotics & Additive Technologies Innovation Research Cluster, Transport & Communication Institute, Riga, Latvia; Architectural Engineering Department, College of Engineering, University of Hail, Hail, Saudi Arabia; New Gate University, Minna, Nigeria; and the University of Law Business School, Birmingham, United Kingdom, to mention a few.

This year's theme, "Global Economic Revolution and the Resilience of the Built Environment in an Emerging World," seeks to explore the dynamic relationship between global economic shifts and the adaptability of the built environment. The theme emphasizes the necessity for resilience, sustainability, and innovation in the face of unprecedented challenges and evolving economic landscapes. The sub-themes of the conference delve into crucial aspects such as sustainable design, technological integration, disaster management, and the role of policy in shaping future infrastructures.

The response to this year's conference has been both enthusiastic and far-reaching, with participants from a wide range of countries, including Latvia, India, Turkey, United Kingdom, Malaysia, Saudi Arabia, Zimbabwe, South Africa, and beyond. The hybrid nature of the event offering both virtual and physical participation has enabled an even broader exchange of ideas and perspectives. The conference serves as a vibrant platform for professionals, academics, and researchers to engage with cutting-edge developments in the built environment and related fields, fostering collaborations that will shape the future of global practice.

A wide range of papers, spanning science, engineering, and the social sciences, have been presented at this year's event, highlighting the interdisciplinary nature of challenges we face and the solutions to these challenges.

We would like to express our deep gratitude to the SETIC 2024 Conference Organizing Committee (COC) for their unwavering dedication and hard work in making this conference a resounding success. We are confident that this event will inspire all participants and leave a lasting impact on the field

ACKNOWLEDGEMENT

The success of SETIC 2024 is built upon the foundation laid by the previous editions of the School of Environmental Technology International Conference held in 2016, 2018, 2020, and 2022. We owe a great deal to the unwavering support and commitment of many, particularly the Vice-Chancellor of the Federal University of Technology, Minna, and the Dean of the School of Environmental Technology, alongside Dr Dodo Y. A., Dr Ajayi O. G., Dr Moveh S., Dr Kayode I. Adenuga and other esteemed colleagues whose efforts has been instrumental to this success.

It is my privilege, on behalf of the Conference Organizing Committee (COC), to extend a big thank you to all that attended the 5th Biennial SETIC, held between October 22nd to 24th, 2024. We are grateful for the opportunity to witness this grand event, now enhanced by the hybrid format, accommodating both physical and virtual participation—an innovation born from the challenges of the global pandemic.

This year's conference had serves as an international platform where scholars, professionals, and practitioners in the built environment and allied fields converge to tackle critical issues around the theme "Global Economic Revolution and the Resilience of the Built Environment in an Emerging World." The conference offered an opportunity to share best practices, theories, and concepts, fostering meaningful discussions that can shape future research and industry practices.

We were honored to have our distinguished keynote and guest speakers:
Prof. Kamuzhanje Joseph, Perch Inc. Development Consultancy Services, Zimbabwe.
Prof. Bldr. Sani Usman Kunya, Acting Vice Chancellor, Abubakar Tafawa Balewa University, Bauchi State, Nigeria.
Prof. Arc. Rajendra Kumah, Director of the School of Architecture and Design, Lovely Professional University, New Delhi, India.
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Asst. Prof. Adham Ahmed Awad Elsayed Elmenshawy, Robotics & Additive Technologies-Innovation Research Cluster, Transport & Communication Institute, Riga, Latvia.
Dr. Ahmed Osman Ibrahim, Associate Prof. Architectural Engineering Dept., College of Engineering, University of Hail, Hail, Saudi Arabia.

Additionally, we extend our appreciation to the esteemed panelists that participated in the Round Table Talk on "Role of the Built Environment in Promoting Security Food Security (The Role of Building Integrated Agriculture [BIA]) in persons of Assoc. Prof. Dr. Habiba Atta (Nigeria), Assoc. Prof. Dr. Samuel Moveh (Latvia), LAr. Ts. Dr. Nurzuliza B. Jamirsah (Malaysia), Arch. Abdulmalik Aminu (Nigeria) and our amiable moderator, Asst Prof. Yakubu Aminu Dodo. The session with them on innovative architectural and urban design solutions for food security was insightful as it addresses pressing needs in the built environment.

With over 150 papers covering the twelve subthemes of the conference, SETIC 2024 was engaging and enriching experience. Through parallel sessions and poster presentations, participants had the chance to delve into key issues surrounding Global Economic Revolution and the Resilience of the Built Environment in an Emerging World. All attendees were believed to have made use of most of the discussions, collaborations, and networking opportunities available to them.

In closing, I would like to express my sincere gratitude to the Dean of the School of Environmental Technology, the Conference Organizing Committee (COC), and the entire School for their trust and support. To our reviewers and committee members, thank you for your dedication and hard work in making this event possible.

Wishing everyone the best and memorable experience as SETIC 2024 lives on in our heart.

Thank you, and God bless you all.

Assoc. Prof. Ogunbode E. B.
Chairman, Conference Organizing Committee
SETIC 2024

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22nd October 2024

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This is to confirm that all papers included in the SETIC 2024 Conference Proceedings have undergone a rigorous peer review process. This process entailed an initial abstract review, followed by a blind review of the full papers by at least two independent referees. The reviewers' feedback was then communicated to the authors for revisions, after which the revised papers were thoroughly evaluated by the Scientific Committee to ensure they meet the highest standards of scholarly quality.

In accordance with the policy of the School of Environmental Technology International Conference (SETIC), only papers that have successfully passed this comprehensive review process and met the requisite criteria for academic integrity are accepted for publication in the conference proceedings. The final decision for publication is based on the recommendations of both the Reviewers and the Scientific Committee.

Selected papers from the conference proceedings will also be considered for publication in reputable academic journals.

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CONTENTS

SECTION 1

KEYNOTE ADDRESSES

KEYNOTE ADDRESS

Towards a Built Environment that we all Want

Prof. Kamuzhanje Joseph

Perch Inc Development Consultancy Services, Zimbabwe.
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Salutations!

The Director of Ceremonies, I bring you greetings and best wishes from the Republic of Zimbabwe. This is my first ever visit to Nigeria and second to West Africa. I did my Master's degree studies at the Kwame Nkrumah University of Science and Technology in Ghana in 1999, and ever since, I have yearned for an opportunity to come back to the region. I would therefore want to take the opportunity to thank, first Dr Sam Medayese, for being true to his word. I met Dr Medayese in Durban in July 2022, at a conference to discuss issues similar to the ones that we are seized with here today and for the next few days. I told him that if ever the opportunity arose, I would love to visit Nigeria, and over two years later, here I am. I would like to thank the organisers of the conference for inviting me to say a few words and share a few thoughts on the built environment.

My remarks are based on the unproved basis that, the challenges that planners and other development stakeholders will never be able to comprehend fully, and therefore address the challenges of the built environment, within the urban space (and dare I say, even the rural space), unless and until we deal with the emerging conspiracy against the enhancement of the urban space, especially for the less fortunate and less privileged in our society.

Director of Ceremony, esteemed ladies, and gentlemen, when I started my undergraduate studies in 1988, the lecturers convinced us that planning, especially in urban areas, was fundamental to achieve four interconnected uses: convenience, order, safety, and aesthetics. Therefore, when we talk about the built environment, we should focus on how much we have gone in trying to achieve those four pillars, and if not, why not. A cursory look at any African urban space, tells us otherwise. Our urban spaces are not convenient. The goods and services are so far away from the people that need them, so disconnected that it takes a lot of courage just thinking about going into town for whatever reason. How often for example are we surprised when we are not in a traffic jam, at any time of day? The same can be said for order. In every town or city that I have gone to, I have asked myself a simple question, where was the planner when all this was happening. That is okay for me as a planner, but I hear what we would like to refer to as laypeople asking the same

question, in even ruder words than what I have said. And the urban spaces are not safe. Take away the fact that most urban areas are not well-lit, we know that in any urban area, there are a lot of no-go places. Muggings and robberies, petty crime and abuse of children and women are the order of the day. The aesthetics of the urban built environment has been taken away by the shortcomings of the first three pillars. I remember the good old days, growing up in Harare, with wide streets, a few cars, a few people, flower pots and gardens all around the city. My favorite pastime was to go and sit in the park and just see the world go by. Whenever I was tired of studying, I would take a walk around town. Now, I cannot recognise that Harare anymore, so many cars, so many people, all the pavements and even the streets are full of vendors selling anything and everything that you can imagine.
And at this point, it is important to ask how we even got here?

I have a few possible reasons and explanations.

Perhaps the best starting point is the legal framework. Most urban spaces are being governed and developed using outdated and archaic pieces of legislation. In Zimbabwe, we use the Regional, Town and Country Planning Act. It was enacted in 1976 and repealed in 1996. But in actual fact, most of the tenets of both the 1976 and 1996 acts are contained in the 1933 Act of almost the same name. And we know for sure that all the pieces of legislation that were passed before Independence in 1980, were framed such that it would be difficult for the majority African population to enjoy the benefits that come with living in an urban area. What this says to me is that unless we work towards more progressive and people-centred legislation, we are just perpetuating the colonialist mentality.

The situation is not helped by the fact that in most countries, both the macro- and micro-economies are performing poorly. This means that the urban space is now characterised by a vicious circle where residents and ratepayers are not able to pay for the goods and services provided by local authorities, which means that local authorities cannot provide the services and the residents do not pay rates as a result. There is need to work effectively towards breaking that circle.

Director of Ceremony, ladies and gentlemen, the urban built environment has been let down by a largely unaware and uninterested citizenry that does not think that what happens in the urban space is their business. I am not excluding myself from this. I have stayed for 5 years in my neighbourhood, yet I barely know, or talk to my neighbours. Worse, I do not even know my councillor or my Member of Parliament. Some of the developments that are sprouting up in our urban areas could have been interrogated a bit more by the citizens.

A key challenge that we all face in developing a habitable built environment is that most of the planning processes are not data driven. Recently, in Zimbabwe, the

President issued a Call to Action which was meant to improve service delivery. The President directed that all local authorities prepare master plans. I took part in the process. The biggest challenge that the process faced was getting reliable data. I am not sure that there is a local authority in Zimbabwe, and the same can be said about local authorities in Nigeria and other African countries, which can confidently claim to know the population of their urban centres. What this means then, is that all these local authorities are under-planning (never over-planning) the services that they offer. Whilst there are other reasons, it is safe to say that the challenges that urban residents face in terms of water, sewer, waste management, electricity, schools, hospitals, and recreational facilities are mainly because the local authorities do not know the number of people they are planning for.

I can then add that most urban local authorities, especially those that started before Independence, were planned to cater for much smaller populations than what they are carrying now. The infrastructure cannot simply cope with the demands that are placed on it now. Director of Ceremony, ladies, and gentlemen, as I wind down my presentation, please allow me to present a few thoughts on how we can move forward.

I have been fortunate enough to have exposure the four key employment sectors in every country. I worked for Government, non-Governmental organisations, the private sector, and academia. I have always analogised my journey to reflect the built environment that we should all aspire to. I am of the considered opinion that the built environment should be developed and operate following rules and regulations set by Government. The built environment has largely become a wild jungle, with no rule of law. One just needs to look at how people are flagrantly going against provisions of layouts and other plans, building standards, by-laws, and how for example, people drive without regard to the law or the people. If the built environment is to adhere to the four principles I stated at the start of my remarks: convenience, order, safety, and aesthetics, planning and other laws must be followed without negotiation and flexibility.

I am alive to the fact that the urban space must be viewed first as an economic space, because that is exactly what it is. At one level, local authorities must operate as private sector entities. Whilst by law, at least in Zimbabwe, they are not allowed to make a profit, they must ensure that, they break even. The services that the local authorities provide should be fully paid for by the consumers. And there should be no negation of this fact. A few years ago in Zimbabwe, the Minister of Local Government, most likely, motivated by politics, directed all local authorities to cancel all the debts owed by the residents. With one stroke of a pen, the Minister, sounded a death knell on civic responsibility. Most of the residents have started to play a waiting game, hoping that this kind of moratorium may be repeated. If local authorities are run any other consideration, then the urban built environment suffers.

I am going to sound as if I am contradicting myself. Having worked in the NGO sector and the humanitarian space, I fully appreciate that there are some in our societies who may not be able to take care of themselves. There is a part of developing the urban built environment that should promote inclusivity. This is built on the notion that the built environment belongs to everyone. This may mean that the built environment caters for the less fortunate people who cannot look after themselves. But I will hasten to add that this should be an exception rather than the rule.

I am quite intrigued by the academic sector. In terms of logic, this should be at the top of the ladder. Academia, as constituted by institutions such as the School of Environmental Technology at this university, has the responsibility of coming up with models, no matter how Utopian" of how the built environment should develop. The discussions on the "smart city" for example should gain even more momentum. My sad observation, however, Director of Ceremony, ladies, and gentlemen, is that academia seems to be lagging behind and just like the planner, running after development. This is an unsustainable position to be in. My plea to this conference, therefore, is that at the end of it all, it should provide a platform that allows academia to regain its rightful place in the urban built environment discourse. Failure to do so will inevitably result in other so-called specialists and experts filling the gap!

Having spoken about these nodes, it is also important to note that, I am also an urban citizen. I stay in the city, the things that I plan for other people, the developments that I would like to see, the services that I want the residents to have, I also want them, maybe even more and even better. Perhaps we need to focus on both ends of the spectrum. Whilst we plan for millions of city residents, we should also consider the needs of this one urban dweller who yearns for a convenient, safe, orderly, and aesthetic built environment.

The five areas that I have spoken about are not mutually exclusive. In fact, they are dependent on one another and as specialists in this area of the built environment, we should aspire to develop models and matrices that create sustainable relationships amongst them.

In conclusion, Director of Ceremony, ladies, and gentlemen, I would like to thank the organisers of this conference once again, for inviting me to participate and to all of you for listening to my remarks.

I wish you all the success in this conference and in your own organisational and personal endeavours.

Thank you and God Bless You All!

KEYNOTE ADDRESS

Global Economic Revolution and the Resilience of the Built Environment in an Emerging World

Prof. Sani Usman Kunya

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Protocols:

1.0 Introduction

I am honoured to stand before such an esteemed audience today as the keynote speaker of the 5th School of Environmental Technology International Conference. The theme, Global Economic Revolution and the Resilience of the Built Environment in an Emerging World, could not be more timely or relevant, especially in the face of the profound transformations we are witnessing globally. The world is changing at a pace we could not have imagined just a decade ago. Technological advances, climate challenges, shifts in global economies, and population growth are reshaping our environments. As experts, scholars, and practitioners in the built environment, our challenge is not merely to respond but to lead these changes with foresight and resilience. Today, I will reflect on this theme and the conference's sub-themes, exploring how we can build resilience in the face of uncertainty while ensuring sustainability and economic progress.

2.0 The Fourth Industrial Revolution: Shaping an Emerging World

The Fourth Industrial Revolution, driven by digital transformation, artificial intelligence, robotics, and data analytics, is reshaping industries at an unprecedented scale. In the context of the built environment, the adoption of technologies such as Building Information Modelling (BIM), drones, and smart cities will redefine how we design, construct, and manage spaces. However, the real challenge lies not in technological availability but in integrating these technologies into our systems effectively. We must ask ourselves: How can we build intelligent, adaptive infrastructures that enhance economic growth while being resilient to disruptions?

Nigeria, as a developing nation, stands at a unique intersection of embracing this revolution while managing its socioeconomic challenges. The integration of Fourth Industrial Revolution technologies in our construction processes and city management is essential to staying competitive globally.

3.0 Climate Change and Urban Resilience

No discussion about the future of the built environment is complete without addressing climate change. The impacts of climate change on cities, infrastructures, and ecosystems are becoming more apparent with each passing year. As architects, engineers, planners, and policymakers, we must move towards a paradigm where

sustainability is at the core of our designs. The urban centers of the future must be resilient enough to withstand rising temperatures, flooding, and other climate-induced phenomena.

Urban green infrastructure and energy-efficient building systems offer significant opportunities for mitigating the effects of climate change. These systems, when combined with modern technology, can form the backbone of urban resilience. We must learn to work with nature, incorporating concepts such as green roofs, permeable surfaces, and natural disaster management systems into our urban plans.

4.0 Cultural and Social Resilience

Our built environment is not only physical but deeply cultural. Africa, with its rich cultural heritage, faces the challenge of balancing modernity with the preservation of its unique identity. How can our construction practices reflect cultural resilience, ensuring that modern buildings and infrastructures do not alienate communities but rather integrate and celebrate local traditions? This challenge is particularly pertinent in urban housing projects, where the need for affordable, sustainable housing often conflicts with the preservation of cultural norms. To this end, fostering cultural resilience means designing buildings and cities that reflect the local context while utilizing innovative materials and processes to ensure long-term durability and functionality.

5.0 Sustainability and the Future of Construction Materials

In line with the sub-theme on construction material development, it is crucial that we focus on sustainable material production. The over-reliance on conventional materials like cement and steel is not sustainable in the long term. Researchers must explore innovative materials, such as recycled aggregates, low-carbon concrete, and biodegradable materials, which can be produced locally and affordably. Additionally, cost control as a tool to enhance resilience of construction projects will be key to ensuring that our designs are economically viable while also environmentally sustainable.

6.0 The Role of Geospatial Intelligence in Building Resilience

With technologies like geospatial intelligence and satellite-based monitoring, we are now able to gather critical data on urban expansion, environmental risks, and infrastructure conditions. These technologies allow us to predict and mitigate the effects of natural disasters, optimize urban planning, and manage resources more efficiently. By incorporating intelligent cadastre and smart cities concepts, we can enhance economic growth and ensure that our cities are built to last.

7.0 Emerging Trends in Real Estate and Facilities Management

As the real estate sector evolves, emerging trends in real estate market investments and facilities management must be aligned with sustainability and resilience goals.

This alignment will ensure that our infrastructure remains functional and valuable long into the future, regardless of economic or environmental challenges.

Conclusion: Building a Resilient Future Together

As we gather here today, I urge all of us to think critically and innovatively about the future of our built environment. The world is changing rapidly, and so must we. Whether through the integration of new technologies, the development of sustainable materials, or the adaptation to climate change, we have the power to lead the transformation of our world.

This conference, with its rich sub-themes, provides a platform for collaboration and innovation. The ideas and solutions that emerge from our discussions here will shape not just the future of Nigeria's built environment, but also contribute to global efforts in creating resilient, sustainable cities.

Let us use this opportunity to share knowledge, challenge assumptions, and build a better, more resilient future for generations to come.

Thank you.

KEYNOTE ADDRESS

Adaptive Architecture: Building Resilience in the Face of Economic Transformation

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Protocols

As I reflect on my journey in the field of physical planning, I am reminded of my first visit to the Federal University of Technology Minna nearly 30 years ago. At that time, the permanent site was still under construction, and the environment was harsh and challenging. It was a landscape dominated by dust and sparse vegetation, a stark reminder of the difficulties we faced in developing functional spaces in such conditions. Yet, amidst this adversity, I witnessed a transformation—a little oasis began to emerge. Over the years, that once barren site has evolved into a vibrant campus, teeming with life, innovation, and learning. This experience sparked my passion for adaptive architecture, showing me, how thoughtful design can create resilience in even the most challenging environments.

Introduction to Adaptive Architecture

Today, I want to explore the concept of adaptive architecture and its significance in the context of Nigeria's economic landscape. Adaptive architecture is more than just a design philosophy; it's a vital response to our ever-changing world. As economies shift and climate challenges intensify, buildings must evolve to meet new demands. This approach emphasizes flexibility, allowing structures to transform their purpose and functionality over time. Imagine a warehouse that becomes a community center or an office space that can easily convert into housing.

By prioritising resilience, adaptive architecture not only reduces waste but also fosters economic transformation. When buildings can adapt, they support local economies by providing spaces that respond to community needs. This versatility can stimulate job creation and drive innovation, as businesses find new ways to utilise existing structures.

Moreover, adaptive architecture often incorporates sustainable practices, using eco-friendly materials and energy-efficient designs. In this way, we're not just building for today; we are crafting environments that thrive in the face of uncertainty, ensuring a brighter future for all.

To illustrate this, let us consider three remarkable examples from around the world: The Edge Platform in New York City The Intercontinental Wonderland Shanghai and the Google Office in Los Angeles.

The Edge Platform serves as a prime example of adaptive architecture and innovation. Located on the 100th floor of 30 Hudson Yards, which is the sixth tallest building in New York City, The Edge opened in March 2020. The superstructure measures 1,271 feet (387 meters), positioning it just behind other iconic buildings like 432 Park Avenue, Central Park Tower, and One World Trade Center. The Edge has quickly become a popular attraction, drawing around 1.7 million visitors annually. Its observation deck, featuring a thrilling glass floor that hangs off the building, offers stunning views of Manhattan and beyond, making it a must-visit spot for both tourists and locals.

However, The Edge didn't have a great start. Although it aimed to make an immediate impact on NYC, the pandemic disrupted its plans, resulting in a temporary closure shortly after its opening. It reopened in September 2020, and since then, it has attracted visitors daily with its multiple thrill elements, including the large glass floor and nine-foot glass walls.

Intercontinental Shanghai Wonderland

The Intercontinental Shanghai Wonderland, also known as Shimao Wonderland Intercontinental, is a striking example of adaptive architecture integrated into a unique landscape. Situated in an abandoned quarry in Songjiang, near Shanghai, this hotel is designed to blend seamlessly with its environment while maximising the potential of the site.

The hotel is partially submerged in the quarry, with stunning views of the surrounding cliffs and water. This design not only minimises the visual impact on the landscape but also utilises the natural topography to enhance the guest experience.

The architecture incorporates eco-friendly technologies, including rainwater harvesting and energy-efficient systems, aligning with contemporary sustainability goals. The adaptive design reflects a commitment to reducing environmental impact while providing luxury accommodations.

The building features underwater rooms, a waterfall, and a range of recreational facilities, demonstrating how adaptive architecture can create unique experiences without compromising on comfort or luxury.

The final international example is across the country from The Edge Platform: Google Los Angeles Office

Google's Los Angeles office exemplifies adaptive architecture through its innovative design and flexible workspaces. Located in the historic Spruce Goose Hangar, this office reflects a commitment to creating a dynamic work environment that fosters creativity and collaboration.

Central theme here is the preservation of Historic Elements. The office design maintains the integrity of the original hangar structure while incorporating modern

amenities. This approach respects the site's history while adapting it for contemporary use, showcasing a blend of old and new. The layout encourages collaboration through open spaces and modular designs that can be reconfigured as needed. This adaptability is crucial in today's fast-paced work environment, allowing teams to adjust their spaces to fit their projects.
The office incorporates green building practices, such as natural light optimisation, energy-efficient systems, and wellness-focused amenities. This focus on employee well-being reflects a broader trend in adaptive architecture to create environments that support both productivity and health.
The Edge Platform, Intercontinental Shanghai Wonderland and Google Los Angeles office serve as prime examples of how adaptive architecture can enhance the relationship between built environments and their surroundings. By integrating sustainability, preserving historical context, and promoting flexibility, these projects not only meet the needs of their users but also contribute positively to their respective locales. As urban landscapes continue to evolve, adaptive architecture will play a vital role in shaping the future of design.

Now, let's turn our attention to Nigeria and examine a local project that embodies these principles: Freedom Park in Lagos.

Freedom Park Lagos: A Symbol of Hope and Liberation is located ated in the heart of Lagos, Freedom Park is a testament to the city's rich history and its people's struggle for independence. The park's significance extends beyond its beautiful architecture and serene environment; it serves as a reminder of the nation's journey to freedom.

History of Broad Street Prison, Lagos
Freedom Park stands on the site of the former Broad Street Prison, a colonial-era detention facility built in 1882 by the British. The prison was notorious for its harsh conditions and was used to detain Nigerian nationalists, politicians, and activists who fought against colonial rule.

Notable Inmates included
Herbert Macaulay, foremost Nigerian nationalist and politician; Obafemi Awolowo, a former Premier of the Western Region and one of Nigeria's founding fathers.
and Anthony Enahoro, a Nigerian politician who moved the motion for Nigeria's independence.
Prisoners faced inhumane conditions, including overcrowding, poor sanitation, and physical abuse. The prison became synonymous with oppression and resistance.

Transformation into Freedom Park
In 2007, the Lagos State Government through architect Theo Lawson transformed the former prison site into Freedom Park, a memorial and recreational space. The

park's design incorporates elements of the original prison structure, preserving the history while promoting freedom and relaxation.

The park features the following:

1. The Memorial Block: Showcases the prison's history and the struggles of Nigerian nationalists.
2. The Museum: Exhibits artifacts and documents from the colonial era.
3. The Amphitheatre: Hosts cultural events, concerts, and performances.
4. The Gardens: Serene spaces for relaxation and reflection.
5. The Wall of History: Displays key events and figures in Nigeria's struggle for independence.

The Significance

Freedom Park is that it serves as:

1. A tribute to Nigerian nationalists who fought for independence.
2. A reminder of the nation's complex history.
3. A symbol of hope and liberation.
4. A hub for cultural and artistic expression.
5. A tourist attraction promoting Nigeria's heritage.

Economic Transformation

The economic transformation facilitated by Freedom Park is multi-faceted, showcasing how adaptive architecture can stimulate local economies:

1. **Job Creation:** The park has directly created employment opportunities for local residents, from park management to event coordination. Additionally, it indirectly supports jobs in surrounding businesses, including hospitality and retail.

2. **Boosting Local Businesses:** Events hosted at Freedom Park draw large crowds, benefiting local vendors and businesses. Restaurants, hotels, and shops in the vicinity experience increased patronage, translating into higher revenues.

3. **Cultural Tourism:** As a tourist destination, Freedom Park attracts visitors both locally and internationally, enriching Lagos's cultural tourism landscape. This influx of visitors promotes awareness and appreciation for Nigerian heritage, further driving economic benefits.

4. **Real Estate Growth:** The revitalisation of the park has led to increased interest in real estate development in the surrounding area. Higher property values benefit local homeowners and encourage investment in further infrastructure.

5. **Community Engagement and Empowerment:** By involving local communities in programming and maintenance, Freedom Park empowers residents, fostering a sense of ownership and encouraging entrepreneurship within the cultural sector.

6. **Sustainability Initiatives:** The park's focus on sustainable practices not only benefits the environment but also promotes green initiatives among local businesses, creating a ripple effect that encourages broader economic transformation.

Conclusion

In conclusion, as we explore adaptive architecture in our unique Nigerian context, we must remember the lessons learned from projects like The Edge Platform and Freedom Park Lagos. By embracing adaptive design principles, we can create resilient spaces that enhance our communities and promote economic stability.

Let us take inspiration from the evolution of Freedom Park and the strategies employed to adapt to climate challenges. Together, we can build a future where our architecture not only withstands the challenges of climate change and economic fluctuations but thrives amidst them.

Thank you.

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Systematic review of climate change impact research in Nigeria: implication for sustainable development - PMC.

Learn more:

1. [Chapter 6: Cities, settlements and key infrastructure | Climate Change 2022: Impacts, Adaptation and Vulnerability] (https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-6/)

KEYNOTE ADDRESS

Tailoring Child Development to Sustainable Built Environment

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Society's Responsibility

- Climate change is a direct threat to a child's ability to survive, grow, and thrive.
- Children are the least responsible for climate change yet, will bear the greatest burden of its impact. (UNICEF)
- For children who are already disadvantaged, the risks of climate change are even higher.
- The climate crisis is a child rights crisis. It is a child rights crisis because not only does it threaten to undo the gains made over the past years, but it also impedes the realization of all the rights of children as captured in the United Nations Convention on the Rights of the Child.

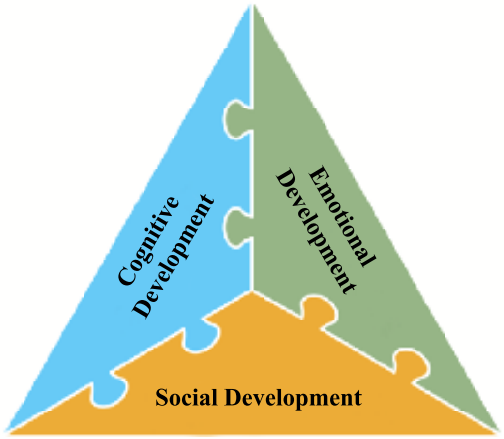
Why is understanding child development so important?

because early interaction is vital

What do we know about child development?

Adult interactions with a young child have a profound impact on cognitive, emotional & social development.

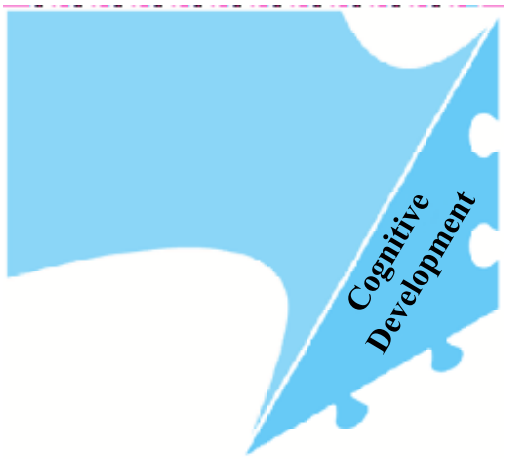
Understanding a child requires addressing the whole child.



drwilliammosier@gmail.com

Curiosity + Enjoyment = Learning

Cognitive development evolves from play, problem-solving & creative decision-making.



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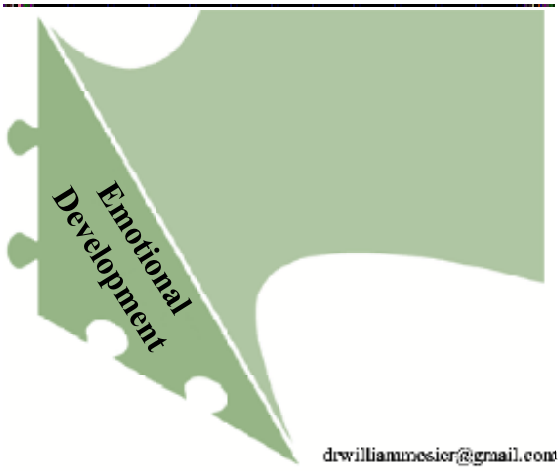
A healthy self-esteem grows out of a healthy self-concept.

A young child's development of autonomy grows out of an initial trust in the primary caregiver.



How can we foster social competence? To nurture social skills adults must model pro-social behavior and communicate empathic understanding.

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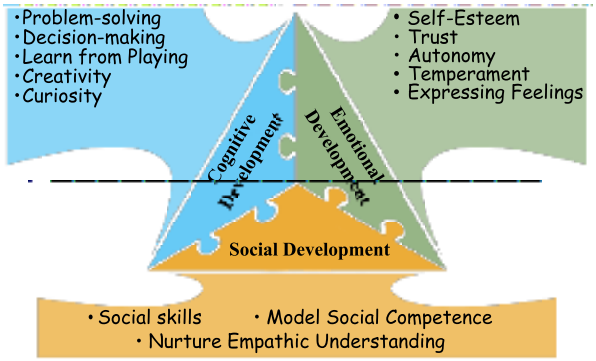
How can we bring it all together?



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There are five basic human drive

Activity

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Exploration

Manipulation

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Production

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Social Interaction

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Environmental factors influence whether a child grows-up emotionally healthy or emotionally disturbed

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Architects and Engineers have a key role in creating play spaces for children that allow them to learn through discovery

The environment is the most critical element in child development. It is a factor we can influence.

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How young children cope with stress is through play

- When a child feels stress there is a failure of the HPA axis to mediate cortisol
- Adverse Childhood Experiences (ACEs) disrupt the function of the HPA axis
- ACEs are, unfortunately, common
- Play helps young children cope

Positive interactions during play are important

- Children benefit from positive adult-child interactions
- Adults should be warm and responsive
- Adults should avoid being aggressive or directive
- Let children be children

Creating Learning Spaces for Children

- The internet is full of models
- It does not have to be expensive
- It does not have to be fancy
- Young children just want the freedom to play

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SECTION 2

CONFERENCE PAPERS

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Volume 2 proceedings

Analysis of Compressive Strength and Deformation behaviors in Quay Concrete Slabs using Ultra Sonic Pulse Velocity and Geodetic Analysis

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Abstract

This study evaluates the compressive strength and deformation of a quay slab using ultrasonic pulse velocity (UPV) testing and geodetic deformation analysis. The slab, measuring 401.532 m in length and 29.644 m in width, was subjected to structural health monitoring techniques. The analysis revealed an overall compressive strength of 40 N/mm^2, with corresponding deformation parameters including deflection rates of 0.2 mm/year horizontally and 0.3 mm/year vertically. Furthermore, the analysis showed that the quay has an average rotation of 0.0000194secs/year, and average velocity of 0.00000000000845m/s2. These results confirm that concrete structures with high compressive strength exhibit minimal deformation, supporting the role of UPV as a reliable indicator of structural integrity.

Keywords: Structural health monitoring, Structural deformation, Least Squares Analysis, Quay

1. Introduction

Amidst numerous cases of building collapse and structural failure, the needs for structural health monitoring (SHM) have become more prominent in recent times. SHM is a critical process in engineering that utilizes sensors, data acquisition systems, and computational algorithms to assess the condition of structures in real-time or through periodic monitoring (Chang, Flatau, & Liu, 2003). The objective in SHM is to detect alarming movements and damages, such as cracks or corrosion, and thus, enable early interventions, improve safety and reduce maintenance costs (Farrar & Worden, 2012). Structural health monitoring involves a combination of structural integrity testing and deformation monitoring. While techniques such as vibration analysis, acoustic emission, and ultrasonic testing are commonly used to monitor changes in structural integrity (Sohn, Farrar, & Hemez, 2004); geodetic measurements analyzed by either least squares (LS) or finite element method (FEM) are used to assess the state/rate of deformation of the structure. Invariably, continued cases of building collapse and structural failure continue to emphasize the need for effective SHM. While compressive strength is essential in maintaining structural stability, understanding its link to deformation behaviors is crucial, especially in large concrete slabs such as quay structures. This study aims to investigate the interrelationship between compressive strength and deformation parameters with a view to provide insight into the structural performance of concrete slabs under load.

Concrete is one of the most widely used construction materials due to its versatility, strength, and durability. Its compressive strength is a critical parameter, as it directly relates to the structural integrity of concrete components, including slabs, beams, and columns. Although, compressive strength test is traditionally tested using destructive test methods like core and cylinder tests (Neville, 2011); non-destructive testing (NDT) methods offer the advantage of testing the concrete slabs without damaging the structure. NDT methods such as rebound hammer and ultrasonic pulse velocity (UPV) are commonly used to estimate compressive strength indirectly. UPV testing (ASTM C597) involves measuring the velocity of ultrasonic waves traveling through the concrete, which can later be related to the material's strength.

Earlier studies have explored the relationship between compressive strength of concrete and building deformations, recognizing compressive strength as a fundamental factor in determining the behavior of structures under load. One of such study by Neville (1995) highlighted the critical role of concrete compressive strength in resisting loads and

preventing excessive deformations. The study showed that lower-strength concrete increases the risk of cracking and deflection under service loads. Similarly, Mehta & Monteiro (2006) emphasized that inadequate compressive strength can lead to serviceability issues like excessive deflections, which can compromise structural integrity over time. Their work demonstrated that compressive strength is directly linked to the stiffness of concrete, which in turn governs the deformation characteristics of buildings. This relationship is particularly crucial in high-rise structures, where vertical deformations can lead to differential settlements and cause structural distress (Mindess, Young, & Darwin, 2003)

Subsequent studies expanded on this understanding by investigating the effect of varying concrete strengths on deformation behaviors. For instance, Mukherjee and Joshi (2005) examined how compressive strength variations influenced structural performance under seismic loads, finding that structures built with higher strength concrete exhibited reduced lateral deformations during seismic activity. Additionally, Kwan and Ng (2013) studied the long-term effects of concrete strength on building deformations, concluding that high compressive strength reduced creep and shrinkage, which are the key factors contributing to deformation over time. Their research highlighted the importance of selecting appropriate concrete strength for different structural elements to mitigate time-dependent deformations.

Consequent upon the foregoing, this study presents a comparative analysis of the results of compressive strength testing and deformation analysis of a quay with a view to analyzing the spatial correlation and interrelationship between compressive strength and deformation parameters (strain, rotation, velocity and deflections) within the study area.

2. Overview of Methods

Theoretical overview of compressive strength testing by Ultrasonic pulse velocity measurement and deformation analysis by the MINQUE-LS estimation approach is presented below;

2.1 Compressive Strength from Ultrasonic Pulse Velocity Measurement

Ultrasonic Pulse Velocity (UPV) measurement is a widely used non-destructive testing (NDT) takes for ultrasonic waves to travel through a concrete specimen, providing indirect information about its density, elasticity, and internal structure. According to ASTM C597 and BS 1881-203, the wave velocity is affected by the concrete's mechanical properties and internal conditions, such as voids, cracks, and aggregate distribution (Malhotra & Carino, 2004). The relationship between pulse velocity V (m/s) and compressive strength fc can be mathematically expressed as:

$$V = \frac{\mathrm{L}}{\mathrm{T}} \tag{1}$$

where

L is the path length (m), and

T is the travel time (seconds).

High pulse velocities often correlate with higher compressive strength, as denser concrete allows waves to propagate more rapidly. Studies such as those by Demirboğa, Türkmen, and Karakoc (2004) have established empirical correlations between UPV and compressive strength, which is often used to estimate the latter without damaging the concrete structure.

UPV's advantage lies in its ability to assess in-situ concrete, making it useful for evaluating structures without the need for destructive core extraction. The correlation between velocity and strength can be improved by considering factors like moisture content, aggregate size, and curing conditions (Neville, 2011). A commonly used empirical relationship for estimating compressive strength is:

$$fc = aV^b \tag{2}$$

where

a and b are constants determined from experimental calibration (Popovics, 2001).

2.2 Determination of Deformation parameters by Minimum Quadrature Unbiased Estimation Lease Squares (MINQUE-LS)

Deformation analysis is a critical process in engineering, geodesy, and structural health monitoring, where the movement or deformation of structures is evaluated based on observational data. The least squares method (LSM) is widely employed in deformation analysis to provide optimal estimations by minimizing the sum of the squared residuals between observed and modelled values (Mikhail & Ackermann, 1976). In its simplest form, LSM estimates unknown parameters in a linear model by solving the normal equations derived from the condition of minimal

squared errors. This method is robust for geodetic networks, where coordinate changes over time are used to infer deformation patterns (Teunissen, 2000). Despite its broad applications, traditional least squares can be sensitive to the assumptions of equal precision in the data. When observations have unequal variances, the weighted least squares (WLS) method, which incorporates variances into the estimation process, offers a more refined solution (Koch, 1999).

An advanced extension of the least squares method, particularly suitable for deformation analysis, is the Minimum Norm Quadratic Unbiased Estimation (MINQUE) approach. MINQUE, first introduced by Rao (1971), is a statistical method used to estimate variance and covariance components in linear models without assuming prior knowledge of these components. This makes it particularly useful in situations where the variances of the observations are unknown or heterogeneous. In deformation analysis, the MINQUE method is applied to estimate not only the deformation parameters but also the variances of the observed points, allowing for more reliable detection of structural displacements or movements (Koch, 1999). MINQUE minimizes the quadratic form of the residuals while ensuring unbiased estimates of the variance components, which provides a significant advantage over traditional weighted least squares methods, especially in cases with complex error structures.

The effectiveness of the MINQUE method in deformation analysis lies in its ability to handle correlated observations, which are common in practical applications where multiple points in a structure or network may deform simultaneously under similar loads or environmental conditions. By estimating the variance-covariance matrix of the observations, MINQUE offers more flexibility and accuracy in deformation modeling, making it ideal for geodetic networks, structural monitoring, and civil engineering projects (Rao, 1971; Amiri-Simkooei, 2007). The method's unbiasedness and efficiency have been demonstrated in several studies, such as those by Amiri-Simkooei (2007), where the variance component estimation in geodetic networks showed superior performance compared to traditional LSM approaches. The MINQUE method is also computationally feasible for large datasets, which is crucial in real-time structural health monitoring and geospatial applications.

According to the MINQUE approach, the deformation parameters are directly related to measured coordinates using the following mathematical formulations;

Let point ''i '' be the fixed point of the structure, then;

$$d_{x_{ij}} + v_{x_{ij}} = \varepsilon_x X_j + \varepsilon_{xy} Y_j + 0 - \omega Y_j \quad (3a)$$

$$d_{y_{ij}} + v_{y_{ij}} = 0 + \varepsilon_{xy} X_j + \varepsilon_y Y_j - \omega X_j \quad (3b)$$

Where;

$d_{x_{ij}}$ = difference in displacement (distance) between i and j in the "x-direction" $[(X_i - X_j)_{t1}$ - $(X_i - X_j)_{t2}]$

$d_{y_{ij}}$ = difference in displacement (distance) between i and j in the "y-direction"

$d_{z_{ij}}$ = difference in displacement (distance) between i and j in the "z-direction"

v = observational residual

$\varepsilon_x, \varepsilon_y$ = strain in the ''x'' and ''y'' directions

X_j, Y_j = X and Y coordinates of point ''j''

ω = rotation

$$\begin{bmatrix} \Delta_{x_{ij}} \\ \Delta_{y_{ij}} \\ \Delta_{z_{ij}} \end{bmatrix} = \begin{bmatrix} \sqrt{[(X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2]} \\ \sqrt{[(X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2]} \\ \sqrt{[(X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2]} \end{bmatrix} \times \begin{bmatrix} \cos\beta & \cos\alpha \\ \cos\beta & \sin\alpha \\ \sin\beta & 1 \end{bmatrix} \quad (4a)$$

$$\begin{bmatrix} \Delta_{x_{ij}}^2 \\ \Delta_{y_{ij}}^2 \\ \Delta_{z_{ij}}^2 \end{bmatrix} = \begin{bmatrix} (X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2] \\ [(X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2] \\ (X_i - X_j)^2 + (Y_i - Y_j)^2 + (Z_i - Z_j)^2] \end{bmatrix} \times \begin{bmatrix} \cos\beta^2 & \cos\alpha^2 \\ \cos\beta^2 & \sin\alpha^2 \\ \sin\beta^2 & 1 \end{bmatrix} \quad (4b)$$

Where;

$\Delta_{x_{ij}} = (X_i - X_j)$

all other parameters are as earlier defined

β = Vertical Angles

α = Horizontal Angles

$$\begin{bmatrix} \Delta_{x_{ij}} \\ \Delta_{y_{ij}} \\ \Delta_{z_{ij}} \end{bmatrix} \times [\Delta t^{-1}] = \begin{bmatrix} \boldsymbol{V_x} \\ \boldsymbol{V_y} \\ \boldsymbol{V_z} \end{bmatrix} \quad (5)$$

Putting equations 3 – 5 together to satisfy the conventional least squares MINQUE condition as given in (6) yields a simplified generalized least squares observation equation for 3D building model deformation modeling.

$$\begin{bmatrix} d_{x_{ij}} \\ d_{y_{ij}} \\ d_{z_{ij}} \\ \Delta_{x_{ij}}{}^2 \\ \Delta_{y_{ij}}{}^2 \\ \Delta_{z_{ij}}{}^2 \\ \Delta_{x_{ij}} \\ \Delta_{y_{ij}} \\ \Delta_{z_{ij}} \end{bmatrix} = \begin{bmatrix} X_j & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & Y_j & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & Z_j & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{ij}{}^2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{ij}{}^2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \Delta t & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \Delta t & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \Delta t \end{bmatrix} \times \begin{bmatrix} \boldsymbol{\varepsilon_x} \\ \boldsymbol{\varepsilon_y} \\ \boldsymbol{\varepsilon_z} \\ \cos\beta^2 \\ \cos\alpha^2 \\ \cos\beta^2 . \cos\alpha^2 \\ \boldsymbol{V_x} \\ \boldsymbol{V_y} \\ \boldsymbol{V_z} \end{bmatrix} + [\bar{v}] \quad (6)$$

3. Study Area

The study was conducted on a jetty facility located at Apapa area of Lagos state. The jetty was constructed to serve as docking/anchor yard for vessels. It is located at 543688.39mE, 711258.131mN. Figure 1 shows the geographical location of the quay and its geometrical expanse.

Figure 1: The study area

4. Materials and Methods

This study involves comparative analysis through two primary tests: integrity testing and deformation analysis. Table 1 summarizes the methods and materials used for these tests;

Table 1: Summary of materials and methods

S/No	Structural Health Component	Method	Materials
1	Integrity Test	Ultrasonic Pulse Velocity measurement	Portable Ultrasonic Non-Destructive Digital Indicating Tester (PUNDIT), and the jelly-like lubricating substance
2	Deformation analysis	Baseline study by GNSS	Differential GNSS receiver linked to CORS by NRTK
		Routine monitoring by Total station	Total station and its accessories
		Horizontal deflection measurement	Total station and its accessories
		Vertical deflection measurement	Dumpy level

The integrity tests were performed using a Portable Ultrasonic Non-Destructive Digital Indicating Tester (PUNDIT) following BS EN 12504-4:2004 and BS EN 12504-2:2001 standards. These tests involved measuring the transit time of ultrasonic pulses through concrete using jelly-like grease as a coupling agent. Upon generation of the pulse, longitudinal vibrations were reflected at material phase boundaries, and the arrival time of these waves was captured by a receiving transducer to calculate the transit time TTT (Figure 2).

Figure 2 (a): PUNDIT sensors

(b) Calibration of US meter

(c) US scan on-going

Deformation monitoring on the other hand was conducted in three stages being;

(i) Baseline Establishment: Three geodetic control points were established around the site to serve as reference for deformation monitoring. These points, placed in zero-deformation zones (near expansion joints), were subjected to a 1-hour static GNSS observation using NRTK linked to local CORS networks. The OSCAR NRTK GNSS receiver was employed to achieve precise geodetic coordinates and accuracy metrics.

Figure 3 (a) Static NRTK

(b) Geodetic BM's

(ii) Routine Monitoring: Daily monitoring over two weeks was conducted at 20 deformation monitoring points (DMP001–DMP020) placed across the quay. Measurements were taken using a Total Station set up on one of the established geodetic points, with references to others.

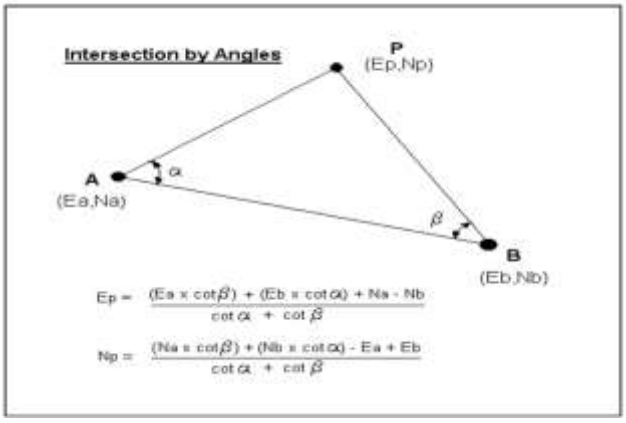


Figure 4. Description of the 2-point resection problem

The observation times for the daily monitoring observations were as follows;

Morning observation: 8am – 10am
Mid-day observation 12noon – 2pm
Evening observation 4pm – 6pm

Figure 5(a) Setting up the Total station

(b) coordinating the DMP's

(iii) Deflection monitoring: Elevation levels at 40m grid intervals were measured using a Dumpy level to assess vertical displacements across the deck, particularly focusing on slope deviations. On the other hand, the horizontal deflections were determined from the coordinate changes.

5. Results and Discussion

The fieldwork yielded two sets of results; compressive strength analysis and deformation monitoring. Both sets of data show a high correlation, confirming the reliability of the tests.

5.1 compressive strength analysis: Compressive strength was evaluated at multiple points across the quay at 20m grid intervals. Table 2 summarizes the average compressive strength measurements. Results indicate an average strength of 40 N/mm^2, consistent with the design specification. This result indicates that the quay slab remains capable of supporting its designed loads. Although the compressive strength of concrete is expected to increase with age (although significant increase in strength reduces after curing); it might as well reduce with time due to a number of factors. Such factors include; environmental exposure consequent upon freeze-thaw cycles (Neville, 1995), chemical attacks by sulfates, acid substances, carbonation, or chloride penetration (Neville, 1995; Papadakis, 2000; Mehta & Monteiro, 2014), improper mix design or curing due to poor workmanship, and excessive loading conditions (Bazant & Planas, 1998; Mindess, Young, & Darwin, 2003). The results from Table 2 indicate that such deterioration has been minimal, further suggesting regular maintenance practices are effective.

The graphical plot (Figure 6) shows the relationship between transmission time, pulse velocity, and compressive strength. The consistency of transmission time across columns suggests uniformity in material properties, while variations in pulse velocity indicate differences in concrete richness and rebar distribution.

Table 2: Average compressive strength test for quay slab

Structural Element	Transmission Time (μs)	Path Length (mm)	Pulse Velocity (km/s)	Ave. Equivalent compressive strength (N/mm2)	Remark
SlabPT 01	26.84	120	4.6938	43.6	Good
SlabPT 02	26.46	120	4.763	45.2	Good
SlabPT 03	26.6	120	4.7436	44.8	Good
SlabPT 04	26.6	120	4.7436	44.8	Good
SlabPT 05	26.56	120	4.745	44.8	Good
SlabPT 06	26.18	120	4.811	46	Good
SlabPT 07	26.68	120	4.724	44.4	Good
SlabPT 08	27.04	120	4.658	42.8	Good

SlabPT 09	26.7	120	4.7178	44	Good
SlabPT 10	26.54	120	4.7516	44.4	Good
SlabPT 11	26.42	120	4.7696	45.2	Good
SlabPT 12	26.74	120	4.716	44.4	Good
SlabPT 13	26.8	120	4.707	44	Good
SlabPT 14	26.42	120	4.7702	45.2	Good
SlabPT 15	26.56	120	4.7448	44.8	Good
SlabPT 16	26.6	120	4.7402	44.4	Good
SlabPT 17	27.08	120	4.6526	42.4	Good
SlabPT 18	26.8	120	4.7038	44	Good
SlabPT 19	26.58	120	4.736	44.8	Good
SlabPT 20	27.12	120	4.6438	42.4	Good
SlabPT 21	26.76	120	4.7074	44	Good

The results presented in Table 2 are further represented by the graphical plot shown in Figure 6.

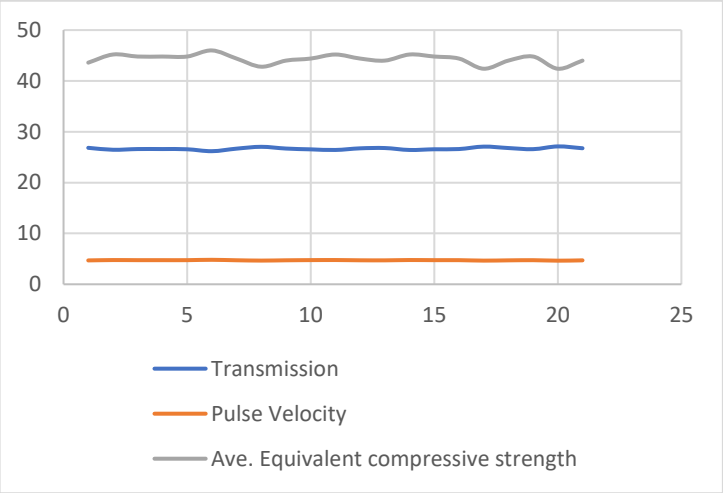


Figure 6: overlay plot of transmission time, pulse velocity and average compressive strength across the quay

5.2 Deformation monitoring

Analysis using MINQUE-LS reveals minimal strain in the horizontal and vertical directions. As shown in Table 3, horizontal strain remained at zero for the first 10 days, while vertical strain values, though minimal, correlated with increased vehicular traffic on the quay.

Table 3: Summary of observed displacements along and across the quay

	Day01 - 03	Day01 - 07	Day01 - 10	Day01 - 14
strain_z	-0.0000000447	0.00000012	0.00000003	0.0000000119
strain_x	0	0	0	0.00000024
rot	0.00000427	0.00000513	0.00004515	0.00002304
vel_x	0.000000000002593	0.000000000002422	0.000000000002056	-0.000000000005384
vel_y	-0.000000000000033	-0.000000000000457	0.000000000002894	0.000000000003497
vel_z	-0.000000000000155	0.000000000008646	-0.000000000010061	0.000000000009600

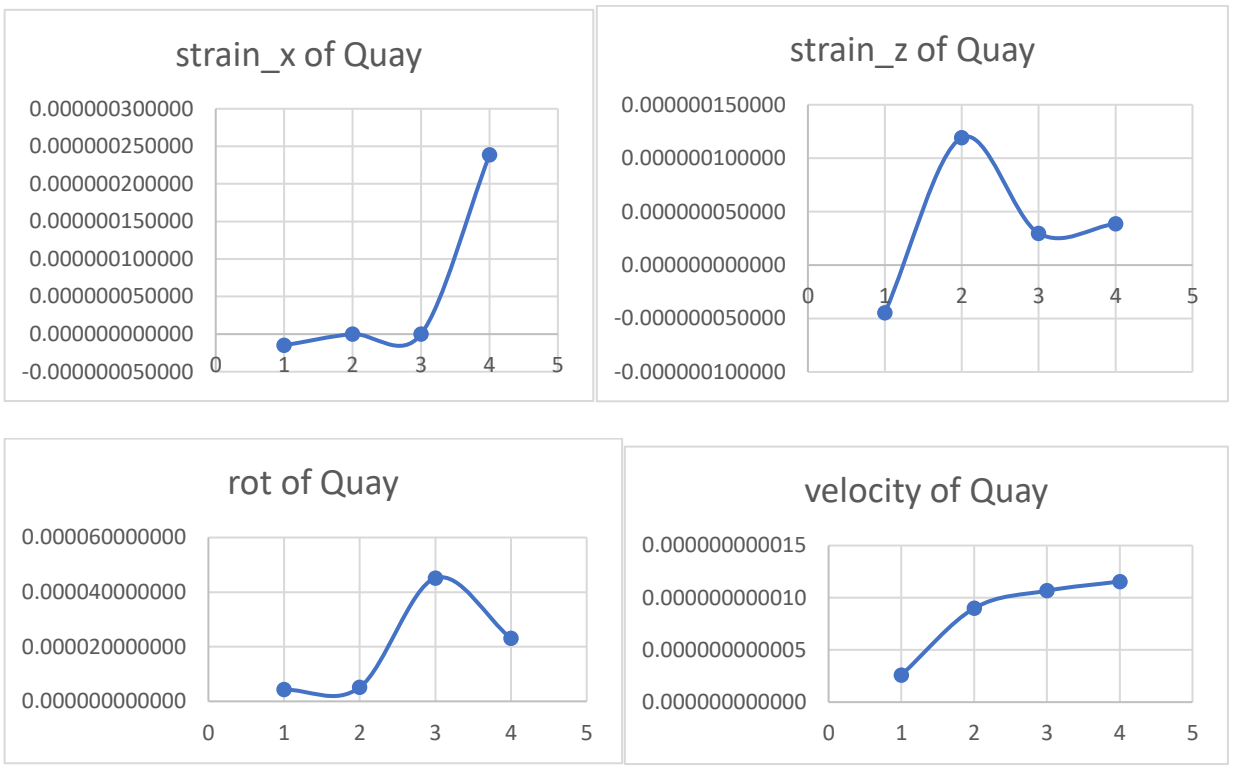
From Table 2, it is observed that the quay is experiencing very minimal strain in the horizontal direction as we see that there was completely no horizontal strain (strain_x = 0) between day 1 – day 10. Also, as expected, we observe that the strain in the vertical direction (strain_z) has the highest value amongst all the parameters. This vertical strain is supposedly caused by the high volume of traffic, vehicular flow and heavy machines that operate on the quay. Nevertheless, the maximum vertical strain value is minimal (0.000000019m) can be considered completely

negligible. Further validating the assumption is the fact that the maximum strain as observed occurred between October 17th – 19th. This period was very busy on the Jetty and it is reflected with the highest vertical strain occurring at that observational epoch. Therefore, Table 3 shows that the quay is apparently stable and undisturbed. These can be further interpreted to correspond to annual deflection values of 0.2mm/yr, and 0.3mm/yr in the horizontal and vertical directions. This value corroborates the compressive strength (integrity test) results which confirms that the quay is very stable and undisturbed. A summary of the results shown in Table 2 is presented in Table 3.

Table 3: Summary of deformation parameters

parameter	**strain_z** (m)	**strain_x (**m**)**	**Rot** (secs)	**Vel (**m/s²**)**
Ave	0.000000056	0.000000036	0.000019396	0.000000000008451
min	-0.000000045	-0.000000015	0.000004274	0.000000000002598
max	0.000000119	0.000000238	0.000045148	0.000000000011549
range	0.000000164	0.000000253	0.000040874	0.000000000008951

As seen, the average horizontal and vertical strain are 0.000000036m and 0.000000056m respectively. These values are very minute and completely insignificant. Furthermore, the average rotation of the quay is 0.0000194secs while the average velocity is 0.00000000000845m/s² which translates into a motion of about 0.2mm/year. These negligible deformation values were plotted in a bid to establish the trend of the observed movements. The trend of movements is seen in Figures 7 (a) – (d) as follows.



Figures 7: Graphical plot of trend of; (a) horizontal strain (b) vertical strain (c) rotation (d) velocity

Graphical plots of trends in horizontal strain, vertical strain, rotation, and velocity (Figure 7) reveal elastic behavior, with fluctuations revolving around central values. This is consistent with normal structural responses to external forces and environmental factors.

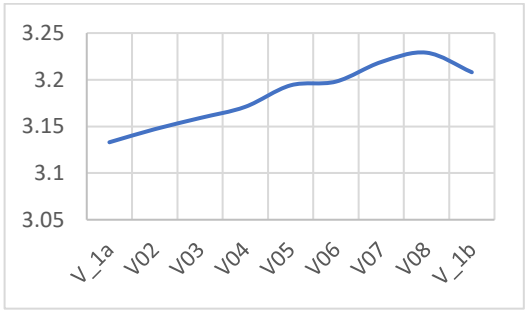
As seen in Figures 8.1(b) – (d), the movements (vertical, rotation and velocity) are elastic as they increase and decrease about their central value. This is normal for all structures as the structure is expected to make linear and non-linear responses to load, environmental conditions, heat and other forms of stress imposed on it. Being elastic movements, we notice that they revolve around their mean value within fourteen days of observation. This means that the structure is performing optimally and is able to self-compensate for the load and stresses imposed on it.

The departure from this trend which we observe in Figure 7(a) is however not worrisome because the value is grossly insignificant and for two consecutive measurement epochs, there was no movement at all on the structure. In line with the deformation results, the vertical alignment surveys also show very minimal vertical deflections of the structure from the designed slope level. Result from 4 of the 20 lines checked is provided in Table 4. The results show that the maximum vertical deflection requires a cut value of 20mm and a fill value of about 5mm across the quay, signifying that the quay is very stable with very minimal vertical deflections. Results for the vertical alignment show that the lagoon-ward slope of the quay is about 2.7% (0.0027).

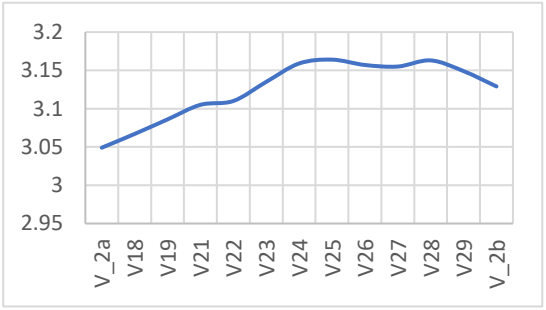
Table 4: summary of vertical displacements of the quay

Line	Slope	Cut	Fill
1	0.0025	20mm	
2	0.0027		
3	0.0029		5mm
4	0.0027		

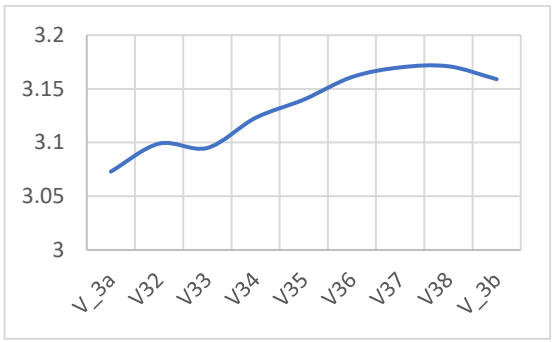
The maximum vertical deviation (being 20mm) is considered allowable given the gentle nature of the slope of the study area. Graphical plots of this observed deviation are shown in Figure 8).



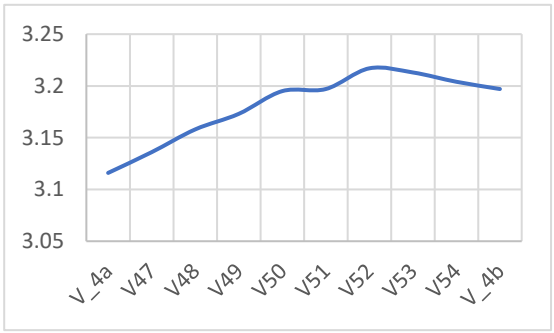
(a) Line 01



(b) Line 02



(c) Line 03



(d) Line 04

Figure 7(a) – (d): observed slope along vertical alignment survey for some lines

6. Conclusion

This study analyzed the compressive strength and deformation characteristics of a quay slab using ultrasonic pulse velocity and GNSS-based deformation monitoring. The results from both tests indicate that the structure remains stable and capable of carrying its design loads, with minimal vertical and horizontal strain observed during the 14-day monitoring period.

The findings suggest that the quay has been well-maintained, with no significant deterioration in compressive strength due to environmental or anthropogenic factors. The minimal deformation values further corroborate the integrity test results, indicating that both methodologies provide complementary data for monitoring concrete slabs.

Future studies should focus on long-term monitoring to assess potential seasonal effects on deformation and structural integrity. Additionally, incorporating more advanced monitoring techniques, such as fiber optic sensors, could provide real-time deformation data for more precise assessments.

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Geospatial Mapping of Signal Strength of Telecommunication (Mast) in Some part of Minna Metropolis Chanchaga Local Government, Minna Niger State.

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Abstract

Geospatial mapping of telecommunication signal strength (SS) is a critical technique used to visualize and analyze the distribution and quality of wireless communication coverage across various terrains and environments. This approach integrates Geographic Information Systems (GIS) with signal propagation models to assess how factors such as terrain elevation, infrastructure, and land use influence signal strength. By providing a detailed spatial understanding of coverage areas network (MTN, GLO, AIRTEL AND ETISALAT), geospatial mapping aids in optimizing the placement of telecommunication infrastructure, identifying and addressing coverage gaps, and improving overall network performance. The technique is invaluable for network planning, particularly in the expansion of services to rural and underserved areas, as well as in urban environments where signal interference and obstruction are common. Furthermore, it supports regulatory compliance, ensures equitable access to communication services, and contributes to environmental sustainability by guiding the strategic placement of infrastructure. As telecommunication networks continue to evolve with advancements like 5G, geospatial mapping remains an indispensable tool for ensuring efficient, reliable, and high-quality communication services.

Keywords: 5G, AIRTEL, GIS, GLO, MTN, ETISALAT

1. Introduction

The influence of telecommunication on the socio-economic development of global cities is substantial. This technology facilitates the rapid and efficient transfer of various media forms across extended distances through diverse systems, including wires, radio, optical, and electromagnetic channels. The advent of the Global System for Mobile Communication (GSM) in Nigeria in 2001 marked a period of exciting possibilities, attracting numerous Nigerians to exploit the burgeoning sector. By mid-2002, the subscriber count in Nigeria reached approximately 2.27 million, skyrocketing to over 143.05 million by 2015 (National Bureau of Statistics, 2015). Nigeria's four major GSM service providers, namely MTN, GLO, Airtel, and 9mobile (formerly Etisalat), exhibit varying subscriber percentages, with MTN leading at 61.21 million subscribers (42.8%), followed by GLO at 21.0%, and Airtel and 9mobile at 20.5% and 22.3 million subscribers (15.7%), respectively (NBS, 2015).

The surge in GSM users underscores the imperative for telecommunication network providers to address the communication needs of this rapidly expanding user base (Olukolajo *et al.,* 2013). To ensure comprehensive network coverage, many telecommunication stations strategically position themselves in close proximity to their target users. These stations, along with cellular telecommunication masts, constitute crucial components of the infrastructure essential for an effective communication system. According to (Hart *et al.,* 2012), telecommunication masts are towering structures designed to support antennas for telecommunications and broadcasting, ranking among the tallest man-made structures. A typical telecommunication mast tower comprises a steel beam frame with a height ranging from 25 to 55 meters and a concrete base of approximately 144m^2 (12x12m). The structure houses antennae, transmitters, and receivers, capturing high-frequency radio waves from cell phones. Antenna ranges vary from 1.5 to 2.4km to as long as 48 to 56km. Enclosed by either block walls or steel poles and wire, the mast structures include a power source and various accessories, catering to the diverse needs of service providers (Hart *et al.,* 2012).

2. Study Area

Minna Metropolis including (Albishiri, Gurara, Gbeganu, Fadukpe, Kure Market, Kpakungu) in Niger State which is situated between latitude 8°00' to 11°30' North and longitude 03°30' to 07°40' East. It shares borders with Zamfara State to the North, Kebbi State to the West, Kogi State to the South, Kwara State to the South West, Kaduna State to the North-East, and the Federal Capital Territory (FCT) to the South East.

Figure 1: Satellite view of the study area (Source: SAS Planet)

3. Methodology

This section addresses the overall structure of the project research. It details the general procedures and methodologies employed, including the types of data collected and their sources, the instruments and materials used for the project's successful implementation, as well as the methods of data processing and presentation. The framework of the methods used are presented in Figure 2.

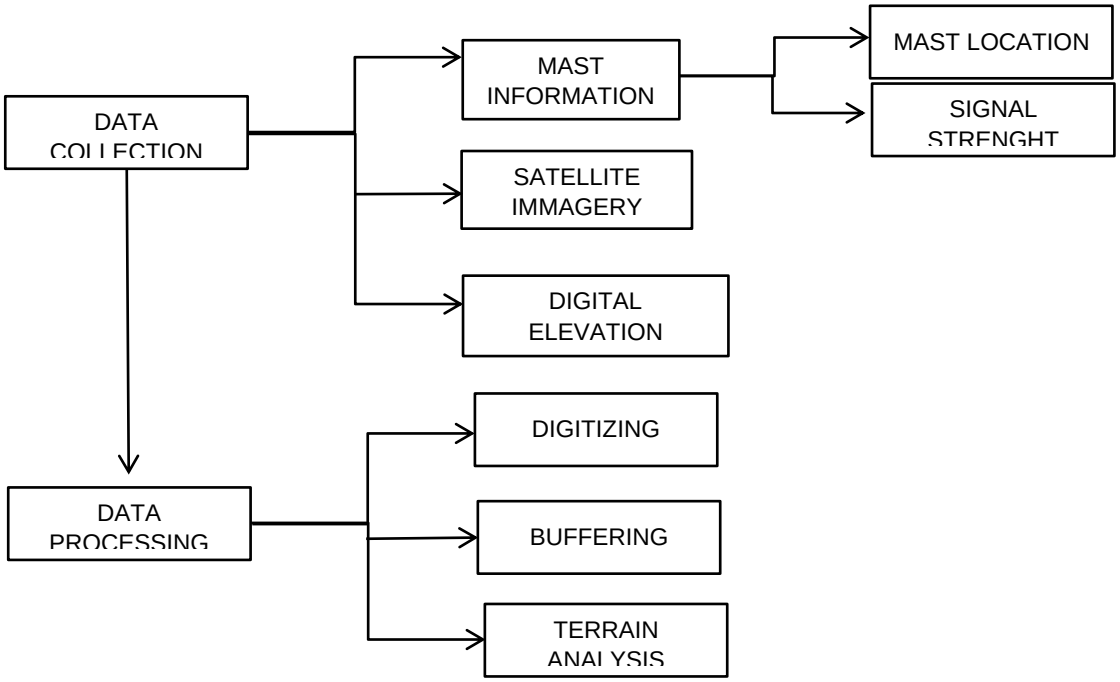

Figure 2: Conceptual framework

3.1 Data collection

The Primary Data acquisition was carried out on the site. These data include mast ID based on the cell type as presented in Table 1, the coordinates of the mast obtained using Hand held GPS and the signal strength of the mast (morning observation) using cell phone (Tecno Pova LD7) and extent of coverage of the mast as shown on Table 2. The secondary data was downloaded which are satellite imagery of some part of minna metropolis, which include: Albishiri, Askia Madinat, Fadukpe, Gbeganu, Gurara, Kasan Gwari, Kure Market, and Kpakungu. The satellite imagery was downloaded from SAS Planet. SAS Planet is a program designed for viewing and downloading high resolution satellite Imagery and conventional maps which are already been Geo-referenced. Digital Elevation Model (DEM) i.e., the 3D representation of s terrain's surface was created from terrain data. A DEM resolution of 30metres was obtained from USGS (United State Geological Survey). This DEM was processed to derived slope, aspect and contour which is correlated with signal strength data to assess the impact of terrain on signal propagation.

Table 1: The Breakdown of Service Providers in Some Part of Minna Metropolis

S/N	Cell type	No. Of Cell
1.	Mtn Nigeria	08
2.	Globacom	05
3.	Airtel	06
4.	Etisalat	02

Table 2: The Breakdown of Service Providers in Some Part of Minna Metropolis

S/N	Name Of Location Of The Mast Provider	Name of service	Mast's Co-Ordinate Easting(m)	Mast's Co-ordinate Northing(m)	Signal Strength (dbm)
1.	Albishiri	MTN/AIRTEL	226890.150	1060941.334	73/75 dbm
2.	Askia Madinat	MTN/AIRTEL	228811.541	1063430.773	68/70dbm
3.	Fadukpe	GLO	227799.131	1063483.812	74 dbm
4.	Fadukpe	AIRTEL/ETISALAT	227776.513	1063879.395	71/72 dbm
5.	Fadukpe	MTN	227934.993	1064087.900	68dbm
6.	Fadukpe Bosso R.	AIRTEL	228626.945	1064496.162	71dbm
7.	Gbeganu	MTN/GLO	227725.073	1062388.025	75/78dbm
8.	Gurara	GLO	227292.799	1061227.296	71dbm
9.	Kasan Gwari	MTN/AIRTEL	228190.949	1065092.111	71/74dbm
10.	Kasan Gwari Estate	MTN	228329.844	1065174.693	70dbm
11.	Kure Market	MTN/GLO	228885.760	1063914.110	72/74dbm
12.	Kpakungu	MTN/AIRTEL	229070.073	1061824.377	71/69dbm
13.	Kpakungu	GLO/ETISALAT	229100.976	1061743.488	69/73dbm

3.2 Data processing

The data processing includes adding attribute data of the masts to ESRI ArcGIS environment and all other data including the satellite imagery which are already been geo-reference, data base creation and digitization of the satellite imagery to obtain a vector-based data in relation to primary data observed. The Satellite imagery of the study area was later taken into ArcCatalog environment where it was spatially referenced to WGS 1984 Zone and digitized after creating shape files that holds the attributes of spatial features on being depicted.

3.2.1 Digitizing

After the satellite imagery was added in the ArcGIS environment, creation of shape file are made for each features like Buildings Masts, Roads, Rivers. Then the Editing was started by click on the Editor toolbar and select "Start Editing", The editing layer was chosen by select the feature Template of Each features. In the "Creature Features" window (usually on the right side), each feature template was selected that corresponds to the type of feature that was digitized (point, line and polygon). When the digitizing was finished then "Stop Editing" was clicked. And the editing was saved.

3.2.2 Buffering analysis

Service areas where each of the mast signal strength reached was depicted by buffering. It involves creating a zone around a spatial feature, typically to a specific distance of radius (300m, 700m and 1000m) to assess the impact of the signal on the zones or areas covered on the Digitized map.

3.2.3 Terrain analysis

The process of DEM was done to derive slope, aspect, contour, and viewshed maps, which were then correlated with signal strength data to assess the impact of terrain on signal propagation. To process slope, aspect, contour and viewshed the downloaded DEM from USGS was add to GIS environment through the clicking of add data tools, by clicked on Arc tools box. The arc tools box shows spatial analysis tools which also shows a lot of analysis tools when clicked, among them is surface analysis tools. Surface analysis tools were clicked and shows slope, aspect, contour, viewshed, and the likes, then the slope, aspect, contour, and viewshed was derived respectively.

4. Result and discussion

4.1 Mapping location of telecommunication mast

In converting the satellite imagery of some part of Minna metropolis Chanchaga Local government into vector format, a procedure called digitization was carried out. After creating the shape file, the masts positions were located and all other features like (roads, buildings, rivers) on the scene of the imagery was converted in points, lines and polygons based on their spatial feature and also shows the location of each mast in the study areas. Which the mast was represented with the symbol shows red and green colour as shown in Figure 3.

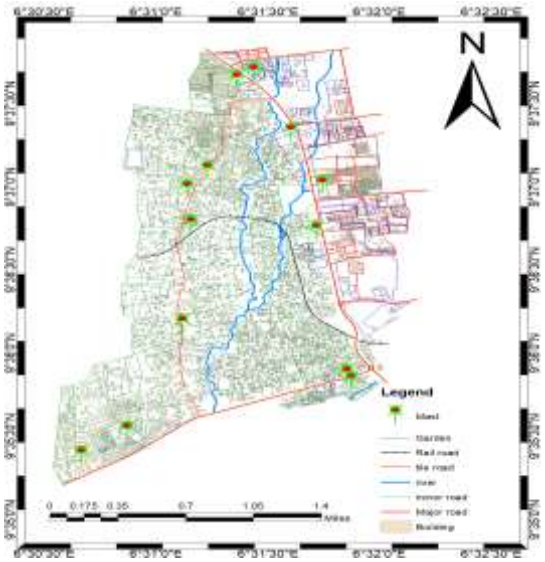

Figure 3: Map showing location of telecommunication mast

4.2 Buffering analysis

This shows the buffering analysis of each mast's radius (300m, 700m, 1000m) of the study areas respectively, that shows the area of strong and weak signal strength. In this analysis the masts radius 300m, 700m, 1000m coverage. It shows the map when the signal was strong, weak and very weak respectively. In telecommunication, buffer zones are typically defined around signal sources like Mast. These zones represent areas at varying distances from the source and were used to estimate signal strength. For instance, buffer zones were created at intervals of 300 meters, 700metres and 1kilometer to represent when the signal is strong, weak and very weak. In radius 300metres coverage, people living within the radius coverage will enjoy the network signal i.e., they will easily access to strong network. In radius 700metres coverage, users around the area experienced weak signal strength i.e., they will not easily access to the network unlike the people living around the radius 300metres. In radius 1000metres coverage people living around the radius will be experienced very weak signal i.e., very poor network.

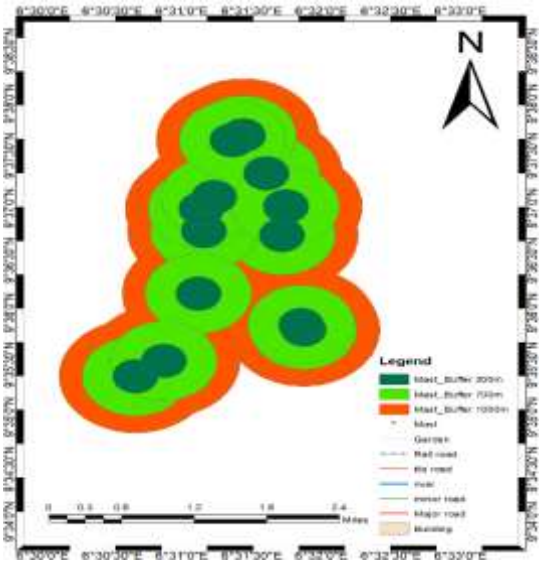

Figure 4: Map showing buffering analysis of masts radius 300m, 700m, 1000m coverage

4.3 Terrain analysis of the study area

Terrain plays a crucial role in the propagation of telecommunication signals. Factors such as slope, aspect, contour and viewshed all influence how signals travel through space. Higher elevations typically provide better signal coverage due to reduced obstructions, while lower areas, particularly those surrounded by hills or mountains, may experience weaker signals due to shadowing effects. The slope of the terrain can lead to signal scattering, reducing the strength in areas with steep inclines. Aspect, or the direction a slope faces, also affects signal reception; slopes facing away from a tower may receive weaker signals due to lack of direct line-of-sight. Slope is the steepness or incline of the terrain. The slope is a critical factor in signal propagation as shown in Figure 6. Slope has a significant impact on the geospatial mapping of telecommunication signal strength. In the context of radio frequency (RF) propagation, slope affects how signals travel over terrain and interact with obstacles. The aspect map for the study area was developed as represented in Figure 7. The Aspect shows the direction that a slope faces, which can affect how a telecommunication signal is received. This is the compass direction that a slope faces. The impact of aspect on signal propagation is closely related to how signals interact with the terrain and environmental factors.

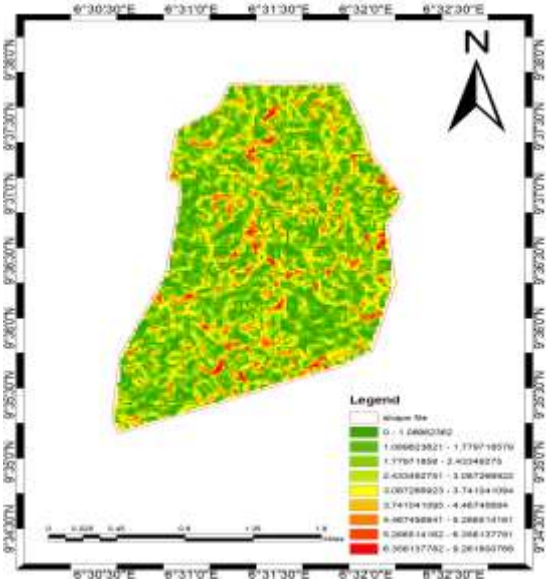

Figure 6: Map showing slope of the study area

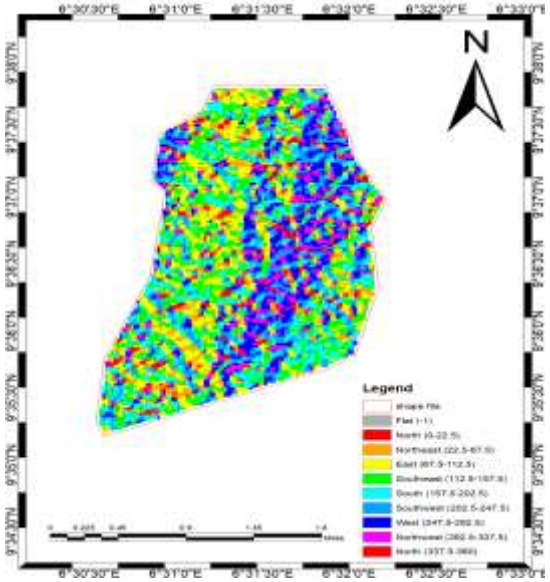

Figure 7: Map showing Aspect of the study area

4.4 Contour and viewshed of the study area:

Contour analysis helps in understanding the terrains impact on signal strength. Contour lines represent the elevation and shape of terrain on maps. It directly affects how signals travel over land by influencing elevation, slope

and the shape of the terrain, they affect line of sight, Signal diffraction, reflection, and path loss. The contour for the study area is presented in Figure 8. A Viewshed represents the geographic area that is visible from a specific observation point, considering the terrain's elevation and observer's height. Viewshed Analysis is crucial tool in this study, it identifies the areas that are visible from the mast location based on terrain and elevation data. It determines whether there is a direct line of sight between a transmitter and a receiver, which is crucial for understanding where signals can propagate effectively. The Viewshed map of the study area is represented in Figure 9.

Figure 8: Map showing Contour of the study area

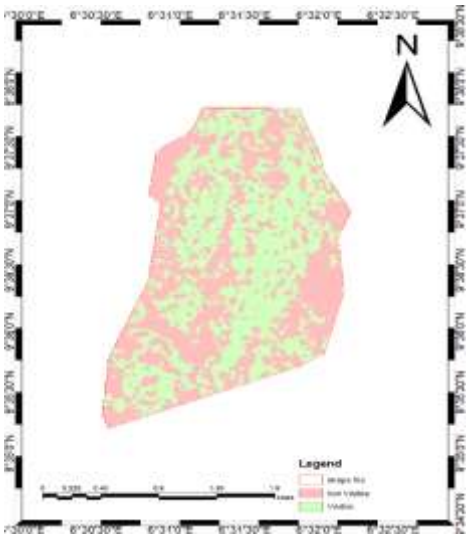

Figure 9: Map of Viewshed of the study area

5. Conclusion

Geospatial mapping of telecommunication signal strength is essential in the planning, optimization, and maintenance of wireless communication networks. By integrating Geographic Information Systems (GIS) with signal propagation models, this approach allows network operators to visualize and analyze how various factors such as terrain, infrastructure, and environmental conditions affect signal coverage and quality. Geospatial mapping is very important in ensuring telecommunication networks are efficiently designed to provide robust and reliable coverage, thereby enhancing user experience and ensuring access to communication services across diverse geographic areas. It also supports regulatory compliance, economic efficiency, and the sustainable expansion of telecommunication infrastructure.

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Contribution of Donor Assisted Programmes to the Spatial Transformation of Rural Communities in Niger and Anambra States, Nigeria

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Abstract

Donor assisted programmes have become an integral part of development programmes in most countries worldwide including Nigeria. A number of research have been carried out to investigate the outcomes of these programmes. While some researchers have paid attention to evaluating the sustainability of these programmes, others have focused attention on investigating factors that determine the implementation of these programmes. This study investigates the impact of three selected donor-assisted pro grammes; Agricultural Transformation Agenda Support Programme Phase 1 (ATASP-1), Value Chain Development Programme (VCDP), funded by International Fund for Agricultural Development (IFAD); and the Third National Fadama Development Project (FADAMA III), on the spatial transformation of beneficiary communities in Niger and of Orumba North were selected from Niger and Anambra States respectively. To evaluate the spatial transformation, a Land Use Land Cover (LULC) analysis was conducted to determine change in land use activities within the period of programme implementation. The land uses investigated were agricultural footprints and built-up areas. The land use landcover analysis covered the period between 2008 when the Fadama III project commenced to 2012 when the VCDP programme commenced to 2017, two years after the ATASP programme commenced and 2024. The classification of the preprocessed images was conducted using the supervised classification method with the Maximum Likelihood Algorithm (MLA), due to its high accuracy in assigning pixels to land cover classes based on the probability of belonging to a particular class. Training samples for the five LULC categories (agricultural land, vegetation, water bodies, built-up areas, and bare grounds) were selected based on both in-situ data and secondary sources, including existing land use maps and Google Earth for visual validation. The findings show significant increase in agricultural activities in Wushishi (Niger State) as well as Orumba North (Anambra State) for the years 2008, 2012, 2017, and 2024. Agricultural footprint increased from 18.16% to 34.69% and 25.82% to 36.45% in Wushishi Local Government Areas over the same period. However, in Orumba North, agricultural footprints increased from 20.46% in 2008, to 46.90% in 2012, before decreasing 36.92% by 2024 as a result of increase in built up areas. The study also shows an increase in built t up areas over the period of time corresponding with intervention of the donor assisted programmes in all the Local Government Areas. The findings from this study revealed that the donor assisted programmes have impacted positively on agriculture and rural transformation by way of increased agricultural activities and built-up area in the local government areas of intervention within the period under investigation and recommends that models similar to those employed by the programmes be employed in implementing future rural transformation programmes.

Keywords: Donor Assisted Programmes; Agriculture; Rural Transformation

1. Introduction

Rural transformation refers to the process of structural change in the rural economy, society, and environment that leads to economic growth and development (Rustiadi *et al*,2023). It is seen as a remedy, course or mechanism to national development. It connotes rapid and radical rural restructuring such as changes in agricultural intensity, crop selection patterns, farmland, land productivity and farm income, labour and technological productivity and a major improvement in rural livelihood (housing, economic and social conditions (Long *et al*., 2011).

About 53 % of Nigeria's population are rural dwellers and are predominantly living below the poverty line (IFAD, 2017), and are generally associated with agriculture which is the means of their livelihood mostly depending on manual and local efforts. From this, it implies that the rural communities depend much on agriculture for their means of livelihood. Notwithstanding its contribution to the national economy and GDP, rural areas in Nigeria tarry in poverty and deeply neglected (IFAD, 2011).

Over the years, rural transformation has been of great concern. Successive government in Nigeria have made concerted efforts to transform rural communities and reduce the persistence of poverty, however, these efforts are yielding little fruits (Friday, 2013). Rural poverty has continued to increase over time, according to Ottong (2006), between 1980 and 1996, rural poverty increased from 28.3 % to 69.8 %. In a bid to address these daunting challenges, several rural transformation plans, policies and programmes have been embarked upon by the Federal and States Governments. These programmes include Agricultural Development Programmes, Operation Feed the Nation, the Green Revolution programme, Better Life for African Rural Women, the various programmes implemented by the River Basin Development Agencies s as well as those carried out under the Directorate for Food Roads and Rural Infrastructure (Ahmed *et al*, 2021).

On the other hand, some previous researches have studied the sustainability of donor funded programmes (Hofisi & Chizimba, 2013; Matsa *et al*, 2023), while others have focused attention on factors that determine the implementation of donor assisted projects (Kalama, 2016; Wachira, 2021), with little attention paid to the contribution of donor assisted programmes to the spatial transformation of the host communities. This study sets out to fill this gap by investigating the level to which donor assisted projects have contributed to the spatial transformation of host communities through expansion in agricultural activities and built-up areas in Nigeria. The study considers three selected donor-assisted programmes being implemented by the Federal Ministry of Agriculture and Food Security, the three programmes all together are implemented in Anambra and Niger States only. The selected programmes are Agricultural Transformation Agenda Support Programme Phase 1 (ATASP-1), funded by African Development Bank, launched in 2013; Value Chain Development Programme (VCDP), funded by International Fund for Agricultural Development (IFAD), launched in 2012; and the Third National Fadama Development Project (FADAMA III), funded World Bank, launched in 2008. However, the Federal Government of Nigeria as well as the participating States Government also contribute a counterpart fund to support the successful delivery of the programmes as well as create a sense of ownership of the programmes by the Federal and participating States Governments. These programmes are being considered in the study to help determine how well have the programmes aided in the spatial transformation of the host communities. It is vital to note that although these three programmes have distinct specific objectives, they are however also geared towards rural transformation. The performance of these programmes (ATASP-1, VCDP & FADAMA III) since inception are yet to be established against the backdrop of their goals as agricultural development among other objectives. Orumba North Local Government Area in Anambra State and Wushshi Local Government Area in Niger State were selected for this study

This paper monitors the change in agricultural footprints and built-up areas in the study areas before and during after the donor assisted programmes. Thus, this paper hypothesises that there is no significant increase in agricultural activities and built-up areas since the intervention of the donor assisted programmes in the study areas.

2. Methodology

2.1 The Study Area

The Landuse land cover analysis was conducted in Orumbba North Local Government Area of Anambra State and Wushishi Local Government Areas of Niger State in Nigeria. Orumba North LGA is made up of 16 autonomous communities, which include; Ajali, (the LGA Head Quarter), Amaetiti, Amaokpala, Awa, Awgbu, Nanka, Ndikelionwu, Ndiokolo, Ndiokpaleze, Ndiokpaleke, Ndiowu, Ndiukwuenu, Oko, Okpeze, Omogho, and Ufuma. It has a projected population of 246,200 and a population density of 770/km2 (National Population Commission, 2022).1t is endowed with fertile land and grows crops like cassava, yam, rice, and palm oil among others. Wushishi LGA of Niger State is made up of 13 districts as follows; Wushishi the LGA headquarter, Zungeru, Tukunji, Yamigi, Sabon Gari, Maito, Lokogoma, Kwata, Kodo, Akare, Barwa, Gwarjiko, and Kanwuri. It has a population of 140,200 and a population density of 76.84/km2 (National Population Commission, 2022).

This study utilized Land Use Land Cover (LULC) analysis for Wushishi and (Niger State) as well as Orunmba North (Anambra State) for the years 2008, 2012, 2017, and 2024 to analyze changes in land use with particular reference to agricultural footprints and built-up areas.

2.1 Data Acquisition

Landsat imagery for the selected years were sourced from the United States Geological Survey (USGS) Earth Explorer database. Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager and Thermal Infrared Sensor (OLI/TIRS) were selected based on data availability and their ability to capture multi-spectral imagery necessary for LULC analysis. These images were chosen for their spatial and spectral resolution, which adequately covered the study areas and provided suitable detail for land classification. Cloud-free images (less than 20% cloud cover) were prioritized to ensure clarity in the interpretation of the land cover types.

2.2 Software and Hardware

The LULC analysis was performed using ArcGIS 10.8 software. ArcGIS 10.8 utilizes a robust set of tools for geospatial analysis, advanced image processing capabilities, and user-friendly interface, which makes it ideal for handling complex LULC analyses. It offers powerful classification algorithms, such as the Maximum Likelihood Algorithm, which was crucial for this study, and allows for seamless integration of satellite imagery from sources like USGS. It also provides high accuracy in georeferencing, preprocessing, and post-classification corrections. Its widespread use and strong community support make it a reliable choice compared to other GIS software, ensuring both accuracy and efficiency in data processing. The processing was conducted on an HP Pavilion 15 laptop equipped with sufficient computational power, including an 8GB RAM and an 11th Generation Intel Core i5 processor and NVIDIA GeForce Graphic Card, ensuring smooth handling of large datasets and efficient processing of Landsat imagery.

2.3 Image Preprocessing

Preprocessing of the imageries was essential to improve data quality and ensure consistency across the different time periods. This involved radiometric correction to remove sensor noise and atmospheric correction to account for the effects of atmospheric particles and radiation on the images. The images were also geometrically corrected and re-projected to the Universal Transverse Mercator (UTM) Zone 32N, which corresponds to the geographic location of the study areas. These steps ensured that all images were aligned correctly and that the analysis was spatially accurate.

2.4 Classification and LULC Analysis

The classification of the pre-processed images was conducted using the supervised classification method with the Maximum Likelihood Algorithm (MLA). Supervised classification has the ability to deliver more accurate and reliable results, particularly when working with predefined land cover categories, compared to the unsupervised classification, which relies on the algorithm to group pixels into clusters without prior knowledge of the land cover types. In supervised classification, the researcher selects training samples based on known land cover types, such as agricultural land, vegetation, and waterbodies, which allows the algorithm to use this information to classify the entire dataset. This method is ideal for studies where specific classes are of interest, as it ensures that the classification is guided by prior knowledge of the area of study, improving the precision of the results. After classification, a confusion matrix was generated to assess the accuracy of the classification process. The matrix compared the classified data to ground-truth points and reference datasets to evaluate the precision of each land cover class. The Kappa coefficient was calculated to provide a statistical measure of the classification's overall accuracy, with values above 0.80 indicating a high level of agreement between the classified data and reference points.

2.5 Change Detection

Change detection between the different years (2008, 2012, 2017, and 2024) was conducted using a post-classification comparison approach. This method involved comparing classified images from different time periods to quantify transitions between the various land cover classes. The changes in land cover were analyzed to determine trends in agricultural expansion, deforestation or reduction in vegetation cover, shrinkage of water bodies, urban growth, and the spread of bare grounds. These changes were calculated as percentages of the total land area for each study location, providing a clear picture of the dynamic land use patterns over the study period. The results of the change detection analysis were visualized through maps and graphs, highlighting the most significant shifts in land use.

3. Land use and land cover (LULC) changes in the Wushishi local government area.

Table 2 and Figures 1-4 presents the land use and land cover (LULC) changes in the Wushishi local government area from 2008 to 2024. The analysis shows that the agricultural footprint increased from 25.82 % to 36.45 % between 2008 and 2024.The built-up areas similarly increased from 13,664.7 Ha in 2008 to 27,465.63 Ha by 2024.

Table 2: Land Use/Land Cover Changes for Wushishi LGA, Niger State

Land uses	2008		2012		2017		2024	
	Size (Ha)	%	Size (Ha)	%	Size (Ha)	%	Size (Ha)	%
Water body	3,001.14	1.59	3,021.11	1.61	3,039.18	1.62	3,058.17	1.63
Built-up area	13,664.7	7.26	17,423.23	9.26	22,745.43	12.09	27,465.63	14.60
Barren land	26,735.22	14.21	22,653.17	12.04	20,153.43	10.71	18,153.47	9.65
Agricultural footprints	48,594.24	25.82	52,591.21	27.95	59,591.21	31.67	68,592.23	36.45
Vegetation	96,185.79	51.11	92,492.37	49.15	82,651.84	43.92	70,911.59	37.68
TOTAL	188,181.1	100.00	188,181.1	100.00	188,181.1	100.00	188,181.1	100.00

Source: Researcher, 2024

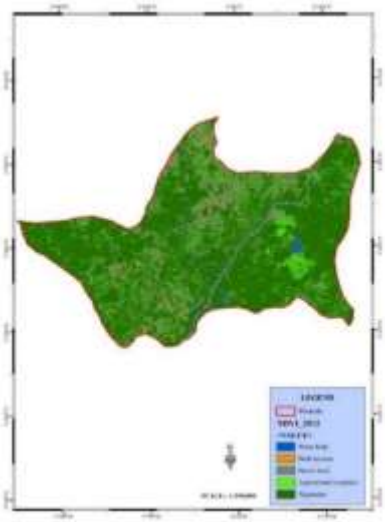

Figure 1: 2008 LULC Analysis for Wushishi LGA, State
Source: Reseaercher, 2024

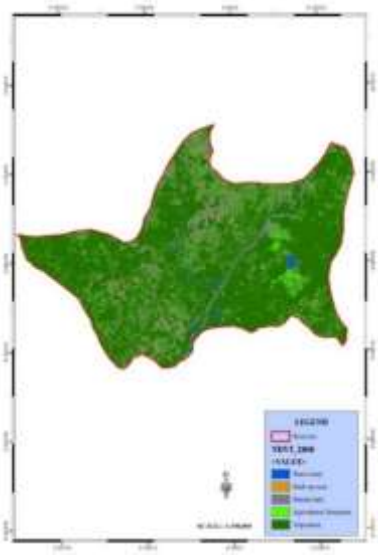

Figure 2: 2012 LULC Analysis for Wushishi LGA, Niger State.
Source: Reseaercher, 2024

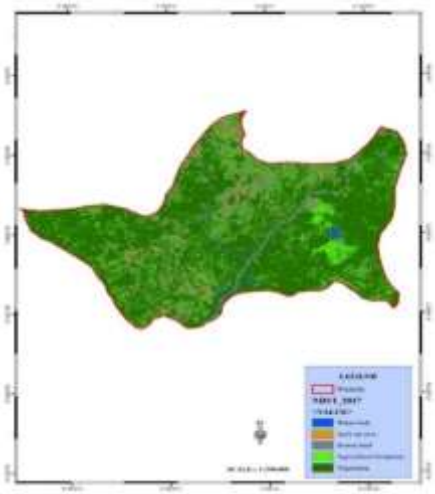

Figure 3: 2017 LULC Analysis for Wushishi LGA, Niger State
Source: Reseaercher, 2024

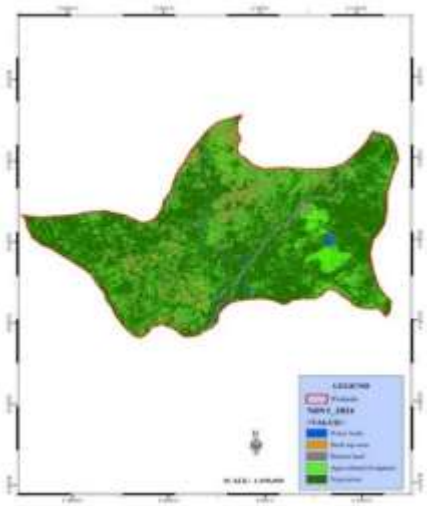

Figure 4: 2024 LULC Analysis for Wushishi LGA, Niger State
Source: Reseaercher, 2024

3. Land use and land cover (LULC) changes in the Orumba North local government area from 2008 to 2024

Table 4 and Figures 5-8 illustrate the land use and land cover (LULC) changes in the Orumba North local government area from 2008 to 2024. The data indicates that built-up areas increased from 7,411 Ha in 2008 to 12,243 Ha in 2024, corresponding to 13.78%, 16.22%, 19.84%, and 22.79% of the total area in the respective years. Additionally, the agricultural footprint fluctuated, occupying 10,999 Ha (20.46%) in 2008, peaking at 25,188 Ha (46.90%) in

2012, before decreasing to 19,872 Ha (36.92%) by 2024. In contrast, vegetation cover experienced a significant decline, with areas measured at 25,758 Ha (47.84%) in 2008 dropping to 15,484 Ha (28.84%) by 2024. Meanwhile, barren land decreased from 9,638 Ha in 2008 to 6,136 Ha in 2024, reflecting a reduction in its proportion from 17.92% to 11.4% of the total land area. These changes signify a notable shift towards urbanization and agricultural development in Orumba North, confirming the contribution of the donor assisted projects to rural transformation in the study areas.

Table 3: Land Use/Land Cover Changes for Orumba North LGA, Anambra State

LAND USES	2008		2012		2017		2024	
	Size (Ha)	%	Size (Ha)	%	Size (Ha)	%	Size (Ha)	%
Builtup area	7,411	13.78	8,718	16.22	10,674	19.84	12,243	22.79
Vegetation	25,758	47.84.	11,317	21.04	12,857	23.92	15,484	28.84
Agricultural Footprints	10,999	20.46	25,188	46.90	22,294	41.46	19,872	36.92
Bare ground	9,638	17.92	8,433	15.68	7,945	14.78	6,136	11.4
TOTAL	**53,770**	**100.00**	**53,770**	**100.00**	**53,770**	**100.00**	**53,770**	**100.00**

Source: Researcher, 2024

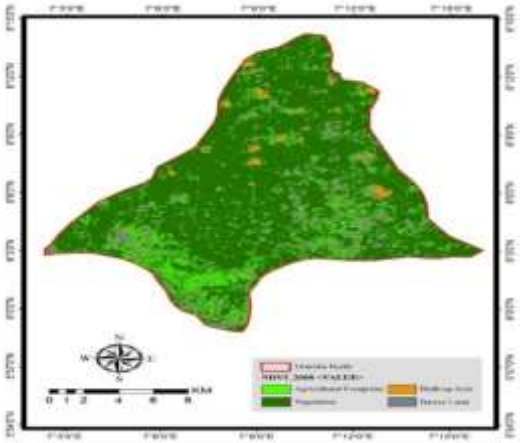

Figure 5: 2008 LULC Analysis for Orumba North, Anambra State
Source: Reseaercher, 2024

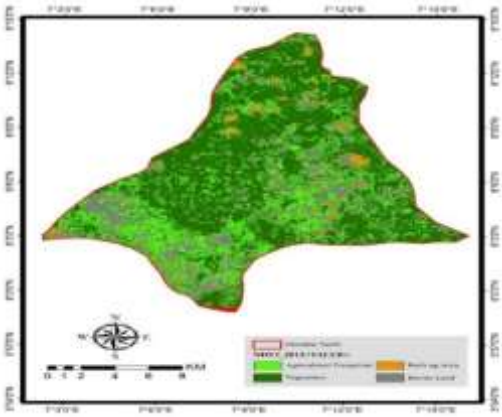

Figure 6: 2012 LULC Analysis for Orumba North, Anambra State.
Source: Reseaercher, 2024

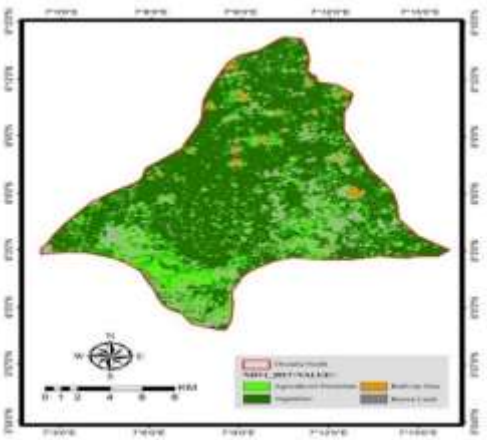

Figure 7: 2008 LULC Analysis for Orumba North, Anambra State
Source: Reseaercher, 2024

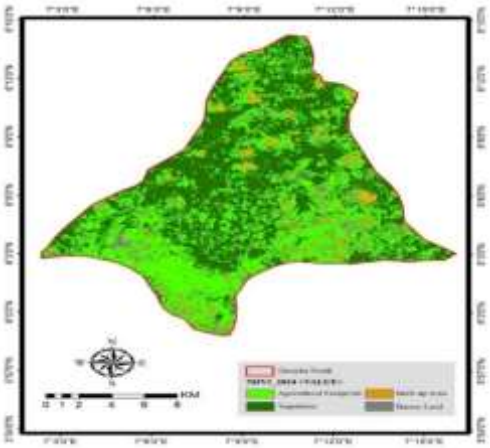

Figure 8: 2012 LULC Analysis for Orumba North, Anambra State.
Source: Reseaercher, 2024

4. Discussion

The study has shown significant changes in land use in Orumba North and Wushishi Local Government Areas of Anamra State and Niger States respectively. The study has dispelled the hypotheses that there is no significant spatial transformation in agricultural activities and built-up areas since the intervention of the donor assisted programmes in the study areas. In Wushshi, Local Government Area agricultural footprint was 25.82 % of the total land area in 2008 before programme intervention. However, by 2012 it had increased to 27.95 % and 31.67 % by 2017 progressing to 36.45 % in 2024. This implies that the community members have benefitted from the programmes and have been engaged in increased agricultural activities over the years in Wushishi Local Government Area. There is also a corresponding increase in built-up area since programme implementation. Prior to the programme intervention, built-up area in Wusishi occupied 7.26 % of the total land area in 2008 but increased to 9.26 % by 2012 and had increased to 12.09 % in 2017 and 14.60 % in 2024, with the intervention of the FADAMA III, VCDP and ATASP I Programmes in 2008, 2012 and 2015 respectively

However, in Orumba North Local Government Area, while there is an increase in built up areas over the years, there is a drop in agricultural land use over the years. Built up areas was 13.78 % of the total land area in 2008 and increased to 16.22 % in 2012 and, 19.84 % in 2017 to 22.79 in 2024 with the intervention of the programmes. On the other hand, while agricultural land use increased from 20.46 % in 2008 to 46.90 % in 2012, it dropped to 41.46 % in 2017 and 36.92 % in 2024, contrary to the development in Wushishi Local Government Area of Niger State.

The general increase in agricultural activities and housing Implies that the programmes have had a positive impact on the income of the members of the community which has enabled them to engage in large scale agriculture and build houses of their own resulting in the spatial transformation of the communities over the years. On the other hand, the decrease in agricultural land in Orumba North Local Government Area implies the higher investment in housing as compared to Wushishi Local Government Area of Niger State. This could be seen from the total percentage built up area for Orumba North Local Government Area of 22.79 % as compared to 14.6 0% in Wushshi Local Government Area in 2024.

5. Conclusion

The land use and cover changes as seen from the analysis across these communities in Niger and Anambra States underscore the dynamic nature of spatial transformation driven by agricultural expansion. The increase in agricultural footprints and corresponding increase in built up areas implies an increase in income from agricultural activities which has resulted in the ability to develop housing. This shows the positive impact of the programmes on the livelihood of the people of the communities s relating to rural transformation. This analysis shows that donor assisted programme can contribute significantly to rural, transformation and development.

Based on the findings of the research, it is recommended that the model adopted by the three programmes be replicated in other parts of Nigeria where such interventions have not been made. It is also recommended that donor agencies should take note of the ecological changes that may occur in communities as a result of increase in built up areas which consume open spaces, water bodies and bare lands. Thus, there is need for further research on the environmental impacts of the FADAMA, VCDP and ATASP I Programmes before commencement of the programmes to proffer solutions to the negative impacts that may accrue. Research should also look into the socio-economic impacts of the programmes as a way of determining their relevance in the Nigeria rural transformation agenda.

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Volume 2 proceedings

Assessment of passive security and access control strategies in design of Courthouses in Abeokuta, Ogun State

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Abstract

This research aims to comprehensively evaluate the integration of passive security and access within a courthouse, delving into the intricacies of design, technology, and human behaviour, with a focus on enhancing safety, functionality, and user experience. Through a comprehensive review of existing literature, case studies, and open-ended questionnaires this study aims to unearth the underlying principles governing effective passive security strategies in courthouse environments. From controlled access points, physical barriers, surveillance technology to enhance control mechanisms and landscape design, each element will be scrutinized through the lenses of threat mitigation, user experience, security, circulation patterns, building layout, space organisation, privacy, parking spaces, spaces standard and spaces allocation. This study employed a quantitative approach, where both primary and secondary data were collected, including case studies, on-site observations, questionnaires, books and journals. Analysis of the data collected, coupled with relevant literature review guides the development of recommendations and design interventions that prioritize security, access control and functionality in court buildings.

Keywords: Access control, court buildings, functional spaces, passive security, spatial organisation

1. Introduction

In recent years, the role of architecture in ensuring the safety and security of public buildings has become increasingly vital. Among these structures, court buildings hold a unique position as symbols of justice and authority (Crowe, T., & Wickersham, J. (2018). The design of these facilities must not only prioritize security measures but also convey a sense of gravitas and command respect. This study delves into the exploration of how architectural principles can be effectively employed to enhance passive security and access control strategies, while simultaneously creating an imposing image for court buildings, O'Neill, M. A. (2019). Around the world, courthouse design has been used to make statements on society and visions for justice in the future, just like how architecture plays a significant role in shaping human behaviour, perceptions, and interactions within built environments (Day, C., Chen, D., & Schmidt, K. (2017). The incorporation of design elements and features that reinforce security measures can help deter threats, ensure the well-being of court staff and visitors, and maintain the integrity of legal proceedings.

Passive security refers to measures and design features implemented to protect buildings, facilities, or spaces from potential threats without requiring human intervention or active management. These measures are intended to mitigate the impact security breaches, reduce vulnerabilities, and enhance the overall safety of the environment. Unlike active security measures, such as surveillance cameras, alarms, or security personnel, passive security features are often integrated into the design and structures of a facility and function continuously without direct human operation.

The concept of passive security encompasses a wide range of strategies and elements. These can include architectural design choices, materials used in construction, landscaping features, and barriers designed to deter unauthorized access or mitigate the effects of potential attacks.

According to the Courthouse Reorganization & Renovation Program, 2017, in conjunction with the National Institute of Law Enforcement and Criminal Justice (NILE & CJ), explained that security in a courthouse encompasses deterrence, detection, and limitation of damage. Effective security design aims essentially to deter potential threats to the safety of persons and facilities within the courthouse. The more effective the deterrence, the lower the incidence of security problems. Where deterrence fails – and it will, at least when persons are intent on causing trouble – it remains for security design to detect threats rapidly and to signal attention of those who can take appropriate action. If a bomb were smuggled into a courthouse, the earlier it can be detected, the more safely the

incident can be handled. Finally, security design seeks to limit damage that may be caused by action following threat. A building with a bomb emplaced, evacuated rapidly, safely and orderly without prisoner escape exemplifies damage limitation.

The incorporation of design elements and features that reinforce security measures can help deter threats, ensure the well-being of court staff and visitors, and maintain the integrity of legal proceedings. Simultaneously, the visual impact of a courthouse can influence public perceptions of justice, conveying notions of fairness, impartiality, and professionalism, O'Neill, M. A. (2019).

2. Statement of the Research problem

Existing courthouses in Nigeria are characterized by inadequate functional spaces, security lapses, and poor spatial organization, limiting their effectiveness in delivering justice. This study seeks to evaluate these issues in Abeokuta's courthouse, focusing on passive security and access control to improve functionality and safety.

3. Aim

This study aims to evaluate the effectiveness of passive security measures and access control systems in the design of courthouses, using Abeokuta, Ogun State, as a case study, to provide recommendations for improving courthouse safety and functionality.

4. Passive Security and Access Control Strategies

The design and functionality of public buildings play a crucial role in shaping not only the physical environment but also the perception and experience of the occupants and visitors, Smith, J. (2016). Within this context, careful attention to both passive security considerations and access control strategies is essential in this study to explore the concept of emphasizing the hierarchy of functional spaces, controlled entry points, physical barriers, electronic access control systems, as a means to enhance security measures. Court complexes serve as vital institutions for the administration of justice, where the rule of law is upheld and legal proceedings take place. However, like many public buildings, it faces challenges in maintaining efficient security protocols while also creating an impression of professionalism and trustworthiness. Balancing these requirements necessitates a thorough examination of the building's spatial organization, security strategies, and design elements, Doe, A. B. (2017).

The goal of passive security is to create an environment that is inherently secure, reducing the likelihood of a successful attack and minimizing the damage if an attack occurs. Key elements of passive security include; building design & layout, structural reinforcements, landscaping and perimeter barriers, lighting and visibility, natural surveillance, signage and wayfinding. Courthouses are critical infrastructure in any country, including Nigeria. They serve as venues for the administration of justice and house sensitive information, valuable assets, and individuals who may be targets for criminal activity or violence. Given their importance, courthouses require robust security measures to protect the safety of judges, court staff, legal practitioners, defendants, witnesses, and the public. Passive security plays a crucial role in achieving this objective. In the context of a Nigerian courthouse, passive security measures must be tailored to the unique challenges and threats faced by the judiciary and legal system in Nigeria. These threats can include armed attacks, riots, vandalism, theft, and even terrorism. Additionally, courthouses in Nigeria must contend with infrastructure limitations, varying levels of resources, and diverse geographic and cultural contexts.

Access control refers to the process of restricting and managing who or what can access a particular system, area, or resource. This mechanism is an essential element in various sectors, including government institutions, private organizations, and public establishments. Establish only one main door through which the public can enter the court building and display a sign at the entrance clearly listing those items that cannot be brought into the court building (Fautsko, 2010). Specifically, in the context of courthouses, access control involves measures that regulate the entry and exit of individuals, as well as the movement of materials and information. In Nigeria, where the judicial system plays a crucial role in maintaining the rule of law, access control in courthouses becomes an important component in ensuring security, confidentiality, and the smooth functioning of judicial proceedings. Given the sensitive nature of legal proceedings, the need for strict access control cannot be overemphasized.

There are various components to an effective access control system in a courthouse. These components work together to ensure that only authorized individuals are granted entry, while unauthorized individuals are kept out. Below are some key elements of access control in Nigerian courthouses: physical barriers, identification systems, electronic access control systems, CCTV surveillance, security personnel, metal detectors and scanners, visitor management systems.

While passive security and access control are distinct concepts, they are deeply interconnected in the context of courthouse security. Both are essential in providing a layered approach to safety, with each complementing the

other in specific ways such as: complementary functions, enhancing response time, preventing over-reliance on one system, mitigating human error, psychological deterrence.
Court facilities should provide a safe and secure environment for the staff, judges, jurors, general public and those held awaiting trial. Court security and access control has a simple but critical purpose – to protect the integrity of court processes and proceedings.
Courthouse facilities should be organized into four zones that group individuals coming to the courthouse based on their function and separate them until they meet in the court room. The four zones are the "public zone," the "private zone," the "prisoner zone" and the "interface zone". Access between the four zones should be controlled by passage through controlled doors.

5. Data Analysis and Research Findings

5.1 Description of Study Area

A careful analysis of Nigerian court buildings that comprise the High Court of Justice complex, Ogun State; Ikeja High Court complex Lagos state; the High Court of Justice complex, Ibadan, as case studies reveals the major techniques employed to satisfy the requirements of a functional courthouse, as well as to find the problems facing such buildings and solutions to such problems in the proposed design.

5.2 Data Collection

5.2.1 Questionnaire Administration

Various units of the high courts were administered the questionnaires that cover the three study areas, as shown in Table 1.

Table 1: Total questionnaires administered in the three study areas

Index Number	Units	Distributed questionnaires	Recovered questionnaires	Percentage of the recovered questionnaires (%)
1	Administrative	42	30	71.4
2	Registry	27	20	74.1
3	Cash office	11	8	72.7
4	Courtrooms	35	26	74.3
5	Library/Archive	13	10	76.9
6	Others	22	16	72.7
	Total	**150**	**110**	**73.3%**

Source: Author's field survey, 2024
Fair responses were acquired from all the high courts visited. The total number of questionnaires distributed was 150 and 110 was recovered, which is equivalent to 73.3%.

5.2.2 Primary Data Analysis

The data collected were subjected to statistical analysis for interpretation and inferences to be drawn. The statistical analysis provides tables, and percentages were used for simple statistical description.

5.2. Security, Access Control and Spatial Organizational Indicators

Some variables were used in the administration of the questionnaire. These variables were identified to have been used to determine the security and access control of some court buildings in Nigeria. All the high court staff and other participants that were administered with the questionnaire were asked to rate these variables as either (i) Satisfied, (ii) Just satisfied, (iii) Dissatisfied, (iv) More Dissatisfied, and (v) Very much Dissatisfied. Every respondent was instructed to choose a rating for each of the 10 listed variables. To analyse the data collected, each of the ratings is assigned a weight value as indicated below.
The weighted value for each factor was obtained by calculating the summation of weighted value (SWV) for each question. This was achieved by the summation of the product of the number of responses to each rating to a question and the respective weight value. This can be mathematically expressed as follows:

$$SWV = PiVi$$

Where SWV is the summation of the weighted value of each of the 10 questions, Pi is the number of respondents choosing a particular rating i and is the weight assigned to rating 1.
Where: SWV = Total weight value
N = Total number of respondents

P = Number of respondents rating an attribute i;
Vi = Weight assigned to attribute i.
For example, the Summation of Weighted Value (SWV) is calculated for communication and spatial pattern within the courtroom for the staff of the High Court of Justice, Ogun State as a variable. Thus: 10 × 5 + 12 × 4 + 12 × 3 + 6 × 2 + 2 × 1 = 148. This is the process used for all 10 indicators in all three high courts studied, as shown in Table 2. From the analysis of the variables' rating of the three high courts, the staff responses in all study area confirmed the validation of the indicators because it almost follows each other according to the orders of importance. However, Table 3 shows the combined rating from the staff and other high court users.
The results show that the high courts in the study area provided good characteristics in area of communication and spatial pattern within the courtroom, court building layout, access control, and space pattern, with SWV values of 148, 153, 145, and 148 respectively. Meanwhile, the study areas are deficient in the areas of adequate parking space, circulation pattern, natural lighting, adequate security, accessibility with other department and presence of privacy, with SWV values of 141, 105, 107, 94, 97, and 99 respectively, which are low in quality and are not adequate. Similarly, in respect of the computation of security and access control indicators of the area, four out of ten variables had SWV equal to or above 145. It shows that users' perception of the overall court area is on the negative side on six factors. This result implied that the architectural design and management of the courthouse in the study areas need to consider some basic security and access control indicator requirements such as adequate parking space, circulation pattern, natural lighting, adequate security, accessibility with other departments, and presence of privacy among others. This is important in determining court building quality, security and well-being of the users in the study areas. The inference of this is that architects and other building professionals engaged in the implementation, redevelopment, and restructuring of existing court buildings, and planning and designing of a new one should involve suitable design principles in conceiving court buildings that meet users need and level of quality.

Table 2. Security and spatial organisation in the court building: Indicators rated by the staff of the High Court of Justice, Ogun State

S/N	Indicators	Ratings (Weight value)	i (5)	ii (4)	iii (3)	iv (2)	v (1)	N	SWV
1	**Communication and spatial pattern within the courtroom**		50	48	36	12	2	42	148
2	**Access control**		45	40	48	10	2	42	145
3	**Court building layout**		50	60	33	8	2	42	153
4	**Space pattern**		50	60	30	2	6	42	148
5	**Adequate parking space**		35	48	48	6	4	42	141
6	**Circulation pattern**		30	32	6	22	15	42	105
7	**Natural lighting**		25	40	9	18	15	42	107
8	**Adequate security**		30	20	6	18	20	42	94
9	**Accessibility with other departments**		30	20	9	20	18	42	97
10	**Presence of privacy**		20	28	12	24	15	42	99

Source: Author's field survey, 2024

Table 3. Security and spatial organisation in the court building: Indicators in the study areas (Total responses from all the High Courts visited)

S/N	Indicators	Ratings (Weight value)	i (5)	ii (4)	iii (3)	iv (2)	v (1)	N	SWV
1	**Communication and spatial pattern within the courtroom**		145	148	75	30	4	110	**402**
2	**Court building layout**		140	144	78	26	7	110	**395**
3	**Access Control**		135	116	99	30	6	110	**386**
4	**Space pattern**		120	152	81	22	10	110	**385**
5	**Adequate parking space**		95	116	105	32	11	110	**359**
6	**Circulation pattern**		85	92	60	56	22	110	**315**
7	**Natural lighting**		70	104	63	46	26	110	**309**
8	**Adequate security**		70	72	63	60	27	110	**292**
9	**Accessibility with other departments**		60	68	84	50	28	110	**290**
10	**Presence of privacy**		55	60	87	56	27	110	**285**

Source: Author's field survey, 2024

5.3 Assessment of Security and Access Control of selected Court buildings

The staffs and other participants of these high courts were asked to assess the security and access control of their various court buildings using the 10 indicators listed earlier.

5.3.1 Adequate Security

Staff and other participants of the various court complex were asked to rate the level of satisfaction of adequate security in their complex. The variable used and their corresponding rating were, Satisfied- 5, Just Satisfied- 4, Dissatisfied- 3, More Dissatisfied- 2, and Very Much Dissatisfied- 1. Total weighted value (TWV) is then calculated by the summation of values gotten from the multiplication of the number of responses for each rating and the respective weighted values as calculated as shown in Table 4.

Table 4. Level of adequate security in the court complexes

S/N	High Courts	Satisfied (5)	%	Just Satisfied (4)	%	Dissatisfied (3)	%	More Dissatisfied (2)	%	Very Much Dissatisfied (1)	%	TWV
1	High Court of Justice, Ogun State	6	14.29	5	11.9	2	4.76	9	21.43	20	47.62	**94**
2	Ikeja High Court Complex	4	10.81	7	18.92	9	24.32	14	37.84	3	8.11	**106**
3	High Court of Justice, Ibadan	4	12.9	6	19.35	10	32.26	7	22.58	4	12.9	**92**

Source: Author's field survey, 2024

From Table 4 above, the summation weighted values are 94 for Ogun State, 106 for Ikeja, and 92 for Ibadan. This shows that High court of Justice, Ibadan has the least adequate security network while Ikeja High Court complex has the highest adequate security amongst the courts in the study area. Also, from the table, 5 respondents representing 11.9%, 7 respondents representing 18.92%, and 6 respondents representing 19.35% in Ogun State, Ikeja, Lagos State, and Ibadan respectively are just satisfied with the level of adequate security in their various complex. It is the High Court of Justice, Ogun State that has the highest percentage of respondents satisfied with the level of adequacy of security which is 14.29%, while the Ikeja High Court complex has the lowest percentage of respondents satisfied

with the level of adequacy of security which is 10.81%. The reason was that the security was better planned and effectively designed for the High Court of Justice, Ogun State compared to that of Ikeja High Court because of the land constrains in Lagos State.

5.3.2 Circulation Pattern

Court building involves a lot of people coming in and out of the complex. Therefore, for safety and security reasons, these people require a separate circulation route. The circulations have to be simple, straightforward, ensure public convenience and avoid confusion. For these reasons, the circulation pattern is important for the location of various functions and departments in the court complex. Therefore, a court complex where members of the public constantly stop to ask for direction is sure of a poorly planned circulation pattern. The respondents were asked to rate the circulation pattern and routes in their court complex in order of Satisfied-5: Just Satisfied-4: Dissatisfied-3, More Dissatisfied-2, and Very Much Dissatisfied-1. The total weighted value was then calculated by the summation of values gotten from the multiplication of the number of responses for each rating and the respective weighted values are as shown in Table 5.

Table 5. Level of circulation pattern in the court complexes

S/N	High Courts	Satisfied (5)	%	Just Satisfied (4)	%	Dissatisfied (3)	%	More Dissatisfied (2)	%	Very Much Dissatisfied (1)	%	TWV
1	**High Court of Justice, Ogun State**	6	14.29	8	19.05	2	4.76	11	26.19	15	35.71	105
2	**Ikeja High Court Complex**	5	13.51	8	21.62	10	27.03	10	27.03	4	10.81	111
3	**High Court of Justice, Ibadan**	6	19.35	7	22.58	8	25.81	7	22.58	3	9.68	99

Source: Author's field survey, 2024

From Table 5, the responses from High Court of Justice, Ogun State shows that 8 respondents representing 19.05% are just satisfied with the circulation pattern while also 8 respondents represent 21.62% of Ikeja High Court, and 7 respondents represent 22.58% of the High Court of Justice, Ibadan. From these statistics, the circulation pattern in the High Court of Justice, Ogun State is the worst with 35.71% very much dissatisfied with the circulation pattern, followed by the Ikeja High Court complex with 10.81% also very much dissatisfied with the system.

6. Summary of findings

From the Table also, it reveals that most of our high courts' buildings are satisfactory in the area of communication and spatial pattern, court building layout and space pattern in the court building complex. While some are satisfactory and some are dissatisfied in building layout, parking space, accessibility with other departments. From all indicators, as shown in the study, the Ikeja High Court is the least distinct and effective as it least satisfies most of the respondent requirement. The indicators show that most respondents are dissatisfied with the complex in term of the security and spatial organisation of the design. From the study, it shows that the effectiveness of high court building depends on: adequate security within the premises; good spatial organisation within the court premises; efficient access control, well-planned building layout; adequate and effective parking space; good circulation; effective communication and spatial pattern within the courtroom; and each department should be accessible to one another.

The lack of adequate parking space and poor circulation patterns pose significant security risks, making it easier for unauthorized access and limiting the effectiveness of emergency responses. Improving these elements would enhance both passive security and overall user experience

7. Recommendations

Based on the findings in this study, the following recommendations were made concerning court buildings with High Court complexes as the focus. In the planning of a courthouse, the architect should be involved right from the inception stage, and made to realise the intricacies of a court design and usage. Based on the findings, priority should be given to improving the spatial organization within courthouses, particularly in addressing parking, circulation,

and security access points. Further research could explore the integration of advanced surveillance systems to enhance passive security.

8. Conclusion

This study assessed the passive security and access control problems in courthouses using the quantitative method. Passive security and access control problems identified are circulation problem, inadequate security, poor arrangement of spaces and access to other departments, inefficient parking spaces. The study highlights the need for improved spatial organization and security measures in courthouses to enhance both functionality and safety. Addressing key deficiencies such as parking, lighting, and circulation patterns will be crucial in designing secure and efficient court environments.

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Exploration of Vernacular Security Strategies in the Yakurr Built Environment, Southern Nigeria.

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Abstract

Security constitutes a vital right and a crucial component of human progress. Wherever insecurity persists, it comes with different shades of poverty, food insecurity, violence, malevolent harm, property destruction, loss of cultural identity, and injustice. In Nigeria and other parts of the world, several rural and urban communities are plagued with numerous security challenges. Insecurity in rural areas is further worrisome as many of them do not have even a police post yet they serve as the primary source of food and raw materials. The perception of security, both individually and collectively, encompasses economic, social, environmental, cultural, and political factors. A descriptive phenomenological approach was employed in the investigation. The criteria for space allocation household layout, and social cohesion among the Yakurr People were evaluated. Oral tradition, comprehensive individual interviews, and focus group discussions were conducted until saturation was achieved about *kerm-kom*, *ekoo* (age grade system), *lokpan-kuma*, cultural diplomatic links among villages, shrines, deities, and sacred sites. The results were subjected to content analysis to produce a variety of vernacular security strategies inside the Yakurr built environment from the 17th century to the present. The Yakurr settlements, resulting from ancient military defeat in their Akpa homeland, have inherently employed these techniques to exhibit security resilience against diverse internal and external security threats in their newly established locations. These ideas can aid architects and other built environment professionals in designing culturally suited security-building projects for rural residents without using costly sophisticated technologies. Furthermore, relief groups, government and other worldwide agencies' attempts to resettle populations who have been victims of insecurity can employ the lifelong built environment security measures of the Yakurr People to design more assault-resilient resettlement homes.

Keywords: community security, passive security measures, vernacular architecture, vernacular Built Environment, social cohesion, Yakurr People

1. Introduction

Security is the summation of strategies for prevention and resilience against crime and harm (Cheng & Chen, 2021) and the perceptions of freedom from anxiety, harm and danger. In Nigeria today, terms like unknown gunmen (Akinyetun *et al*., 2023), bandits, armed herdsmen, farmers-pastoralists clashes, kidnapping, violent extremism, terrorism, religious and ethnic insurgence associated with insecurity are in common use with dire environmental, economic and social consequence. Hence there are environmental consequences of insecurity; built environment professionals have roles to play from preventive, resilience, and remedial measures along the chain

Isah Iliyasu *et al*. (2022), Binns (2021) and Ogbodo (2022) aptly noted that poverty, insecurity, terrorism, and climate change are the four (4) main challenges the world is facing in the 21st century. They further established that the relationship between the rate of crime, insecurity, and the built environment cannot be ignored but rather deserves more empirical research. Furthermore, the works of environmental geographers, urban planners, and architects can offer explanations and proffer effective solutions to community insecurity through their designs. Thus there ought to be effective collaboration between security agencies and non-security agencies like built environment professionals (BEPs) in preventing crimes and reducing insecurity. Security is the business of all (Ogbodo, 2022).

Several discussions centre on urban security with sparse mention of rural security (Balogun & Adeoye, 2022). Rural communities like urban centres also have security challenges (Moxey, 2023). Rural communities remain the main source of food and raw materials. However, the increasing cost of food in Nigeria is tied to the prevalence of several security challenges in rural communities. No state in Nigeria is spared. Hence, the need to explore the security resilience strategies of vernacular built environments for adaptation by built environment professionals. Scarlata

(2023) identified passive and active security measures to keep buildings safe. Passive security systems do not require human interaction such as cameras, locks, and fences while active security needs more human involvement.

2. Literature review

This is a brief overview of the scholarly works around vernacular architecture, vernacular built environment, built environment professionals, and their role in community and neighbourhood security and security strategies.

2.1 Evolutionary trends of community security around the world

As communities and settlements evolved, the need for protection from wildlife attacks and rival settlements became top priority. These inspired communities to develop various defense strategies and structures. The earliest strategies in the primitive era involved the use of natural defenses, such as caves, mountains, or islands. Later, the Egyptians had pyramids, fortresses and city walls just like the Great Wall of China are still pieces of evidence of their civilization's efforts at securing their borders and territories. During the medieval era tall castle walls, heavy iron gates, guarded entryways, openings for archers, moats, and drawbridges have been used to secure communities and cities around the world. In these modern times, communities and countries devote a lot of resources to secure their citizens and territories from attacks. A combination of surveillance equipment, computerised entry controls, and detection devices, together with conventional security measures like barrier walls, the layout of buildings, and spatial neighbourhood plans have been used to curb internal and external security breaches (Blessing, 2023; Saferworld, 2014).

All security strategies are distinct and particular to the setting of the neighbourhood, community, or nation. It has been affirmed that alterations in social interactions within a community and between communities significantly boost the Security of those communities (Jädersand, 2021). In Nigeria before colonisation, several strategies were used to secure lives, properties, and communities. The Igbos used shrines and deities to curtail criminal activities, theft, and bloodshed, defend their territories from attack, and secure lives and properties (Anedo, 2020; Ani, 2020). With shrines and deities, internal security challenges and crimes were promptly and adequately resolved within the scope of their civilization. These community security tokens are embedded in their built environment.

2.2 Vernacular architecture

The word 'vernacular' was derived from the Latin word 'vernaculus', meaning native, local, indigenous, or traditional. Although 'vernacular' generally refers to the dialect or speech of a people. So vernacular architecture can be defined as the 'native science of building' that suits the locals (Oliver, 2006). Vernacular architecture is the process of planning, designing, and constructing buildings, other physical structures, and the spaces in between based on the culture, traditions, local conditions, available materials, technology, and the peculiar situation of a people at a particular time (Ghisleni, 2020). It is a location and ethnic-based architecture. Oliver (2006) has advocated for the inclusion of vernacular architecture in the curriculum of schools of architecture worldwide.

2.3 Vernacular built environment

The vernacular built environment of a society comprises the spaces created by its inhabitants, reflecting their economic prosperity, dominance, prevailing religion, accessible construction materials and resources, local technology, microclimate, history, traditions, and sociocultural biases (Mustafa *et al*., 2013). Kaklauskas and Gudauskas (2016) support the viewpoint of Mustafa *et al*. (2013), characterising the built environment as 'a material, spatial, and cultural manifestation of human labour that integrates physical components and energy for living, working, and leisure.' Labour patterns differ among cultures and regions. The characteristics of the built environment are the indicators of the economic prosperity, dominance, prevailing religion, and societal tendencies of its inhabitants Moreover, Rashid (2020) identifies spatial planning, construction materials and processes, and sociocultural characteristics as essential elements to examine when assessing the built environment of a community.

2.4 Built environment professionals and community security

Dalit (2019) asserts that experts in the built environment bear the obligation of ensuring that the urban or rural environment is safe for inhabitants through their design, decisions, and choices. Furthermore, BEPs can create models to assess the security of a community. Chansomsak and Vale (2010) also noted that architects serve crucial functions as built environment professionals and citizens in formulating sustainable community security plans. Furthermore, Rechkemmer (2023) mentioned that architects might employ site planning, clear sight lines, adequate building materials, proper wayfinding procedures and spatial arrangement of buildings to accomplish passive security. He further claimed that these tactics are optimum after the security goals are explicitly specified by all

relevant stakeholders. He also listed security as one of the criteria a building should meet irrespective of the typology or status of the end users.

Marzbali (2015), Maghsoodi-Tilaki (2021), and Maghsoodi Tilaki *et al*. (2022) all suggested that environmental and landscape design components that promote social cohesion, spaciousness, clean, tidy, flexible, and properly lighted spaces, can limit crime rate within a community and further increase the dwellers' perception of safety. Also built environment professionals participating in building or planning neighbourhoods should incorporate characteristics that would promote a sense of ownership in the intended occupants. This is because a community's built environment covers all building typologies, zoning of neighbourhoods, open spaces, streets, and pedestrian walkway designs. It is thus the responsibility of built environment professionals to prioritise the community residents' security.

2.4 Yakurr People

The Yakurr People are a block that relocated from their Akpa ancestral territory due to their default in the completion of funeral ceremonies. The migration was owing to their military loss to the Akpa warriors. Thus, all Yakurr communities moved and established themselves between 1617 and 1767 (Ubi, 2019), except for Ekom Agoi. Ekom Agoi relocated from Agoi Ekpo as recently as 1945 because of the inhumane acts of World War II. Colonialists recommended the name Yakurr for ease of administration. According to Enang (2009), the Ayiga clan comprising Assiga (Old, New, and Beach towns), Inyima, and Ekpeti as well as the Agoi communities made up of Agoi Ibami, Agoi Ekpo, and Ekom Agoi were annexed into the Yako proper comprising of Ugep, Ekori, Nko, Mkpani, and Idomi due to linguistic similarities to form the administrative Yakurr Local Government Area of Cross River State. The 2006 population census reported that Yakurr's population was 196,271. 99,485 males and 96,786 females (FGN-Gazette, 2009). The Yakurr Local Government Area (LGA) contains roughly 30,201 households with an average of 8 persons per household and an estimated density of 23 residents per square kilometre. The female represents 51.11% while the male represents 48.89%. The LGA is currently made up of two hundred and thirty-nine (239) communities or neighbourhoods (Water-Sanitation-and-Hygiene-Programme-WASH-Yakurr, 2019).

3. Theoretical Framework

Oscar Newman's defensible space theory is the underpinning theoretical framework of this study. In his defensible space theory, Newman (1966) and Newman *et al*. (1996) stated that a defensible space is a model that can inhibit crime in residential environments. The concept of 'environments' used here consists of specific buildings, projects, or even communities or neighbourhoods. Criminal justice experts, social researchers, urban planners, law enforcement agencies, and architects extensively examined, applied, and evaluated Newman's defensible space theory. The theory affirms that the pattern of layout of buildings can deter security breaches. The theory further stated territoriality, surveillance, image, and milieu as the key theory and design principles (Donnelly, 2010).

Territoriality encourages the community's subdivision into smaller spaces for residents to see as their own. This increases the sense of ownership, place attachment, and belonging among residents. Surveillance entails that the arrangement of buildings within a community should encourage clear lines of sight into adjoining streets and other public spaces like playgrounds and markets. The principles of image embody the ability of the architectural style to provide a feeling of safety and where the stigmatisation of other residents is minimal while milieu emphasises that the location of a housing project in crime-prone areas should be near safer zones like busy streets, crowded business district and government institutions. The theory also encourages residents to build in a way that allows for enhanced neighbourhood surveillance as a passive security measure. (Marshall, 2016). The theory further states that communities or neighbourhoods with social cohesion, at threshold capacity, good connectivity, and communal culture can reduce crime and improve the security of residents. Newman's Defensible space theory has been executed in numerous projects and communities in the United States and globally.

4. Research Methodology

A descriptive phenomenological approach was used for this study (Moran, 2019). The snowball sampling technique was employed to interview informed individuals in Ugep, Ekori, Mkpani, Idomi, Agoi Ibami, Agoi Ekpo, and Assiga New Town. This sampling technique was employed to identify individuals within these communities tasked with performing certain rituals that invoke the intervention of the deities and ancestors during times of insecurity. Additionally, focus group talks were conducted with representative elder councils from Assiga New Town, Agoi Ibami, Mkpani, Kekomkolo, and Kebong in Ugep until saturation was achieved about *kerm-kom*, *ekoo* (age grade system), *lokpan-kuma*, cultural diplomatic links among villages, shrines, deities, and sacred sites. The case study approach was employed to analyse Yakurr house plans, assess the criteria for spatial allocation of bedrooms in household layouts, and evaluate social cohesion among the Yakurr people. Observations, both participant and non-participant, were also conducted at several festivals. Finally, since the study was conducted spanning numerous

villages, some features of data gathered in one community were presented in another community for verification or otherwise. This is to enable the research to adopt a generally agreed outcome and interpretation from the lenses of all the communities in the study area. This methodology has been affirmed by Lumivero (2022) as adequate in as much as the environment where they lived experiences of the people under study are not ignored. The rural communities of Yakurr Local Government Area were selected for this study because they are devoid of unknown gunmen, bandits, armed herdsmen, farmers-pastoralists clashes, kidnapping, violent extremism, terrorism, religious and ethnic insurgence associated with some rural and urban areas in Nigeria.

5. Analysis and Results

The security strategies of the Yakurr People are explored from the household configuration to the house form and finally the community organisation. These layers harmonise to form a passive security network for the Yakurr People.

5.1 Cultural security practices of the Yakurr People

The cultural practices of the Yakurr People that enhance security resilience can be seen in the zoning, location, and allocation of rooms, the spatial location of *kerm-kom* (community sit-out), alert sounds of *lokpan-kuma* (wooden slit drum) and *Ejukwa* (town criers), shrines, deities, and sacred sites. Others are the assigned roles of *ekoo* (age grade system) within the community, settlement patterns, and cultural diplomatic links among villages.

a. Spatial location of rooms

For the Yakurr People, zoning, location, and allocation of rooms have security implications. The most popular concept of architectural design is making the main entrance of a building bold and conspicuous. However, the Yakurr People mask the main entrance of their buildings. The main entrance door opens into the corridor (Figures 1). This makes it challenging to predict the navigation into the house spaces from the main entrance lobby. The edam toh (lounge) as shown in Figure 1, has several accesses thus masking the precision of any form of attack on the husband and father of the house. Unlike the termites where the queen is the most guarded, the husband and breadwinner of the house is the most protected among the Yakurr People. This can be seen by the location of the husband's bedroom, which is usually at the point of optimum safety from external attack. The next most secure bedroom is that of the first wife or the man's favourite wife. It is always located next to that of the husband's room. If the man marries more than one wife; the other wives will be allotted bedrooms that will offer additional shield to the man (Figures 2 and 3). Where the rooms are not sufficient to cater for the expanding family; the husband can share his bedroom with his first or favourite wife.

This is a unique security strategy, as the definition of bravery among the Yakurr People abhors the killing of women. Thus, the wife is the security shield of the man, hence the logic behind the location of their bedrooms. The research also revealed a pseudo arrangement for the allocation of spaces to family members with the husband at liberty to relocate to any other room, if he feels his safety is threatened. It is important to note that most of the rooms designated as children's bedrooms are for male and female children, and extended family members of the husband.

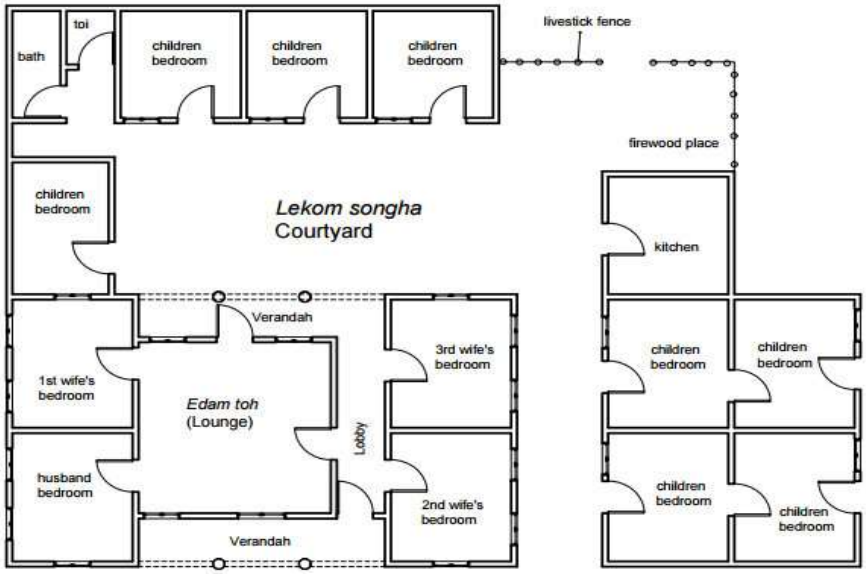

Figure 1: Typical building configuration of the Yakurr People before the 21st century

It is important to note that most of the rooms designated as children's bedrooms are for male and female children, alongside extended family members of the husband. The male children grow into adults, marry, and start family life in that one room. A typical residential bungalow of the Yakurr People has a population large enough to fend off minor attacks or alert the neighbourhood of attack.

Figure 2: Spatial security arrangement of Yakurr homes

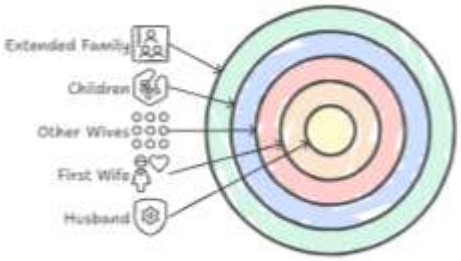

Figure 3: Yakurr household security structure

b. Yakurr Household configuration

The concept of household here is a family whose members live under the same roof and share food from the same pot daily. A typical mud and thatch building configuration of the Yakurr People before the 1960s can accommodate at least two (2) households. However, as at the time of this study, single residential bungalows of the Yakurr People as shown in Figure 1 accommodate between two (2) and thirteen (13) and an average of five (5) households. This population cluster of people is a natural security buffer at the household level. This phenomenon is captured in the anecdote of the *Okpebri* (Village Spokesman/prime minister) of Ugep: *Amọọn yosoo yọta yaseen; Kodạmbọọ kọmọọn tạ kọyaa kạ kawọng* … (we are more in number than strangers; our right hand shall always be up…). This is a symbolic reinforcement of the power of numbers in a household.

c. Spatial location of *Kerma-kom* (community sit-out)

Every community, ward, paternal family, or neighbourhood has a main access road or path. This main access route also has a shaded spot nearby, where the villagers sit, relax, and have fun from morning till late into the night. This space in the neighbourhood or community is known as *Kerma-kom* (Figure 4). This is where communal sharing of food, knowledge, norms, values, latest gossip and news in the community occurs. Neighbourhood and community dwellers whether rich or poor, elderly or young, male or female, and irrespective of social status congregate at *Kerma-kom*. Based on the peculiarities of the community; *Kerma-kom* may also have a hut called *ketopowa.* K*etopowa* may have a fireplace to keep the villagers warm during the cold season. The fire is also used to roast bush meat, corn, yam, and other food items for communal feasting by all present at the time.

In the vernacular-built environment of the Yakurr People, *Kerma-kom* serves as the neighbourhood or community security post. The indigenous people always sitting at *Kerma-kom* promptly detect every strange or suspicious movement within the community. Crimes and criminal activities are first reported, detected, and managed here before any further actions are taken. Guilty offenders of minor criminal cases within the neighbourhood are disciplined here by flogging and other forms of punishment.

Just as Igwe-Okomiso *et al*. (2024) observed about the Yakurr People, at the level of the community, rural dwellers adopt community policing and routine neighbourhood watch to forestall security breaches from *Kerma-kom* security post. More so, important community antiquities and artifacts are kept and preserved around *Kerma-kom*.

Figure 4: Spatial location of the *Kerma-kom* of Ekpeti community

d. *Lokpan-kuma* (wooden slit drum) and *Ejukwa* (town criers) Central alarm system

Each Yakurr community has a central alarm system in the form of *Lokpan kuma* (wooden slit drum) (Plate 1) and *Ejukwa* (town criers) (Plate 2). There are specific sounds made by the designated drummers of the *Lokpan kuma* that have the interpretation of danger or attack. The sounds are peculiar to members of the community. Visitors and strangers may hear the sounds but cannot interpret the message. Specific spots are allotted to the *Lokpan kuma* and the *Ejukwa* within the community. These are spots that allow for wider coverage of the neighourhood as no modern communication gadgets are used.


Figure 5: Lokpan kuma


Figure 6: Ejukwas performing

e. Shrines, deities, and sacred places

Some common rural built environmental elements are shrines, deities, and sacred places. These special features of a community are mysteriously laden with intangible powers to secure a community, deter crime, and punish offenders. Some routes and land boundaries of a community that may be used for enemy attack are secured with shrines, deities, and sacred places. These supernatural elements of the Yakurr People are like the Benin Moats, China Great Wall or the Walls of Jericho. Despite the neglect of these indigenous elements of the Africans due to modernism and foreign religious apostasy; shrines, deities, and sacred places provided the Yakurr People access to tap into the supernatural for communal safety and preservation. For instance, the Agoi communities of the Yakurr People, own a deity called *Akpo-kááte* and also perform annual rituals like *Nkosi, Wukuni,* and *Esor* that secure all their boundaries and also regulate criminal activities like theft, murder, malicious damage, and 'land-grabbing'.

f. *Ekoo* (Age grade system)

Among the Yakurr People, the age grade system is an autochthonous cultural practice. Male and female indigenes with one (1) to three (3) years age difference is clustered into the same age grade at twenty years old. At the average age of forty (40) years, the age grade is recognised in the community through the performance of yearly rites for about three years.

The ritual procession rites are guided by well informed elder of the community. At the completion of these rites, the age grade can be given among others, the task of securing the community, as vigilante whenever there are security threats. So, the pride of every age grade is to ensure that during their time, threats to the community security are eliminated.

Figure 7: Ekoo performing rituals of community recognition during the 2021 New Yam festival

g. Compact nature of settlement

All Yakurr villages as postulated by Udo (1965) and Okafor (1981) for the then Eastern Nigeria, have a nucleated settlement pattern. Yakurr communities expand following their land tenure system solely driven by kinship inheritance along patrilineal and matrilineal ties. The settlements are free from any dots of farmland but have designated spots for playgrounds, markets, village squares, traditional grooves, deities, town criers, shrines, and sacred places. Some main paths and footpaths are selected as cultural routes. The compact nucleated settlement of Yakurr communities was for security purposes and ease of communication. The motivation of the people for living so closely together was to ensure that any attack on one is promptly detected, dealt with, and eliminated. The strategies for conveyance of information are also rooted in the sociocultural fabric of the people. Every Yakurr village consists of distinct wards. The wards are a collection of paternal families. The wards originate from the village square and spread outwards. It is unpopular to find adults and well-meaning individuals in a ward build their residential houses in another ward, even within the same community. This is a demonstration of a very high sense of belonging among the Yakurr People.

h. Inter-community diplomatic ties

All the communities in Yakurr have cultural diplomatic relationships with selected nearby communities. The pattern of these ties is unique and sacred and often involves blood covenants, deities, or cross-cultural traditional sacred clubs. This relationship ensures that security threats more than two (2) communities apart are promptly detected and managed. These inter-community diplomatic ties form a resilient security network that has been yielding results. There is a litany of evidence of the inter-communal transfer of warriors, war charms, weapons, defense, and attack skills among communities with diplomatic ties. An attack on one community can be an attack on many. The autochthonous tokens of these inter-communal ties are important elements of the vernacular-built environment of Yakurr communities preserved over time.

6. Discussion

Ceccato and Brantingham (2024) has observed that the work of built environment professionals has profound effects on the morphology of rural and urban neighbourhoods. From the view of defensible space theory, territoriality is a security measure in neighbourhoods and communities and can be seen in the Yakurr built environment. The Yakurr People live in compact and distinct families and wards. This organic territoriality among the Yakurr People greatly enforces the security resilience, as new faces within the community and farmlands can be detected with ease.

Community surveillance has become an established built environment feature of the Yakurr People through their *Kerma-kom.* The *Kerma-kom* is strategically located within the neighbourhood where clear lines of sight into adjoining streets, farm roads, schools, and other public spaces like playgrounds and markets are possible. *Kerma-kom* further provides the residents with the opportunity to bond, ease stress, recreate, and spread gossip while watching the movement of people from the security perspective. *Kerma-kom* together with the adjoining *ketopowa* forms the virtual city gate (Marzbali, 2017), high walls, and castles used as passive security measures in ancient civilisations.

The *edam toh* (lounge) and the location of the husband's bedroom is an architectural style that provides a feeling of safety. The *edam toh* erases any form of stigmatisation as it can be used for dinning, relaxation, family prayer and

meeting room, and reception of visitors by all residents of the house. Hence, any activity taking place in the *edam toh* is monitored closely by all the members of the family. This is a vernacular household security strategy of the Yakurr house form. Likewise, milieu emphasises that the location of a housing project should be within proximity of busy zones or security agencies. However, several rural areas in Nigeria neither have busy commercial zones nor a police post. The passive security strategy of the Yakurr People is living close to each other to naturally create a busy neighbourhood. Worthy of note are the inter-community diplomatic ties that exist within the communities of the Yakurr People. These ties ensure that each community has another community acting as its security watchdog. Finally, the community culture of the Yakurr People enforces the security resilience of their built environment. The presence of shrines, deities, and sacred places has continued to connect the people to their ancestors, who provide them with an intangible form of community security. Some security threats and criminal activities have been forestalled by shrines, deities, and sacred places. The age grade system further boasts the resilient built environment security capacities of communities. Members of each age grade take turns to act as community or neighbourhood vigilantes.

7. Conclusion and Recommendations

The Yakurr vernacular built environment has been organically developed based on the needs of the people as an embodiment of their tradition, culture, belief system, and civilisation. The compact settlement pattern of the People makes them resilient to various forms of external invasion prevalent in other parts of Nigeria. Shrines, deities, and sacred places form an intangible security hedge for the people. Aside, from the quest for modernity and anything 'white', the efficacy of these supernatural entities of the people still holds water to date. The functional and spatial location of *kerma-kom, edam toh,* and bedrooms together with the Yakurr age grade system reinforces their volume of social cohesion, unity, brotherhood, and sense of belonging. These attributes of the people have been identified to foster security resilience and perception of safety within a neighbourhood or community. Additionally, the location of *kerma-kom* provides a single major entry point into the community, hence the movement of people and objects is open to all. This also enforces communal surveillance.

Finally, community or neighbourhood state of affairs, the pattern of settlement, communal culture, and inputs from security agencies on the trend of criminalities and pattern of security breaches can be harnessed by Architects and other BEPs to generate security resilient designs and neighbourhood layout plans. In instances where social cohesion and territoriality are difficult to attain within a community or neighbourhood, the main entry points into a community or neighbourhood should be gated. Customised traditional alarm systems like bells, drums, and town criers can be strategically located within the community-built environment to promptly warn the residents of criminal activities and security breaches. This age-long strategy can still limit the level of insecurity and improve the perception of safety among residents. These techniques can be adopted by relief groups, governments, and other worldwide agencies, relief groups in their efforts to resettle populations who have been victims of insecurity.

7.1 Implications to Built Environment Professionals (BEPs)

BEPs have strategic roles to play in building community and neighbourhood security resilience viz:

a. Resilient security solutions within a community should integrate the traditional knowledge base of the dwellers.
b. There is a need for more effective collaboration between security agencies and BEPs in curbing community insecurity and crimes. Data on the pattern of crime in homes and neighbourhoods from security agencies can be analysed by BEPs as a guide for the future design of more security-resilient buildings around the neighbourhood.
c. The efforts of BEPs in providing a security-resilient built environment should have the input of well-informed members of the community. This will make the solutions offered to be functional, socially, and culturally suitable.
d. Case studies are important tools for building capacity and sharing knowledge. The process of formulating solutions to insecurity can be gotten from the study of other security-resilient built environments.
e. Vernacular built environment features like shrines, deities, and sacred places are vital for the sustenance of rural security. The quest for modernity should not replace these supernatural entities in providing a safer community.

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Impact of Christian Missions on the Settlement Pattern of Yakurr Communities in Southern Nigeria

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Abstract

African rural communities are blessed with land good for cultivation and housing purposes. Individuals, communities, corporate bodies, the state, and supernatural entities claim land ownership in these areas. Every rural community in Nigeria has evolved customary procedures for land tenure embedded in their aboriginal traditional processes that are generational. These procedures influence the successful development of housing and settlements within rural communities. Through the narrative method; stories about Christian missions, housing, and rural settlement sprawl were captured through observation of mission sites, with the aid of Google Earth Pro Software and focus group interviews with church and community elders. Christian missions in Yakurr communities of Ugep, Ekori, Mkpani, Idomi, Assiga Old Town, and Assiga New Town between 1910 and 2010 were sampled. The transcribed interviews were content analysed with NVivo 12. The outcome is consistent criteria for land allocation to Christian missions rooted in the sociocultural configuration of the People's Cultural beliefs and myths which significantly influenced settlement patterns in the Yakurr communities. Certain plots of land were believed to harbour malevolent forces or were associated with premature death and other negative experiences. These perceptions made such plots undesirable for residential purposes among the locals. To mitigate these fears, communities often allocated these parcels to Christian missions, viewing the church as a protective shield against supernatural threats. Consequently, with the church hall and manse serving as central places on such land; adjacent plots are attractive to the villagers for housing. The influence of these cultural beliefs and myths underscores the complex interplay between intangible forces and tangible land use, shaping how rural settlements expand and evolve. Understanding these indigenous practices is crucial for stakeholders involved in housing delivery in these areas.

Keywords: Christian missions, church, housing, Indigenous practices, land tenure, supernatural entities

1. Introduction

In all theories and belief systems about creation, land is the most important. The land has unique functions in supporting the generations unborn, the living, and the dead. Although all humans were born to meet land, it remains one of nature's most original and inestimable gifts. Besides labour and capital, land is the other and most prominent element of production.

Every rural community in Nigeria has organically generated distinct customary practices for land tenure. These methods that allow rural residents to inherit, own, transfer, utilise, and manage land are all ingrained in Aboriginal traditional systems that are generational. In certain societies, these land tenure mechanisms have gone through passive adjustments, although some essential principles are still kept. For instance, aside from land being a common property; land inheritance, ownership, transfer, usage, management, allocation, and the resolution of land-related conflicts are conferred on family heads and the council of elders (Obioha, 2012).

However, contrary to the position of Ekpodessi and Nakamura (2023) on the security and legality of land acquired through traditional procedures; Obioha (2012) earlier said that the allocation of land based on customary procedures has been recognised by the village council and protection against eviction. He also noted that customary landowners have access to basic communal land rights. The Nigerian customary laws also respect customary land tenure systems and allocation methods. Nevertheless, Chukwunweike (2023) emphasised that land is expected to be given for housing, commercial, public, institutional, religious, recreational, agricultural, and industrial purposes in a sustainable fashion. The procedures and reasons for allotting land can impact the growth of settlements and also improve the development of houses inside African rural communities.

Furthermore, several pieces of literature exist about the advent of missionaries in Nigeria and their spiritual impact on the people. More so, it is general knowledge that the Christian missionaries were allocated plots of land for their operations. On such landed assets they built church halls, vicarages, or manse for the priests or pastors, schools, and healthcare facilities as part of their evangelical strategies. The church buildings also beautified the local environment and were key rural landmarks (Innocent & Udobi, 2024).

2. Literature review

A search of published literature was performed to evaluate the meaning of Christian missions, the history of missions in Africa, and if the church was authorised to hold landed assets. The settlement and house development pattern in typical African rural settlements was also reviewed.

2.1 Review of Christian Missions in African Communities

A Christian mission is a deliberate attempt to continue evangelism or other endeavours in the name of the Christian faith, such as the creation of hospitals or schools. It also entails deploying teams across borders to spread the Christian faith. Christian missions in West Africa commenced in the fifteenth (15th) century. The Portuguese reached the West African coast through the Atlantic Ocean for mineral exploitation, colonial empire development, and Christian missions (Boaheng, 2018). Braun (2024) also argued that African coastal communities were the entry points of the Europeans into West Africa.

Earlier, within the first three centuries to 313 AD, the church started to accept gifts of members' goods and later acquired properties to strengthen their propagation and charitable activities ("Church Property," NA). Wealthy and powerful members of the community also aided the church in the acquisition of land and evangelism. Pavliková-Vilhanová (2007) and Masuku (2023) noted that Christianity developed in the subsequent centuries to the point that schools, hospitals, factories, printing companies, literature, and bible translation efforts became part of Christian missions. There was also an interchange of cultures. However, the Christian missions assisted European imperialism and further promoted Christianity as superior to existing African traditional religions and cultures (Andrew, 1997). Christian missions discreetly subjugated Africans, making them subject to colonial masters, and further clad Africans in African soil on European clothes despite the severe disparities in climate and sociocultural makeup (Kohn, 1962; Masuku, 2023; Saayman, 1991).

This contrasts the strategy of Matteo Ricci's Jesuit in his Christian mission to China. He explored the Chinese cultural fabric as a blueprint for Christian missions (Eerdmans, 2003). Records of the China protestant faith missions of Hudson Taylor (1832–1905) and Henry Grattan Guinness (1835–1910) saw Taylor a Briton donning Chinese costumes and even chatting in Chinese in his home (Chisholm, 1911). The outcome had a significant impact.

Okon (2014) further stated that Christian missions provided civilisation and development to African countries but was unclear about the nature of progress. He also indicated a substantial relationship among Christian missions, colonial trade, and colonial governance. In divergence, Jedwab *et al*. (2021) noted that Christian missions in Ghana from 1828 to 1932 produced negligible socioeconomic advantages for their host people. Rather, fertile, table and strategically located land were assigned to the missionaries. Even in South Africa, Mlambo (2024) also noticed that Christian missions backed apartheid and supported the subjugation of the blacks while also acquiring territory. Nonetheless, Johnson (1967) strongly emphasised that the parameters for the site selection and location of Christian missions, notably in African countries, deserve empirical study.

2.2 Evolution of settlement patterns

A settlement is a collection of buildings where people live (Živković, 2019), and how they interact with their natural landscape, such as water, land, plants, and mineral resources. Each community has a location, site, and setting. The site of a settlement is the real land where the settlement is established, while the location of a settlement is usually indicated using a precise combination of latitude and longitude. The choice of a site is dictated by physical variables such as water supply, availability of fertile farmlands, protection from prospective invasions by rivals and foes, topography, and shelter. Politics, accessible technology, culture, and economic issues such as communication, trade, mineral, and forest resources also affect the siting of settlement places (Ambe, 2018; Rashid, 2020; Rosenberg, 2018).

However, in Nigeria, Udo (1965) and Okafor (1981) asserted that the then Eastern Nigeria had a nucleated settlement structure. They further claimed that the settlements expanded largely due to the land tenure system and kinship inheritance along patrilineal and matrilineal links. The communities were also intermingled with farmlands and customary religious grooves, sacred trees, and deities; which further altered the pattern of spread of the settlements.

2.3 The Yakurr People

This research focused on the Christian missions in Yakurr Local Government Area of central Cross River State. The Yakurr people have a rich cultural heritage that spans their entire calendar. Of utmost importance is the Leboku New Yam celebration held by the people between July and October of every year in all Yakurr villages. Effective age grade system (*ekoo*) is existed in all Yakurr villages. Figure 1 is excerpt from the year 2021 *Leboku* festival events of Mkpani community of Yakurr Local Government Area, Cross River State.

Figure 1: Mkpani New Yam Festival featuring 'Feed the Community' parade by an Ekoo (Age grade)
Source: Authors (2021)

Finally, the Yakurr people, like their nearby Igbo brothers, live in nuclear compact villages (Forde, 1937), Among Yakurr communities, land is a common property, and concerns of land tenure among the Yakurr People are vested on a council of elders and family heads. Several pieces of evidence exist regarding the footprint of Christian missionaries in Yakurr communities. However, there is scant documentation about how the missionaries were granted land for their mission work and the subsequent impact on the housing development and settlement pattern of the people. This is the fulcrum of this paper.

3. Theoretical Framework

Research on human behaviour and culture generally requires numerous theories to elucidate. However, for this study, the theory of conservation of resources and the central place theory were used as the underpinning theories.

3.1 The Conservation of Resources (COR) Theory

The Conservation of Resources (COR) Theory discusses the reasons that urge humans to both retain their current resources and pursue additional resources Hobfoll (1989). From time immemorial, hereditary resources like land have been greatly regarded and cherished by all humans irrespective of cultural colouration, beliefs, religion, literacy level, and financial situation (Muñoz-Viñas, 2012). For instance, Umeh (1973) pointed out that individuals, communities, supernatural creatures, corporate entities, and the government have land ownership rights. He also reported that in an African context, unseen powerful, and supernatural individuals own property, water bodies, and forest reserves.

Additionally, Hobfoll (1989) claimed that when there is a threat of a loss, psychological stress will set in. COR states that loss of resources can push people to some levels of stress (Halbesleben *et al*., 2014). Abdullayev (2021) has further stressed that the cultural environment of a locality in the shape of deities, shrines, and historical monuments considerably impacts the spirituality of the inhabitants of the place and portray the people's lives and peculiar belief systems (Mather, 2003). Motonaka (2005), Progano (2018); Progano and Kato (2018, 2020) in their independent investigations have suggested that sacred locations, sites, routes, and shrines form a distinctive cultural landscape within the locality. It can thus be hypothesised that these supernatural powers can restrict human access to the physical land they occupy and further confine or change the spread of human activities, housing, and settlement patterns. This lack of resources might produce mental and spiritual distress among the population.

3.2 Central Places Theory in Rural Setting

In urban geography, central place theory is a spatial theory that enlightens the causes behind the global dispersal patterns, sizes, and sprawl of cities and towns. It also intends to establish a framework that permits the study of rural areas for historical as well as modern locational housing and settlement trends (Briney, 2023). Gbamwuan (2023) further observed that most Tiv communities in North Central Nigeria are dispersed settlements but with the entry of the missionaries, new cluster settlements developed around the newly built church buildings. Hence, the Christian missions in African rural communities over the years have transformed settlement patterns and become a central place in the settlement configuration of various African communities.

4. Research Methodology

The narrative analysis method was employed for this inquiry. This method was favoured as it permitted the study of how the Yakurr People constructed stories about their experiences and drives related to the construction of

residential housing and settlement sprawl before and after the missionaries came. Furthermore, an inductive technique was employed to create new concepts from the data collected and reviewed.
Primary data for this research were obtained from individual and focus group interviews with knowledgeable church and community elders using an interview guide. Some mission stations were also visited for observation. Secondary data were gathered from church archival records, pictures, and publications regarding church history (Ani, 2020; Bassey, 2021). To ascertain the trend and validate the findings, the site placement and land allocation criteria of Christian missions in Yakurr communities were examined as follows: four churches in Ugep, three in Ekori, two in Mkpani, two in Idomi, two in Assiga Old Town, and one in Assiga New Town. The churches were founded between 1910 and 2010. The recorded conversations were content analysed utilising the NVivo 12 application while Google Earth Pro was employed to examine the spread of dwellings and the following settlement pattern around Christian mission zones.

5. Analysis and Results

After analysing the obtained data, the narrative content analysis established the conditions under which Christian missionaries were awarded land in Yakurr villages. The consequent impact on the villagers' land-use pattern and housing also manifested.

5.1 Criteria for allocation of land for Christian missions in Yakurr communities

This study isolated five main criteria the elders and people of Yakurr considered before allotting land for Christian missions. These criteria are rooted in the sociocultural configuration of the People, their lived experiences, and their set of beliefs.

a. Land claimed by deities and shrines

Plots of land allotted to Christian missions were those that the villagers in the past willingly gave to supernatural entities like shrines and deities. It was revealed that over the years, human entry into the land and other adjoining plots of land for housing and cultivation purposes were resisted by these supernatural entities who have firmly laid claim to the land. Human encroachment in the form of housing and farming resulted in the untimely death of the client, farmer, or their immediate family members, sudden lunacy, twisting of the victim's neck, nightmares, and physical attack by snakes or other wild animals.
A text query result in Figure 2 demonstrated that cultivating or building a house on specific plots of land is related to premature death and other bad experiences. These isolated apieces of land were specifically designated for Christian missions.

Figure 2: Result of text search query
Source: Authors, 2024

A villager's lived experience about land claimed by a deity is summed in the following anecdote APCN 2:
"I know of two persons who built on the land and were killed by the deity. "Before we came, there use to be a big tree here. We started prayers on the plot after allocation to us and then one night, thunder struck and pulled down that big tree. We decided to locate the Church altar where the tree was".

b. Land claimed by water spirits

Several streams both seasonal and all–year round streams, dot the settlements of the Yakurr people. These streams fulfil both the bodily and spiritual needs of the inhabitants. Some of these streams have been determined to be the dwelling of water spirits (mammy water). Hence parcels of land around these streams have been avoided by the inhabitants because the water spirits do not accept any sort of interference that will lead to deforestation around the stream. The lived experiences revealed that persons who had interactions with the water spirits were generally childless, emotionally unstable, and physically destitute. To date, certain indigenes of Yakurr are afraid to go close

to or through particular streams for fear of being assaulted by some water spirits. The land around these streams was allocated to the church for missions at little or no expense.

c. Land claimed by dreaded village clubs and societies

Some of the activities and occasional exhibitions of these clubs and societies are nurtured in secluded sites called *ketam* (club house) outside the established village hub. These plots of land become dreaded or forbidden forests years after the demise of some powerful front-liners of the group or exile of the club or society. It is thought that the land previously occupied by those clubs and groups is marked with charms to fend off non-members and any type of trespass.

Figure 3: Lebilembi ta (shrine) still in the compound of Assemblies of God, Church – Ijiman, Ugep
Source: Authors, 2021

Hence, even when the village settlements grow to these locations, the inhabitants become afraid to build houses on those plots of land. Those who attempted to accomplish their residential housing projects on those plots were chased away mystifyingly. These sorts of pieces of land are freely donated to Christian missions. Figure 3 depicts the shrine (stone) of such a powerful club still surviving in the premises of a church compound.

According to a respondent about UAGC: *"This is not just a story. Some people who attempted to build in this place before the land was given to the Church were chased away mysteriously"*.

The Yakurr communities' administrative structure comprises some powerful village clubs and societies. These clubs and societies are assigned some functions within the community leadership.

d. Accursed vacated lands

Christian missionaries in Yakurr commenced in 1910 with the establishment of All Saints Presbyterian Church in Ijiman, Ugep. The area largely assigned to them was the one that was the prior settlement of the Mkpani people. Mkpani people are the closest brothers of the Ugep people and they lived together following migration from their original country Akpa. Mkpani community further migrated from the present location of All Saints Presbyterian Church in Ijiman, Ugep to their present settlement after a 'bitter quarrel' with the Ugep community (Forde, 1937). The circumstances surrounding the exodus caused the Ugep people to label the area 'accursed'. No indigene of Ugep farmed or constructed a dwelling on such land until the property was assigned to Christian missions.

According to Obol Oji Lopon Sunday Eteng Okoi, the Obol Lopon (Community Head) of Mkpani: *"When I was made the Obol Lopon of Mkpani, I was told that the land where the All Saints Presbyterian Church in Ugep (UPCN) is located belongs to us. I was also shown the place where our grandparents planted a coconut tree that the church came to meet".*

It is also usual among the Yakurr People to gift Christian missions' pieces of land that are under major disputes. Especially if these arguments have led to a series of deaths among the warring parties. The explanation is that such plots of land are called 'accursed' due to charms and rituals buried in them. In most circumstances, the method of reversing or annulling the effects of those charms is undiscovered before and after the demise of the major contestants.

e. Proximity to the residence of church members

Another reason for land allotting land to the first Christian missions was proximity to the church members. In Assiga communities, it was observed that the land allotted to the Christian missions was found near the boundary of the two (2) communities of the Assiga Old Town and Assiga New Town. Another school of thought for allotting land to the Church at the boundary of the two communities was to fend off community disputes between the two (2) communities and foster peaceful coexistence.

f. Influence of community elders

Yakurr villages have vested in their various council of elders the authority of land tenure. Hence, various cases abound of their influence on land allotment to Christian missionaries. The key criteria examined by the various councils of elders for the allocation of land to Christian missions are those indicated from a to e.

6. Discussion

Morris (2008) noted that the compassion and provisions of God Almighty have been severely misinterpreted and misrepresented by individuals in different cultures of the world. The outcome is deities, shrines, and sacred places that affect the growth of settlements and other human activity. The tactic taken by the Yakurr People to date was to freely hand out those pieces of land and its environs to Christian missionaries. The instant the parish priests or pastors effectively deforest and put those heretofore forbidden land to use, the villagers would progressively build houses near those places, irrespective of the inconveniences that may emerge due to the vicinity to those worship centres.

The landscape of African communities is rich with diverse cultural identities, encompassing shrines, mammy water, forbidden forests, and sacred grooves. These supernatural entities, in conjunction with the people's sociocultural ideas, render certain plots of land sacred (Figure 4) and unsuitable for human use.

For instance, interaction with mammy-water spirits can hamper physical advancement in life, thus, people avoid water bodies considered to house mammy-water spirits. Mammy Water they feel can lead to financial collapse and significant physical and mental health difficulties. Water spirit can also bring about material failures if her demands are not met (Wintrob, 1970).

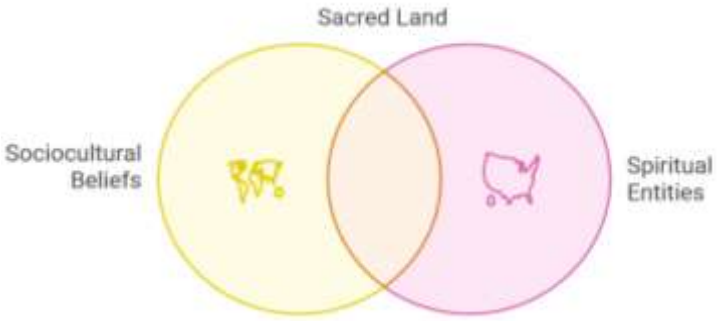

Figure 4: Factors influencing land allocation to Christian Missions in Yakurr communities

6.1 Historical trend of Christian missions on housing and settlement pattern

One might have been inclined to assume that the practice of allocating land to Christian missionaries was owing to a lack of understanding, illiteracy, and the conquering might of the whites at the time. However, as shrines and deities are rooted in the cultural landscape of the people, the criteria for allotting lands to Christian missions still hold footing even in the 21st century. From the first church to be established in Ugep in 1910 to the most current church sampled for this study established in 2010, the trend is the same. Lands entrusted to the Church were those the locals could not use for fear of death, as well as other types of vengeance from supernatural forces and demonic spirits that have claimed the land.

7. Conclusion And Recommendations

Ikhuoria (1987) has long since maintained that African nations witnessed expansion in three (3) waves: precolonial, colonial, and post-colonial. He further noticed that each of these waves had a unique land-use pattern. Before the entrance of Christian missionaries, the rural land use of the population was subsistence farming based on shifting crops, hunting, and shelter. However, throughout the colonial era, Christian missions within Yakurr villages, built church meeting spaces, manse to accommodate parish priests or pastors, and primary schools. The presence of the

Church through her missionaries offered basic primary education to the people in 1912, when the first primary school in the present Yakurr Local Government Area of Cross River State, Nigeria was constructed in a mud and thatch building. The mud and thatch classrooms only gave way for stone-brick composite walls after forty-two (42) years. So, during all these years that the church and school grew, no death was recorded because of the land they were allocated.

Interestingly, the Church further proved to the rural people that the land previously claimed by deities, water spirits, and scary cults could still be used for cultivation by building school demonstration farms. Also, the villagers can build houses on those plots of land and live quietly in them by establishing residences for the priests and pastors on those hated property plots. Finally, burial places are sacred and must not always be associated with prohibited or bad forests, hence the church established cemeteries on the previously inaccessible land areas.

The leadership of villages donated sections of land claimed by deities, shrines, and water spirits, as well as other supernatural energies, to Christian missions to deforest, neutralise, and demystify (Figure 5). Christian missions were utilised as a buffer to separate the community from the forces that prevent human access and connection with certain parcels of land within the community.

Figure 5: Summary of the impact of Christian missions on the settlement pattern of Yakurr communities

7.1 Implications to Built Environment Professionals and Stakeholders in Housing

a. Cultural and spiritual feasibility assessments of building projects: Several projects pass operational, technical, economic, financial, legal, and environmental feasibility tests yet fail to meet end users' cultural and spiritual needs. Residents' cultural and spiritual demands should guide housing building locations. This is crucial because humans are spiritual. Land selection for any project should be based on cultural and spiritual feasibility from the people's perspective, not the project team, corporate, or individual client's (Figure 6).

b. Land ownership by intangible forces: This study supports the idea that supernatural entities and other forces own land as well as humans, communities, and the state. Unless proper procedures are followed, these intangible landowners might suspend all known physical land ownership claims and disrupt building efforts. This caused the collapse of some incomprehensible building projects in different civilisations. All building and real estate specialists should fight this trend.

c. Facility placement for optimal performance: The location of a building facility is crucial to its optimal performance, attainment of goals, the satisfaction of users, and total profit turnover. Church building projects in rural settings will be more successful if positioned close to the members' houses. This will encourage all ages of members to attend church activities on time. The priests and pastors can also be easily visited in cases of urgency. This will also encourage the rural members' farming activities because they can return from church and directly proceed to their farms, and vice versa.

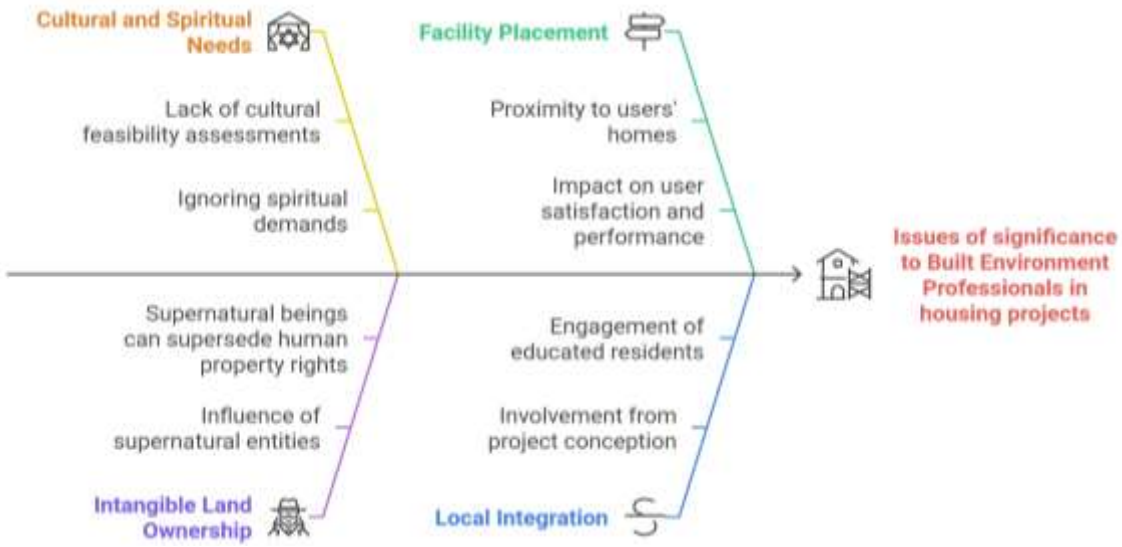

Figure 6: Challenges in housing projects for Built Environment Professionals

d. Integration of the locals right from the conception stage of the project cycle: Key stakeholders in housing delivery should always integrate the locals right from the conception stage of the project cycle. This will help to define the criteria for the seamless and timely completion of housing projects within budget while achieving user satisfaction (Musa & Amirudin, 2016). Project failures related with the area can be avoided with the engagement of educated residents

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Systematic Review of Application of Zeta Potential Methods to Cement and Superplasticizer

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Abstract

Cement and superplasticizer compatibility is a topic of interest in several studies of cement and superplasticizer chemistry. Apart from rheology and adsorption, zeta potential measurement is an interesting means of understanding this chemistry through electrical charges developed between the phases of cement and superplasticizer. Two methods have been used to understand this phenomenon (Electrophoresis and Acoustophoresis). Still, it has been reported that the Electrophoresis method is deficient and its result cannot be relied on. However, researchers continued publishing results using this method. Apart from this, many experimental measurements undertaken gave a variety of results which make it impossible to have a generally accepted value of zeta potentials for cement superplasticizer suspension. Therefore, this article systematically reviews the experimental methods used in measuring zeta potential and collate results obtained since 2002 when the Acoustophoresis method was first introduced to cement superplasticizer chemistry. Scopus database was used to obtain information on the past research relating to the subject matter, a quantitative assessment was done using bibliometry analyses and PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) for qualitative assessment. At the end of this study, it was discovered that 60% of authors used the electrophoresis method (showing that a larger number of authors are not aware of the deficiency) while 40 percent used the acoustophoresis method. The values of zeta potentials using electrophoresis ranges vary in a non-definite manner and acoustophoresis ranges from +9mV to -6mV. This research encourages the use of acoustophoresis in measuring zeta potentials because of contamination arising in the use of electrophoresis leading to varying results. It also serves as an article of reference for past zeta potential results relating to cement and superplasticizer

Keywords: Superplasticizer, Compatibility, Zeta Potential, Electrophoresis, Acoustophoresis

1. Introduction

Portland cement in concreting production hydrated with water tends to flocculate due to van der Waals' force; molecules of different charges attract each other and produce electrostatic interactions between the opposite charges and surface chemical interactions between the hydrating particles. (Marchon *et al.,* 2016; Zhang & Kong 2015). This will result in the formation of an agglomeration of particles with open structures with spaces that entrain water molecules (Chen *et al.,* 2020). In concreting, it is a well-established fact that water and concrete strength is inversely proportional (Ojo *et. al.,*2023). Due to the reduced amount of water, water molecules are not immediately available for hydration and do not have a lubricating effect on cement particles therefore more ions that are supposed to produce lubricating effects are not available (Flatt & Ferraris 2002). In the presence of a superplasticizer, deflocculation or dispersion of cement particles occurs so that ions that tend not to be enough are well dispersed and utilized. This deflocculation occurs due to adsorption and electrostatic repulsion (otherwise called zeta potential) (Plank & Hirsch 2007;).

There are majorly four generations of superplasticizers and among these, three have the same mechanism of creating zeta potentials that is; electrostatic repulsion, while the last generation uses steric repulsion to create zeta potentials (Ojo *et al.,* 2021; Ojo *et al.,*2023). The complexity of chemistry between superplasticizers and cement leads to compatibility issues. Compatibility issue arises when a combination of cement or cementitious compound, superplasticizer, and/or admixture behave contrary to expected performance leading to loss of workability, alteration of setting behavior, reduced rates of strength gain, segregation of concrete, change in long time response and loss of fluidity (Tiji & Liji, 2016). Researchers tend to assess this chemistry from electrical and acoustic instruments of zeta potential. Globally two instruments in the past have been used to understudy zeta potential

charges between cement and superplasticizer, they are; electrophoresis (using electrical charges) and acoustophoresis (using sound waves). For instance, a novel fluorescent polycarboxylate superplasticizer modified by anhydride naphthalene groups was assessed in terms of fluidity retention using zeta potential (Qu *et al.,* 2018) and rate of loss of workability in a Comb-typed polycarboxylate superplasticizer equipped with hyperbranched polyamide teeth was assessed using zeta potential (Zhu *et al.,* 2018).

In 2002, Flatt and Ferraris, argued that electrophoresis is deficient because it involves the dilution of cement and superplasticizer suspension to about 100-200mg/L because the velocity of the particles in suspension needed to be timed. They said the dilution alters the outcome of result using this method. They further stated that this dilution causes larger particles to settles and finer particles are measured. This problem is complex due to variety of cement particle sizes in the market and leading to prediction of different outcome by many researchers and variety of superplasticizers available, compound the problem. Surprisingly, many authors still continues using this method, and producing variety of results. Although, there is a paucity of studies suggesting why authors chooses any of the two methods; may be availability. However, the Journal that published this deficiency has not published any journals using electrophoresis method. Therefore, this article tends to systematically review past literature available in scopus data base that used this method to analysed super plasticizer and cement interaction and evaluate the results or range of results obtained.

2. Literature Search

Literatures published on zeta potential were extracted from the scopus database (this include all published materials in all journals in scopus database) and screened until the volume was reduced for easy reference. As at 17/7/2024, the keyword "Zeta Potential" was searched on the scopus database, 104,215 documents pop up in the scopus database relating to the search criteria without filter. The search was increased to "Zeta Potential" AND "Superplasticizer" AND "Cement" to reduce the number of documents retrieved. After this, 227 documents were retrieved relating to the search criteria. This showed that about 227 documents were the times authors have used zeta potential to assess the compatibility of cement and superplasticizer according to scopus database.

3. Review Methodology

A systematic review involves the use of literature as a facilitator, thereby answering some salient questions and also identifying research gaps and areas where further researches are required or propose a new method (Khan *et al*.2020). In this review, an attempt is made to evaluate the number of literatures on zeta potential usage in measuring the performance of superplasticizers and cement, available on the Scopus database. The number of journals that have continued to use this method since 2002 was identified.

In other to achieve the aim of the review, a literature review was done from the year 2002 to 2024, 2002 was the year when it was published and the results of electrophoresis can't be relied on. PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) (Chen & Zheng 2019) was used to evaluate the qualitative review while bibliometric analysis was used for the quantitative review. There are four stages of PRISMA, they are; identification, screening, eligibility, and inclusion as listed in Figure 1.

3.1 Identification

Typing all the above search criteria and the two methods at once will give no document. This is understandable because the scopus database is a computer database using artificial intelligent, it was looking for information on documents having all the search criteria. Journals relevant to the subject matter were identified using the search combination of three key subject in the topic, they are; Zeta Potential, Superplasticizer and Cement. Journals on cement and superplasticizer, where zeta potential was used to assessed their behaviour was identified. Therefore, the search criteria used were narrowed down to only Zeta Potential" AND "Superplasticizer" AND "Cement". Using this search criterion, 227 documents were retrieved.

3.2 Screening

The retrieved documents were thoroughly screened to enhance the quality of this literature review with the aid of scopus database and deduction based on available facts. The documents were screened to only article removing, conference paper, conference reviews, book chapter and data paper. This is because article has empirical results which are needed to be extracted to give value to this review. Documents such as conference reviews and paper, book chapter and data paper are mostly opinion from published articles. 46 documents were removed and 181 documents were retrieved. The screening was further done to eliminate article published not in English language. Any article published anywhere using English language were assessed. This is because the author can only read

English language and extracting data results from articles not in English language will require further process. 143 documents were retrieved leading to further removal of 38 documents.

3.3 Eligibility

A hundred and forty-three documents retrieved after screening included all publications on the subject matter from the first publication to date. As stated earlier this literature review focuses on the year beginning from 2002 after one of the methods used in analyzing zeta potential was reported to be inefficient. Therefore, the search was limited to 2002 to 2024 and 131 documents were received eliminating 12 documents (Figure 1). In addition, after critically reading the abstract and articles, some of these documents were found to be irrelevant. For instance, so of the articles were published on roads (asphalt), petroleum and metals. This review is on building construction or bridges where concrete as applied. This has led to removal of 33 articles.

3.4 Inclusion

Ninety-Eight (98) articles were included in this literature review for further analysis. These Ninety-Eight (98) articles were broken down into the two methods (Figure 1).

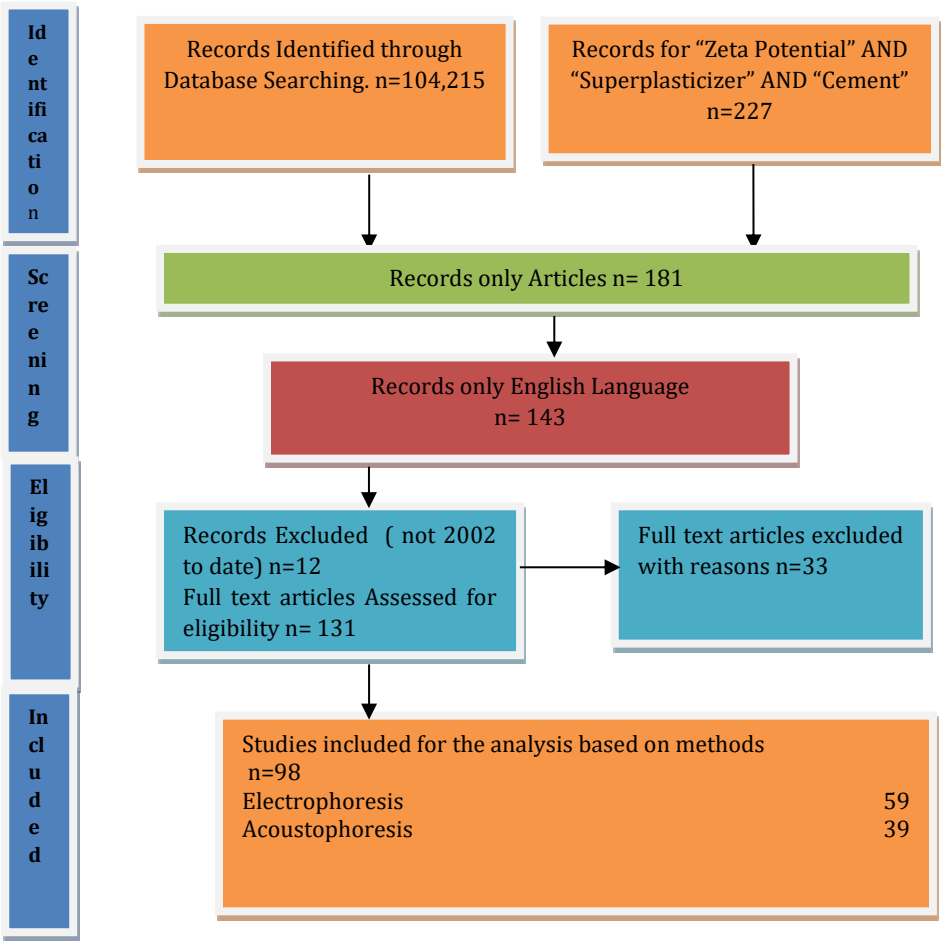

Figure 1: PRISMA 2009 flow Diagram (Chen & Zheng 2019)

3. Results and Discussion

3.1 Breakdown of Articles using the Two Methods

After assessment of documents retrieved from Scopus database and breaking it down using PRISMA, a total of 98 articles retrieved showed that 59 articles were published using electrophoresis while 39 articles used acoustophoresis. The result showed that 60% of article still use electrophoresis and 40% of articles used acoustophoresis method (Figure 2). According to Flatt & Ferraris (2002), this information showed 60% of publications on cement and superplasticizer where zeta potential was assessed are either not aware or don't understand the working principle of the method used. Therefore, their results could not be relied on. Critically assessing the authors (Figure 3), those that used Acoustophoresis were journals published in the journal that

published the inefficiency of Electrophoresis method or journals closely related. While majority of those that used Electrophoresis method are journals not from "Cement and Concrete Research". This might be reason why authors continuously use the method tag as inefficient due to the fact that they are unaware that the method is inefficient.

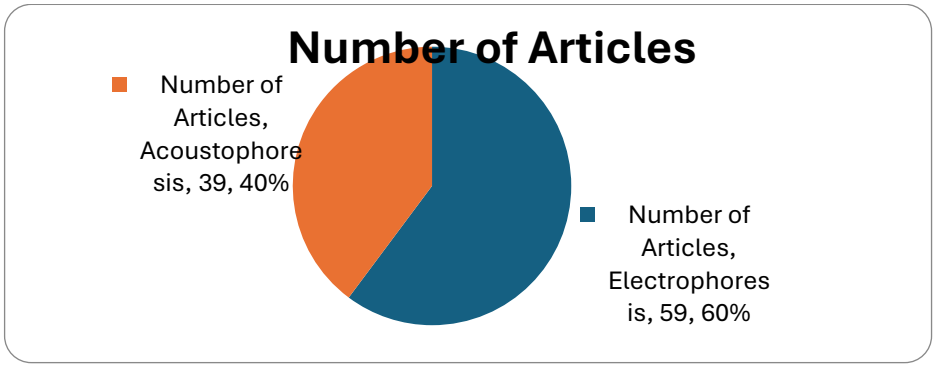

Figure 2: Pie Chart on Method of Assessing Zeta Potential

3.2 Citations on Articles that used Electrophoresis Method

Despite the report by Flatt & Ferraris (2002), some of the articles got more citations. For instance, Yoshioka *et al.* (2002) got 500 citations on their articles titled 'Adsorption Characteristics of Superplasticizers on cement component materials', followed by Ouyang *et al.* (2006), Zou *et al. (*2017), Mendoza *et al. (*2013), Liu *et al*. (2017) and Qian *et al.* (2018) with 170, 131,122,82 and 80 citations respectively (Figure 3).

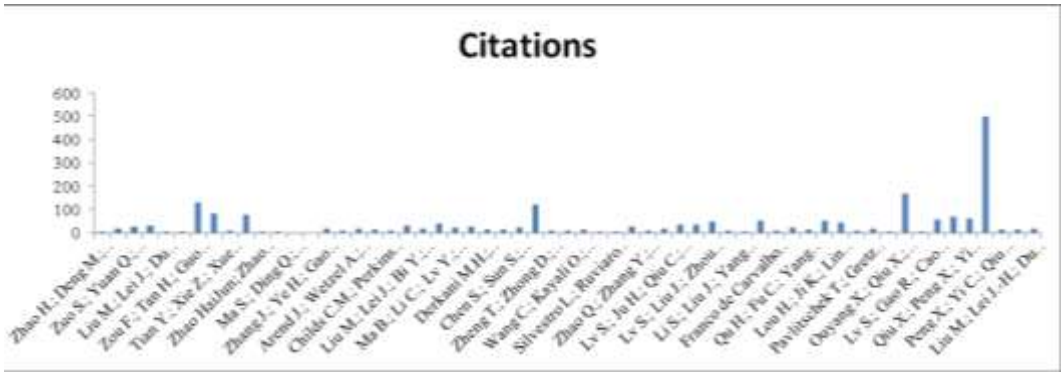

Figure 3: Citations from authors that used Electrophoresis

3.3 Citations on Articles that used Acoustophoresis Method

The citation by authors that used acoustophoresis were more than those that used electrophoresis. This could be due to the report by Flatt & Ferraris (2002). More than 25% got citations above 100 (Figure 4); this could be due to acceptability of this method. Plank & Hirsch (2007) got 536 citations on their article titled 'Impact of Zeta Potential of Early Cement Hydration Phases on Superplasticizer Adsorption'. Others respectively, have 317, 289, 257, 221 and 207 citations by Zhang & Kong (2015), Zingg *et al. (*2009), Plank *et al. (*2008), Ferreira *et al. (*2010) and Plank & Winter (2008) (Figure 4). Interestingly, Plank Johann contributed close to 50% of the publications.

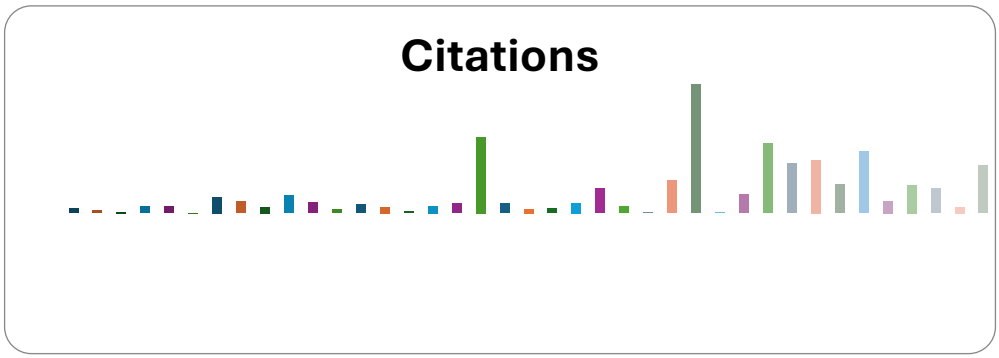

Figure 5: Citations from Authors that used Acoustophoresis

3.4 Zeta potential results

Table 1 shows the results of zeta potential for the first six of the two methods (Electrophoresis and Acoustophoresis) with higher citations. It can be observed that most results from acoustophoresis methods were between +9mV to -6mV, for zeta potential values where PCE was reacted with cement. Where higher values of zeta potential were as in the case of Ferreira *et al*. (2010) and Plank & Winter (2008), the compounds tested were either not cement or PCE while the authors that used electrophoresis had results of varying ranges which cannot set at a particular range, for instance ordinary cement paste got -45mV and PCE got 0mV (Mendoza *et al*. (2013), whereas for others +10mV to -10mV for cement paste and PCE got a range between -2.5mV to -30mV. The wide variation of results in the Electrophoresis method might be due to the effect of dilution. As stated in Table 1 amount of dilution varies from one author to another. This will affect the reliability of the results obtained from the Electrophoresis method.

Table: Results of first Six Highest Cited Articles that used the two Methods

S/N	Authors	Method Used	Remarks
1	Plank & Hirsch (2007)	Acoustophoresis	Zeta potential of different hydrated phases of cement; Ettingite, Monosulphate, Syngenite, Portlandite and gypsum were determined using acoustophoresis. The results showed that they have zeta potential of +4.15mV, +2.84mV, +0.49mV, -4.40mV and -0.06mV respectively. According to authors it is an indication for better adsorption of superplasticizer.
2	Zhang & Kong (2015)	Acoustophoresis	Acoustophoresis was used to determine the zeta potentials of fresh cement pastes at varying superplasticizer/cement ratio. Zeta probe was inserted into a constant stiring paste and zeta potential was obtained. The values obtained ranges from +9mV to -2mV for Poly Carboxylate Ether (PCE) and +9mV to -6mV for Naphthalene Sulphonated Formaldehyde (NSF) as the percentages increase from zero to one percent. No further dilution of paste was done.
3	Zingg *et al.* (2009)	Acoustophoresis	Three PCE based superplasticier was synthesized and mixed with cement paste of varying C_3A content. Zeta potentials were determined by using acoustophoresis where a high frequency electric field causes the paste to oscillate. Zeta probe was inserted and values obtained. The zeta potential increases from -6mV to -2mV as the percentage of PCE addition increases from zero to one percent.
4	Plank *et al.* (2008)	Acoustophoresis	Six(6) PCE of varying side chain and Methoxy or Hydroxy termination were synthesized and mixed with cement paste and zeta potential determined accordingly. Acoustophoresis was preferred over Electrophoresis because the test could be done at very solid concentration of cement paste without further dilution. The results showed that as the percentage of PCE increase from zero to one percent, zeta potential increase from –6mV to +2mV
5	Ferreira *et al.* (2010)	Acoustophoresis	PCE with powder (such as Magnesium oxide (MgO), Calcite, Quartz and Mica) having same charge density with cement was prepared and subjected to zeta potential test where zeta probe working on the principle of acoustophoresis was used. It utilizes an alternating electrical field that induces oscillation of the charged particles. The results showed that as the percentage increase from zero to two percent, zeta potential reduces 8mV to -3mV for MgO, -5mV to -10mV for calcite, -15mV to -24mV for Quartz and -25mV to -30mV for Mica. The higher negative value is because it is not portland cement that was tested but a simulation. Zeta potential measurements with electroacoustic spectrometer was used because it allows to measure samples with very high volume fraction without dilution. Ordinary

6	Plank & Winter (2008)	Acoustophoresis	Portland cement was reacted with PCE and Casein. As the percentage of superplasticizer increase from 0 to 0.6%, zeta potential charge increase from -5mV to 0mV for PCE and reduces from -5mV to -12mV for Casein.
7	Yoshioka *et al.* (2002)	Electrophoresis	Electrophoresis method was used in this study where samples for zeta potential measurement were prepared by diluting different cement mineralogy and PCE with deionized water up to 1500 times and mixed for 3 min. Four mineralogy composition of cement was reacted PCE. They are; C_3S, C_2S, C_3A and C_3AF. The zeta potential results were -5mV to -10mV for C_3S, -5mV to -15mV for C_2S, -10mV to -15mV for C_3A and -10mV to -15mV for C_3AF
8	Ouyang *et al.* (2006)	Electrophoresis	Calcium Lignosulphoate was synthesized and the adsorption in term zeta potential was determined. The method used was Electrophoresis where cement to superplasticizer or water was diluted in a ratio of 1:500. The zeta potential reduces from +10mV to –30mV as the superplasticizer increase from 0 to 1%.
9	Zou *et al.* (2017)	Electrophoresis	Sodium Glyconate (SG) and PCE-SG solution were first prepared. Cement (1.0 g) was mixed with the solution (20.0 g), respectively, and stirred for 4 min. The suspension (0.5 g) was added into the deionized water (45.0 g) and mixed. Zeta potential was measured with a zeta potential analyzer working on the principle of Electrophoresis. As the percentage of superplasticizer increase from 0 to 2%, zeta potential reduce from -1mV to -2.5mV for SG and -4mV to -4.5mV for PCE-SG.
10	Mendoza *et al.* (2013)	Electrophoresis	Cement composite materials adsorbed PCEs at different PH have zeta potential between reduced from -45mV to 0mV at a constant PCE but varying PH was done by Electrophoresis method. Two PCE have varying topological structure were synthesized and reacted with cement at 0%, 0.2%, 0.5%, 1.0%, 2.0% and 3.0% by weight of cement (bwoc) respectively. Malvern Zetasizer Nano ZS90 zeta potential analyzer working on
11	Liu *et al.* (2017)	Electrophoresis	principle of Electrophoresis was used. Diluted cement slurries were prepared by placing 1.0g of cement in PCE aqueous solution with a W/C of 0.5. All suspensions were mixedfor 3 min before testing. The result showed PCE1 has zeta potential value of +2mV to -8mV while PCE2 has +2mV to -6mV.
12	Qian *et al.* (2018)	Electrophoresis	The zeta potentials of cement pastes containing PCEs with reduced viscosity at PCE dosages of 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.0% by weight of cement (bwoc) respectively were determined by Malvern Zetasizer Nano ZS90 zeta potential analyzer working on the principle of Electrophoresis method. Diluted cement slurries were prepared by placing 0.5 g of reference cement in PCE aqueous solution with a W/C of 0.5. All of the suspensions were mixed for 5 min before testing the supernatants. The zeta potential results were +10mV to -5mV for PCE1, +10mV to -10mV for PCE2, +10mV to -20mV for PCE3, +10mV to -23Mv for PCE4, +10mV to -27mV for PCE5

4. Conclusion

It could be concluded that the authors were still using the electrophoresis method. Many authors got higher citations and 60% of the publications used the Electrophoresis method and the values obtained were confusing. It will be hard to hinge future research on any of the results by Electrophoresis method. The results of electrophoresis may have higher negative value due to the reason by Flatt & Ferraris (2002) that finer suspension was tested and dilution has a way of influencing the results leading to higher adsorption rate in some cases and lower adsorption in another case and higher negative zeta values in some cases. On the contrary, the Acoustophoresis method offers a definite close range for specimens of cement and PCE. The value is +9mV for cement paste only and -6mV for cement paste plus PCE. This can be attributed to the fact dilution doesn't happen in the Acoustophoresis method.

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Adaptation of Bioclimatic Architecture Principles for Optimising Thermal Comfort of Airport Hotel Buildings in Abuja, Nigeria

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Abstract

The integration of bioclimatic architecture strategies presents a promising approach to enhancing thermal comfort in architectural design, particularly in regions with diverse climatic conditions, such as Abuja, Nigeria. Understanding the climate and bioclimate of a city is crucial, especially given the ongoing challenges of urbanisation and shifts in global climate patterns. This study identifies bioclimatic architecture elements with a view of optimizing thermal comfort in hospitality buildings, such as hotels in Nigeria. The study utilised a quantitative approach to collect data through the use of questionnaires on bioclimatic architecture strategies that can be adopted to optimise users' thermal comfort in hotel buildings. Purposive sampling techniques was used. The sample population consists of Architects, quantity surveyors, builders, hotel managers and other professional within the built industry. The questionnaire was administered to educational ranges from first degree, masters and post graduate degrees. Parameters consider includes natural ventilation, solar shading, green roof systems, insulation, use of local materials, building orientation, thermal mass and rain water harvesting. The rank of the various elements was established from the administered questionnaire. 150 questionnaires were distributed with a return of 103, indicating a 68.6% return rate. The Relative Importance Index was used to assess bioclimatic design elements for optimizing thermal comfort in hospitality buildings. Of the nine variables evaluated, natural ventilation ranked first, followed by building orientation, landscaping for microclimate control, and the use of local materials. The adaptation of bioclimatic design elements towards optimizing the overall thermal comfort of occupants in hospitality buildings such as airport hotels is essentially paramount. Findings have shown that aside from the comfort of the users of this buildings, bioclimatic design elements have inherent ability of drastically reducing energy cost for running such buildings and simultaneously protecting the environment in a world where climate change has become a major issue.

Keywords: Bioclimatic architecture, Hospitality buildings, Nigeria, Users' Thermal comfort

1. Introduction

Cities with hot climates are faced with complex challenges that requires the need to plan, design and ensure the building of more resilient and sustainable cities so as to mitigate their effects on public health and human comfort (Bouthania *et al*, 2022). Lai *et al* (2019) had promulgated the idea that the long-term solution to environmental problems lies in adopting strategies that combine technological innovation with locally adapted and climate appropriate solutions as shown in Figure 1.

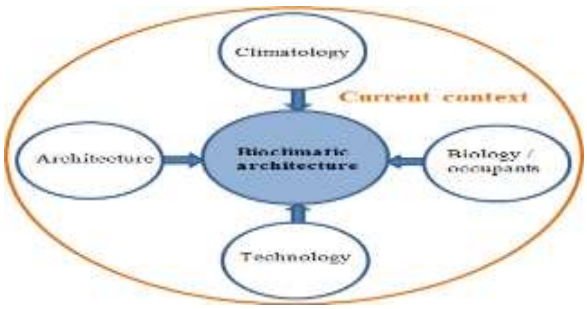

Figure 1: The bioclimatic architecture (Nguyen & Reiter, 2017)

In a rapidly changing world where climate change, environmental degradation and the growing concern for over dependence on non-renewable energy is becoming key environmental issues, it is argued that it is necessary to redefine the environmental and architectural attitudes to an environmentally-friendly approach (Evans, 2007). Bioclimatic architecture combines the interests of sustainability, environmental consciousness, green, natural, and organic approaches to evolve a sustainable solution by considering the characteristics of the site, its neighbourhood context, the local microclimate and topography (Al-musa'ed, 2011). This approach takes advantage of the climate through the right application of design elements and building technology for energy saving as well as to ensure comfortable conditions within buildings (Goulart and Pitta, 1994). Hence, this study seeks to identify the bioclimatic design elements that can be adopted in hospitality buildings to optimize comfortable conditions for occupants in hotels.

2. Literature Review

Thermal comfort plays a vital role in promoting occupant well-being and productivity. ANSI/ASHRAE defines thermal comfort as a cognitive state where individuals feel content with their surrounding thermal environment, typically assessed through personal evaluation (ASHRAE, 2010). Similarly, BS EN ISO 7730 characterizes it as the mental state indicating satisfaction with the thermal conditions (HSE, 2012). This highlights the importance of thermal comfort in architectural design, as it directly influences how occupants perceive temperature, whether they feel hot, cold, or comfortable. The word bioclimatic is the amalgamation of two (2) words, "bio" means life or natural form of living things, and "climate" means, the prevailing weather condition of a particular place (Adedayo *et al*., 2013). The bioclimatic design concept suggested a logical sequence of analysis through the detection of appropriate strategies and purposeful environmental control in response to the rational use of resources to achieve human thermal comfort (Hamza *et al*., 2022). Therefore, the bioclimatic design concept makes judicious use of favourable environmental conditions and moderates the unfavourable aspects through the appropriate design decisions. The need for energy efficiency, environmental protection, thermal comfort, and improved occupants living conditions has led to attention in the implementation of the principles of energy-efficient design (Hamza *et al*., 2022) as presented in Figure 2.

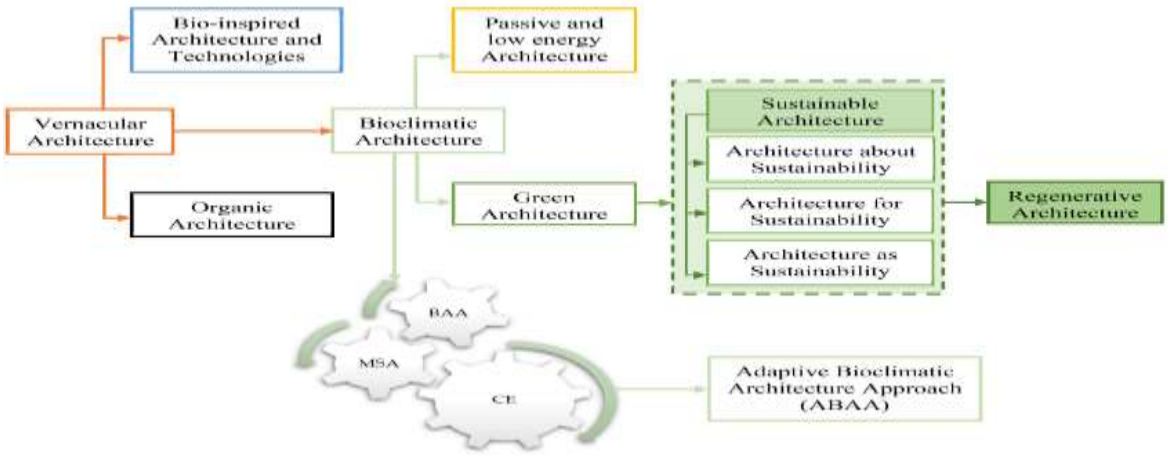

Figure 2: New pathway towards adaptive Bioclimatic Architecture approach (Genovese and Zoure, 2023)

With this objective in mind, it is argued that bioclimatic design concepts allow the architect to optimize the building's occupant thermal comfort and minimize the effects of global climatic problems. The development of bioclimatic design considers the local climatic conditions such as sun, wind, rain, air temperature, mean radiant temperature, humidity, and airflow (Kolawale, 2012). To achieve optimal thermal comfort in building design, several factors must be considered. According to Squair, (2023), building orientation plays a critical role in harnessing natural light and heat, reducing reliance on mechanical systems by managing solar gains efficiently. Cross ventilation is another key aspect, as strategically positioned windows and doors can promote natural airflow, enhancing comfort in warmer periods (Squair, 2023; ANSI/ASHRAE, 2023). Furthermore, using construction materials with high thermal mass, such as stone or concrete, also can help stabilize indoor temperatures by absorbing and releasing heat gradually (Felimban *et al*., 2023). Insulation of roofs, walls, and floors also plays a pivotal role in preventing unwanted heat transfer, thereby contributing to both comfort and energy efficiency (ANSI/ASHRAE, 2023). The size and location of windows are essential for regulating heat gain and loss. Well-placed windows can balance daylighting needs while minimizing excessive heat, especially in hot climates (Felimban *et al*., 2023). During extreme heat, cooling

mechanisms such as passive shading or mechanical cooling systems may be necessary. Incorporating smart systems, including IoT-enabled sensors, can further enhance temperature regulation and energy efficiency (Erişen, 2023).

2.1 Building orientation

Bioclimatic architecture is the practice of designing buildings that interact with and respond to the local environment in order to maximize comfort and reduce energy usage. Although various theories support these concepts, only two of them are explored in this study. The two theories are Thermal Comfort Theory (TCT) and Climate-Adaptive Design Theory (CADT). Thermal Comfort Theory states that building design should strike a balance between environmental influences (air temperature, humidity, air velocity) and human characteristics (metabolism, garment insulation) in order to attain thermal comfort (Nicol & Humphreys, 2002). This principle is applied in bioclimatic architecture, which creates buildings that naturally manage indoor temperature through passive heating, cooling, and ventilation.

The Climate-Adaptive Design Theory advocates for building designs that adapt to regional climatic conditions, maximizing the benefits of the natural environment. Givoni (1998) emphasised the importance of building orientation, shape, and materials in optimising thermal performance based on the site-specific climate. By incorporating these theories, bioclimatic architecture aligns the built environment with natural ecosystems, enhancing energy efficiency and co-creation. According to Cahyaningrum *et al*. (2017), the bioclimatic approach's general design concepts include: energy conservation, consideration of the local climate, environmental friendliness, adapting to the building's site characteristics, and providing comfort features for the building's occupants. Mirza *et al*. (2023) noted that the five bioclimatic architectural design concepts can be broken down into three fundamental ones: energy conservation, climatic responsiveness, and environmental friendliness, in an effort to increase user comfort. This is further broken down into various component as shown in Figure 3.

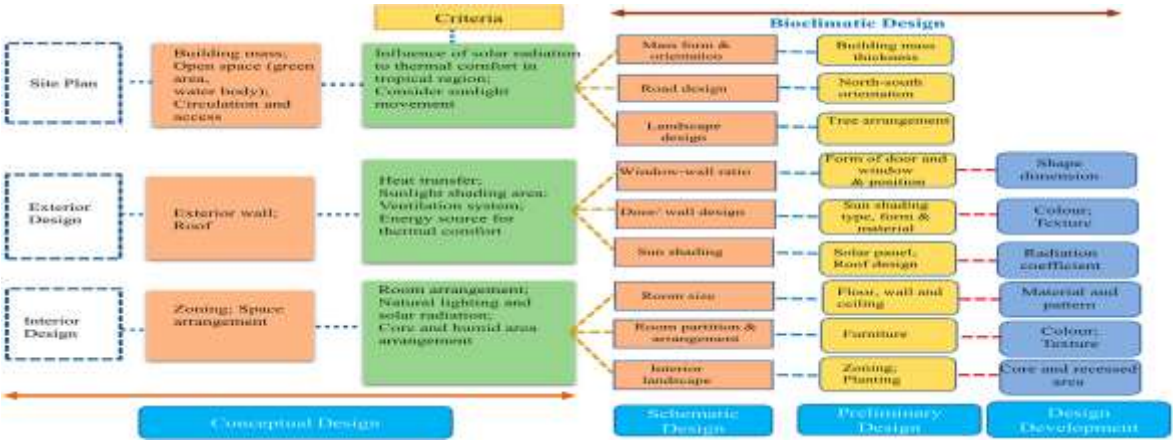

Figure 3: Bioclimatic components (Nag, 2019).

2.2 Hotels Types and Classification Systems

Mackenzie (2009) defined hotels as establishment held out by the proprietor as offering sleeping accommodation to any person presenting himself who appears able and willing to pay a reasonable sum for the services and facilities provided and who is in a fit state to be received. Different types of hotels offer different kinds of services to their guests and are run differently to meet the guests' needs (Mackenzie, 2009). According to Bundhun (2012), hotel classifications are based on star ratings. There are wide variety of rating schemes used by different organization around the world. Many have a system involving stars, with a greater number of stars indicating greater luxury. The World Tourism Organization (WTO) classified hotels based on: the location, the purpose functional/on time of stay of guests, the operating system, the form of exploitation, the form of ownership, the accommodation capacity, the target markets and the standards of service and facilities offered.

3. Research Methodology

A quantitative design approach was adopted for this study to identify the elements of bioclimatic design strategies that can be adapted in hotel buildings. The study area is Abuja, Federal Capital Territory, which is located in the north-central region of Nigeria and serves as the Nation's Capital. Purposive sampling technique was used to select professionals in architecture, building, quantity surveying, hotel managers and experts in the built environment. For the purpose of this research, a sample size of 150 respondents was selected, 102 responses were obtained and

analyzed. The reliability test was performed for the research instrument and the overall reliability index obtained was 0.75. The research instrument used was tables showing the rank for the elements most adopted by the respondents in hotel buildings. The Relative Important index formular is given as: RII=(∑W)/(A*N), Where W Weight given to each statement by the respondent, A=Highest response integer which is 5 and N= Total number of respondents for users=102*5=560=510

4. Findings and Results

A total of 102 responses were collected from the 150 questionnaires distributed, resulting in a response rate of 68%. Among the respondents, 38.2% were aged 32-39, 21.6% were 39-46, 14.7% were 46 and older, and 6.9% were between 18-26 years. The gender breakdown showed that 71.6% were male and 28.4% were female. In terms of educational qualifications, 50% held a first degree, 42.3% had a master's degree, 6.9% held a doctorate, and 1% had a secondary school certificate. The Relative Importance Index was used to assess bioclimatic design elements for optimizing thermal comfort in hospitality buildings. Of the nine variables evaluated, natural ventilation ranked first, followed by building orientation, landscaping for microclimate control, and the use of local materials (Table 1).

Table 1: Relative importance index ranking for bioclimatic design elements

S/N	Variable	∑w (weight given by respondents)	RII (Relative important index)	Ranking
01	Natural ventilation	438	0.859	1
02	Orientation of building	417	0.818	2
03	Landscaping for microclimate control	407	0.798	3
04	Use of local material	405	0.794	4
05	Solar Shading	393	0.770	5
06	Insulation	371	0.727	6
07	Green roofing	369	0.724	7
08	Rainwater harvesting	361	0.708	8
09	Use of thermal mass	360	0.706	9

Solar shading was ranked fifth, followed by insulation in sixth place. Green roofing, rainwater harvesting, and the use of thermal mass were ranked seventh, eighth, and ninth, respectively. Natural ventilation, ranked as the most important variable, aligns with Thermal Comfort Theory, as it facilitates air movement crucial for maintaining thermal balance in buildings. As Nicol and Humphreys (2002) noted, effective ventilation helps regulate indoor air temperature and humidity, enhancing occupant comfort. Table 2 indicates that respondents agreed that natural ventilation, solar shading, insulation, building orientation, use of thermal mass, rainwater harvesting, landscaping for microclimate control, use of local materials, and green roofing are all highly effective bioclimatic design elements for integration in tropical wet and dry climate regions.

Table 2: Bioclimatic elements integrated in wet and dry climate region

S/N	Variable	Mean score	Decision
01	Natural ventilation	4.29	Effective
02	Solar Shading	3.85	Effective
03	Insulation	3.64	Effective
04	Green roofing	3.62	Effective
05	Use of local material	3.97	Effective
06	Landscaping for microclimate control	3.99	Effective
07	Orientation of building	4.09	Effective
08	Use of thermal mass	3.53	Effective
09	Rainwater harvesting	3.54	Effective

According to Table 3, the respondents agreed that the level of satisfaction of air conditioning, window treatments, use of bioclimatic design elements and regular maintenance of HVAC systems are high while the level of satisfaction of ceiling fans is moderate.

Table 3: Satisfaction level of thermal comfort

S/N	Variable	Mean score	Decision
01	Air conditioning	4.28	High
02	Ceiling fans	3.29	Moderate
03	Window treatment	4.0	High
04	Use of bioclimatic design elements	3.81	High
05	Regular maintenance of HVAC systems	3.73	High
06	Guest feedback mechanisms	3.51	High

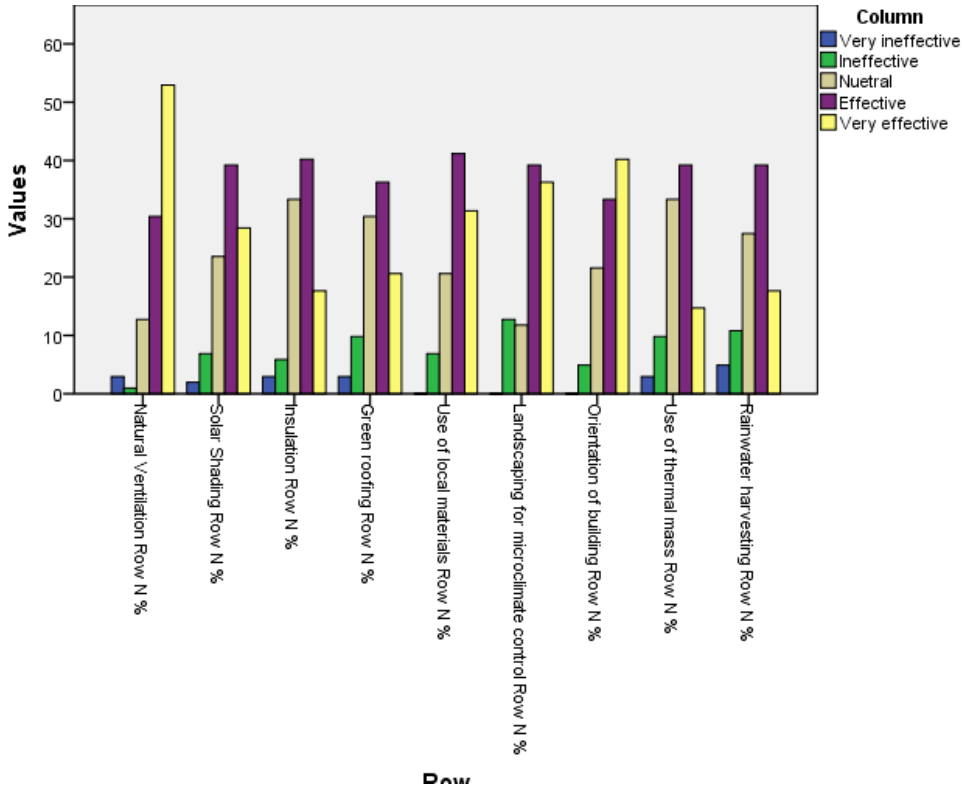

Fig 5: Ranking of the effectiveness of bioclimatic design elements

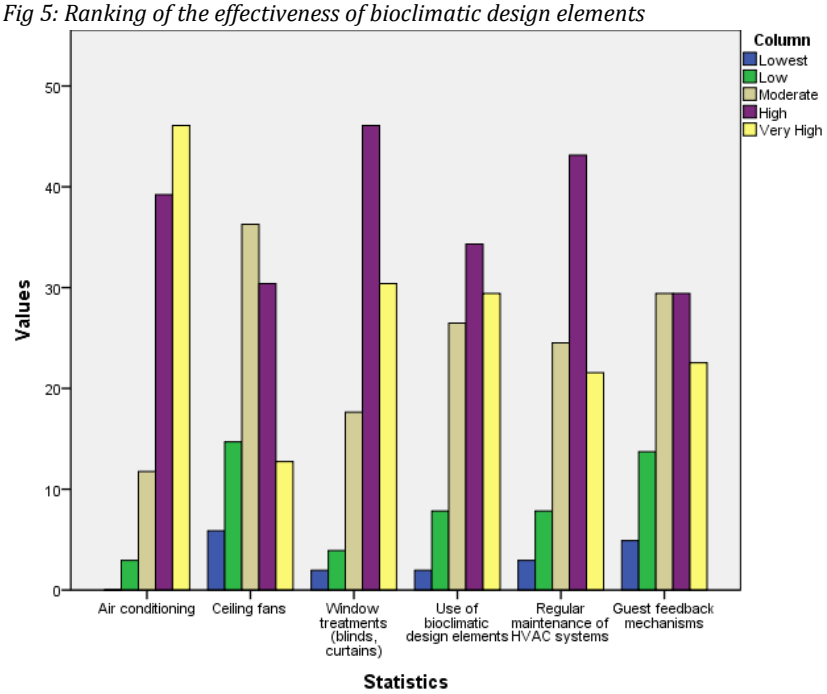

Fig 6: Satisfaction level for bioclimatic elements adapted in hotel buildings.

5. Discussion of Findings

The results of the ranking of bioclimatic design variables provide crucial insights bioclimatic elements utilized for optimizing thermal comfort in hospitality buildings, particularly via the lenses of Thermal Comfort Theory and Climate-Adaptive Design Theory indicated in the review. Prioritizing natural ventilation allows hospitality buildings to passively cool areas, particularly in warmer climates, reducing the need for mechanical cooling systems such as ceiling fans. This also minimizes energy use and helps with environmental initiatives. The second most important factor in thermal comfort is the building's orientation. Building orientation has a direct impact on solar heat gain and wind exposure, both of which influence internal temperatures (Olgyay, 2015). Proper orientation maximises passive solar heating in colder months while minimizing it in summer months, enhancing the building's ability to maintain a stable inside environment without relying heavily on artificial heating or cooling. The third-ranked variable, landscaping for microclimate control, relates to thermal comfort by changing the surrounding environment to generate cooler outdoor settings. Trees and flora can provide shade and evapotranspiration, reducing the heat island effect and improving airflow, so contributing to the building's overall thermal comfort (Nicol & Humphreys, 2002). According to Climate-Adaptive Design Theory, these findings emphasize the need of designing buildings that adjust to their individual climatic environments. Natural ventilation is an adaptable strategy that uses local wind patterns to optimise airflow inside the building, minimizing reliance on mechanical ventilation. This lends credence to the concept that buildings should be designed to work with rather than against the climate (Givoni, 1998). The second and third factors, building orientation and landscaping for microclimate control, increase the design's versatility. Both components respond to the temperature and geography of the building's location, allowing for optimal solar exposure and wind direction while also controlling external environmental factors. According to Givoni (1998), these measures contribute to the creation of a more energy-efficient building that adjusts to the local environment. Other elements, such as sun shading and insulation, albeit ranked lower, are also important in the context of climate adaptation.

Solar shading protects the building from excessive heat gain, especially in hotter areas, whereas insulation keeps internal temperatures stable by decreasing heat loss or gain through the building envelope. Both solutions help to preserve thermal comfort by adapting to seasonal and diurnal temperature variations (Olgyay, 2015). The emphasis on natural ventilation and building orientation as top-ranking variables emphasises the importance of these aspects in obtaining optimal thermal comfort, which is consistent with Thermal Comfort Theory and Climate Adaptive Design Theory. These findings highlight the need for bioclimatic design techniques that prioritise comfort while also responding to local climatic conditions to improve energy efficiency and sustainability. The results of Table 3, which show high levels of satisfaction with air conditioning, window treatments, the use of bioclimatic design elements, and regular maintenance of HVAC systems, as well as moderate satisfaction with ceiling fans, can be interpreted using Thermal Comfort Theory and Climate-Adaptive Design Theory. While mechanical and passive systems are well-received, the reliance on air conditioning underscores the need for a more integrated bioclimatic strategy to deliver thermal comfort in a sustainable manner. The moderate satisfaction with ceiling fans shows that further optimisation of passive cooling solutions may lessen reliance on mechanical systems. However, while lower-ranked variables like green roofing, rainwater harvesting, and thermal mass use are crucial for sustainability, they may have a smaller direct impact on thermal comfort than natural ventilation and orientation. However, they still contribute to climate-responsive design by lowering energy usage and increasing the building's overall resilience to climatic changes (McDonough & Braungart, 2002). This gap can be further researched and expanded on.

6. Conclusion

The adaptation of bioclimatic design elements towards optimizing the overall thermal comfort of occupants in hospitality buildings such as airport hotels is essentially paramount. Findings have shown that aside from the comfort of the users of this buildings, bioclimatic design elements have inherent ability of drastically reducing energy cost for running such buildings and simultaneously protecting the environment in a world where climate change has become a major issue. Recommendations from the respondents are that enhanced natural ventilation system, improved insulation materials and adoption of advance solar shading techniques in hospitality buildings should be ensured in order to optimize thermal comfort. Also, highly recommended are increased use of green roofing, more extensive landscaping for microclimate control, greater use of local and sustainable materials and integration of renewable energy into hotel designs.

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Assessment of delay factors that influences cost performance of Building Maintenance in Nigeria

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Abstract

One of the major challenges facing building maintenance in Nigeria is delays in the maintenance process. Delay factors can influence the cost performance of building maintenance, which can have significant economic implications for building owners and the construction industry as a whole. The study therefore assessed the delay factors that influence the cost performance of building maintenance in Abuja, with the ultimate goal of improving the cost performance of building maintenance. A quantitative research approach was employed with the use of a questionnaire to collect data from property managers and professionals in five federal ministries in Abuja. For this purpose, 100 copies of the questionnaire were distributed, while 80 copies were returned and used for analysis; this gives a response rate of 80.0 %. The analysis of the collected data was carried out using frequency count, percentage, mean item score, and Spearman rank correlation analysis. Findings from the study reveal "that "building age, is the most important delay factor affecting the cost performance of building maintenance, with a MIS of 4.75. On average, all the delay factors affecting the cost performance of building maintenance in Abuja are extremely important (average MIS = 4.19). The maintenance and operation costs for the last 10 years were estimated to be high; the annual inspection cost was estimated to be high; the annual inspection cost was estimated to be average; the life cycle replacement cost of buildings was estimated to be high; and finally, the cost of periodic works and repairs was estimated. Finally, the most effective strategies for improving the cost performance of building maintenance projects are "supply chain optimisation" (MIS = 4.39). The study concluded that the impact of delay factors on cost performance in building maintenance projects in Abuja is very significant and high. The study recommended that in order to address the major delay factors affecting the cost performance of building maintenance, it is crucial to develop a robust contingency plan that addresses building age, building area or size, and vandalism by users.

Keywords: Building, Cost Performance, Delay Factors, Maintenance

1. Introduction

Many researchers study cost performance in different stages throughout the life cycle of construction projects including the maintenance stage. In Nigeria, the maintenance of buildings is crucial for ensuring their longevity and functionality. However, the cost performance of building maintenance projects is often affected by various delays encountered during the process. These delays can lead to cost overruns, schedule extensions, and overall inefficiencies in the maintenance of buildings.

Despite the importance of timely and cost-effective maintenance, there is a lack of comprehensive understanding of the specific delay factors that significantly impact the cost performance of building maintenance projects in Nigeria (Nor, *et al*,.2015). Recent studies have suggested that the maintenance cost of aging infrastructure is projected to escalate significantly over the coming years, exacerbating the financial strain on governments and necessitating urgent action to address these challenges (U.S. Green Building Council. n.d.).

(Okosun and Olagunju, 2017) identified inadequate funds and high maintenance cost, as some of the major factors contributing to maintenance problem of buildings in Nigeria higher institutions. Similarly, (Ogwu *et al.*, 2018) also identified lack of maintenance policy, inadequate provision of funds for maintenance and poor execution of maintenance as key factors that militate effective maintenance of buildings at higher institutions.

(Ofide *et al.*, 2015) further pointed out that the higher institution in Nigeria have a budget for maintenance though in a short-term form and despite the fact that the annual estimated range of maintenance budget for the higher institution is about 50million naira and above, it is still not sufficient to meet the maintenance need of the higher institution.

(Adamu, 2015) concluded that Maintenance activities at Nigerian public universities are not adequately funded and the problem may be partly blamed on lack of proper maintenance planning and operations programs. Furthermore,

the managers do not have proper knowledge of the conditions of the facilities; therefore, proper estimate of the maintenance requirement are not feasible (Adamu, 2015).
(Faremi *et al.,* 2016) also identified budget constraint, poor budgetary control poor maintenance tracking, poor workmanship and many more as some of the factors that affect maintenance cost of tertiary institutions buildings in Nigeria.
It is imperative that this research endeavor be undertaken to contribute to the preexisting corpus of knowledge by evaluating the delay factors that influence cost performance of building maintenance in Abuja, with a focal point on improving cost performance of building maintenance. The objectives of the study are to:
i. To identify the major delay factors affecting the cost performance of building maintenance in Abuja.
ii. To assess the cost performance in building maintenance project.

2. Literature review

The complexity in modern building is evidence that high technology is being employed, Despite the existence of such technology in building deteriorate over a period of time. As such there is need of maintenance of such building. The study has highlighted the current delay factors in cost performance of building maintenance to include: Supply Chain Disruptions, Workforce Shortages and Skill Gaps, Regulatory Compliance and Permitting Delays, Weather and Climate Events, Technology Implementation Challenges, Scope Changes and Client Requests, Inadequate Planning and Communication, Budget Constraints and Financial Uncertainty, Asset Condition and Ageing Infrastructure and Health and Safety Concerns. In conclusion, more robust efforts are needed to tackle the issue of poor cost performance in building maintenance. The summary of the current delay factors in cost performance of building maintenance, as identified from the review of literature, is given in Table 1.

Table 1: Identify the major delay factors affecting the cost performance of building maintenance in Abuja

S/No	The major delay factors in cost performance of building maintenance	Source(s)
1	Building age	Hanna *et al,* (2020); Tesha, 2018; Chung *et al.,* 2020; Abdellatif and Alshibani, 2019; Martin, 2016; Zaki *et al*., 2018; Adam *et al*., 2017; Heravi & Mohammadian, 2021; (Ogbu, 2017
2	Building area or size	
3	Vandalism by users	
4	Faulty design	
5	Building services	
6	Building materials	
7	Deferred maintenance	
8	Poor maintenance tracking	
9	Budget constraint	
10	Poor quality of spare parts	
11	Low concern for future maintenance	
12	Lack of quality control	
13	Delay and failure in reporting maintenance problem	
14	Poor workmanship	
15	Poor budgetary control	
16	Third party vandalism	
17	Poor or lack of training	
18	Non standardized components/material	

3. Research methods

This study adopted survey research design because it enables a researcher to collect data from a population of interest systematically. It tends to be quantitative in nature and aims to collect information from a sample of the population such that the results are representative of the population within a certain degree of error. The targeted population for this study were experienced construction professionals in building maintenance and management in five public buildings, which are the Federal Ministry of Works and Housing Headquarters, the Federal Ministry of Power, the Federal Ministry of Education Abuja, the Ministry of Defence, and the Ministry of Health. The study's population consists of the facilities managers of the five ministries with the highest allocation in the 2023 budget proposal. The sample frame for this study consists of facility managers and professionals (i.e., architects, builders, engineers, and quantity surveyors) who work in the works department of the selected ministries and are actively involved in building maintenance activities for a minimum of 10 years. It was in this frame that the research samples

were drawn. In view of the fact that this study has set criteria for selecting qualified respondents for field work, only eight (80) of the one hundred (100) professionals meet these criteria. Therefore, the sample size for the study is 80. criteria for the selection of the respondent are active involvement in maintenance management of public buildings and the respondent's experience in the cost of maintenance management of the buildings. The questionnaire was, however, administered to them accordingly. A structured questionnaire and data collection checklist were employed to collect data for the study. A questionnaire was employed to collect data on the research objectives based on a five-point Likert's scale format in order to sample the opinions of respondents. For this purpose, 100 copies of the questionnaires were distributed, while 80 copies were returned and used for analysis; this gives a response rate of 80.0%. A data collection checklist was used to collect archival data on maintenance costs recorded for a period of 10 years (2013–2023). The analysis of the data was carried out using descriptive methods of analysis, which include frequency count, percentage, and mean item score (MIS). Frequency counts and percentages were employed to analyse the data to be obtained from site observation.

4. Data Analysis

4.1 Results and discussion on the major delay factors affecting the cost performance of building maintenance in Abuja

The use of Mean Item Score (MIS) was employed to examined the major delay factors affecting the cost performance of building maintenance in Abuja. The result of the analysis is presented in Table 2. The MIS result of the major delay factors affecting the cost performance of building maintenance in Abuja is presented in Table 2.

Table 2: Major delay factors affecting the cost performance of building maintenance in Abuja

Major delay factors affecting the cost performance of building maintenancee	**MIS**	**Rank**	**Interpretation**
Building age	4.75	1st	Extreme Important
Building area or size	4.67	2nd	Extreme Important
Vandalism by users	4.62	3rd	Extreme Important
Faulty design	4.54	4th	Extreme Important
Poor maintenance tracking	4.53	5th	Extreme Important
Budget constraint	4.42	6th	Very Important
Poor quality of spare parts	4.33	7th	Very Important
Low concern for future maintenance	4.27	8th	Very Important
Lack of quality control	4.23	9th	Very Important
Building services	4.20	10th	Very Important
Building materials	4.15	11th	Very Important
Deferred maintenance	4.00	12th	Very Important
Building services	3.98	13th	Very Important
Delay and failure in reporting maintenance problem	3.95	14th	Very Important
Poor workmanship	3.90	15th	Very Important
Poor budgetary control	3.85	16th	Very Important
Third party vandalism	3.80	17th	Very Important
Poor or lack of training	3.78	18th	Very Important
Non standardized components/material	3.75	19th	Very Important
Average	**4.19**		Very Important

Table 2 revealed the MIS ranking of Nineteen major delay factors affecting the cost performance of building maintenance identified from a literature review based on respondents' opinions. It was revealed that "building age, building area or size, vandalism by users, faulty design, and poor maintenance tracking are the extremely important delay factors affecting the cost performance of building maintenance, with MIS of 4.75, 4.65, 4.62, and 4.54, 4.53, respectively. Other delay factors, ranging from budget constraints (MIS = 4.42) to "non-standardized components or materials" (MIS = 3.99), are also very important. On average, all the delay factors affecting the cost performance of building maintenance in Abuja are extremely important (average MIS = 4.19). The result of the study here agrees with the results of past studies, which revealed that timely delivery of projects within budget and to the level of the quality standard specified by the client is an index of successful project delivery. Delays are unacceptable since they will lead to significant losses, including low productivity (Gunawan, 2021). Also, in line with the findings of this study, Olarewanju *et al.* (2022) find that if the upkeep of a building is not adequately managed, it will typically result in buildings that are, in the long run, extremely costly to buy or operate. Therefore, delays in building maintenance

projects give rise to dissatisfaction among the parties involved, and the main role of the project manager is to make sure that the projects are completed within the budgeted time and cost.

4.2 Results and discussion on cost performance in building maintenance project

Table 3 shows the level of cost performance in building maintenance projects in selected five federal ministries buildings. The maintenance and operation costs for the last 10 years were estimated to be high; the annual inspection cost was estimated to be high; the annual inspection cost was estimated to be average, the life cycle replacement cost of buildings was estimated to be high, and finally the cost of periodic works and repairs was estimated.

Table 3: Cost performance

Cost in Naira	Low	Average	High
Maintenance and operation costs for 10 years			High
Inspection cost		Average	
Life cycle replacement cost			High
Costs of periodic works and repairs			High

4.3 Impact of delay factors on cost performance in building maintenance project.

The use of MIS was adopted to determine the impact of delay factors on cost performance in building maintenance projects. MIS was used to rank respondents' opinions on the impact of delay factors on cost performance in building maintenance projects using only the data from the questionnaire, while analysis was used for the same purpose but with the use of both the questionnaire and the data collection checklist.

4.4 Results and discussion on the impact of delay factors on cost performance in building maintenance project.

The use of Mean Item Score (MIS) was employed to examined the Impact of delay factors on cost performance in building maintenance project. The result of the analysis is presented in Table 4. The MIS result of the Impact of delay factors on cost performance in building maintenance project is presented in Table 4

Table 4: Impact of the delay factors on cost performance in building maintenance

Code No.	Impact of the delay factors on cost performance in building maintenance	MIS	Rank	Interpretation
3	Labour Costs	4.57	1st	Extreme significant
D4	Material Costs	4.37	2nd	Very significant
D8	Equipment Costs	4.19	3rd	Very significant
D3	Contractual Penalties	3.70	4th	Very significant
D6	Administrative Costs:	3.50	5th	Very significant
D7	Loss of Revenue or Productivity	3.39	6th	Significant
D2	Legal Costs	3.36	7th	Significant
D5	Reputation Costs	3.23	8th	Significant
D9	Inflation and Price Fluctuations	3.10	9th	Significant
D10	Risk Management Costs	3.00	10th	Significant
	Average	**3.64**		Very Significant

The review of literature identified ten (10) impact of delay factors on cost performance in building maintenance projects. It was revealed from Table 4 that "labour costs" (MIS = 4.57) have an extremely significant impact on delay factors influencing cost performance in building maintenance projects. "Risk Management Costs" has the least significant impact on delay factors influencing cost performance in building maintenance projects (MIS = 3.00). On average, the impact of delay factors on cost performance in building maintenance projects is very significant (average MIS = 3.64). The study by Memon *et al.* (2014) also corroborates the findings of this study by revealing Efficient cost performance is achieved when the expenditure is in line with the estimated cost of a project; however, nowadays, it is a universal challenge for all businesses to achieve cost-effective operation. This view is supported by Kaliba *et al.* (2009), who stated that the impact will be detrimental, especially in the case of developing countries

whose wealth measure is largely dependent on the performance of the construction industry. For instance, construction projects in developing countries such as Botswana, Malaysia, Nigeria, Pakistan, and Zambia are almost identical in terms of facing cost overrun issues (Adeyemi and Masalila 2016; Memon *et al.* 2014). More recently, Chen *et al.* (2015) investigated maintenance cost increases due to rising project complexity and found that this cost typically varies with project size and the nature of project complexity. Recent evidence suggests that more than half of building projects' operation and maintenance costs exceed both construction costs and time targets (Ali *et al.* 2018). On the other hand, a high level of efficiency is achieved when the expenditure falls below the planned cost for the operation and maintenance work.

5. Conclusions

This study identified the problem of delay factors that influence cost performance in building maintenance being executed by most of the property managers and construction professionals in Abuja, mainly due to a lack of comprehensive understanding of the specific delay factors that significantly impact the cost performance of building maintenance projects. In view of this, the study assesses delay factors that influence the cost performance of building maintenance in Abuja, with the ultimate goal of improving the cost performance of building maintenance. It was found that the most important delay factors affecting the cost performance of building maintenance are "building age, building area or size, vandalism by users, faulty design, and poor maintenance tracking." On average, all the delay factors affecting the cost performance of building maintenance in Abuja are extremely important. It can therefore be concluded that the impact of delay factors on cost performance in building maintenance projects in Abuja is very significant, high, and capable of being continuously improved, provided specific strategies are implemented. In the light of the findings and conclusions of the study, the following recommendations were made:

1. In order to address the major delay factors affecting the cost performance of building maintenance, is crucial to develop a robust contingency plan that addresses building age, building area or size, vandalism by users.
2. It is crucial to adopt a multi-faceted approach. Effective communication, robust management, and the integration of advanced information systems and technology are foundational strategies. Additionally, enforcing legal and regulatory compliance, alongside ensuring sound financial management, can significantly reduce the risk of delays. These strategies, when implemented cohesively, can streamline processes, enhance coordination, and facilitate timely project completion.

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Assessing Cost-Based Factors Inhibiting Adoption of Knowledge Management Cost-Based Models in Nigerian Construction Firms

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Abstract

The Nigerian construction sector is dominated by small and medium-sized Nigerian Construction Firms (NCFs) who contributes significantly to tax revenues, employment, and infrastructure. However, their inability to innovate prevents most from scaling up to larger, more sustainable firms. NCFs attribute inability to innovate to cost-based factors which hinders their capacity. Low profits derived from poor project cost performance significantly contributes to this incapacity. Deploying Cost-based Knowledge Management (CKM) models in construction is an innovation which improves project cost performance. This study assessed cost-based factors that inhibits adoption of CKM in NCFs. The study sampled 247 NCFs registered with Bureau of Public Procurement (BPP) in the civil works category using a survey research design. Principal component analysis reduced the variables employed for the study and the relative importance index identified factors of importance. Tangible expenditure, budget limitations, intangible expenditure, and cost of knowledge are factors with high importance levels. The results of the average communalities of the variables that measured them also showed strong validity. Others are funding/financial resources and construction project cost which equally showed similar results. The study contributed to theory by articulating the needed knowledge on cost-based factors for CKM adoption. It will assist NCFs' identification of cost-based factors when planning strategy for CKM adoption.

Keywords: Cost-based Factors, Cost-based Knowledge Management, Cost Performance, Nigerian Construction Firms.

1. Introduction

The Nigerian Construction Industry (NCI) significantly contributes to the country's economy, by providing infrastructure development services, employment opportunities, and tax revenue (Obodo *et al*., 2021). However, Nigerian Construction Firms (NCFs) within the industry faces numerous challenges, which includes poor project cost performance, low profitability, and stagnation (Adu *et al*., 2020). Effective Cost Management (CM) is crucial for NCFs' economic sustainability (Okolie *et al*., 2020). This is because the earnings of a construction firm are derived from net profits arising from prudent CM of the projects they execute.

Knowledge Management (KM) has emerged as a strategic tool for improving processes and competitiveness in construction firms (Bamel *et al*., 2021). KM Cost-based models, in particular, offer a promising solution for optimising project cost performance (Gao *et al*., 2020). Despite the potential benefits of the models, the adoption of Cost-based Knowledge Management (CKM) remains limited among NCFs (Okolie *et al*., 2020). CKM channels cost-based knowledge through KM implementation processes to improve the CM function on construction projects, thereby, optimising cost performance (Gao *et al*., 2020). Research has identified various factors inhibiting KM adoption in construction firms, including organizational culture (Idris *et al*., 2016), technological constraints (Sani *et al*., 2019), and economic barriers (Okolie *et al*., 2020). Despite this, there is a paucity of studies specifically examining the cost-based factors hindering the adoption of KM in Nigerian construction firms.

This study aims to bridge this knowledge gap by investigating cost-based factors inhibiting adoption of CKM in NCFs and examining the perceived importance of these factors by NCFs. The study provided valuable insights for construction firms seeking to adopt innovative methods to improve project cost performance in the NCI.

2. Cost-based Knowledge Management

Adoption of innovations such as Cost-based Knowledge Management (CKM) to improve CM processes are still searching to find coherence in Literature. Existing KM models are not cost-based and are more predominantly used in other industries rather than in construction (Hwang *et al*., 2020). The construction industry KM models are activity or process-based models (Sensuse and Cahyaningsih, 2018), while many are country specific and designed for matured and informatized organisations (Yap and Skitmore, 2020). Despite the obvious advantages adopting innovative KM models may have, NCFs are particularly wary of innovating due to the perceived cost-based factors that will take a chunk of their gross earnings. Several cost-based factors exist that NCFs need to understand, plan-on, and ensure adequate strategy for their implementation (Adu *et al*., 2020). A summary of these cost-based factors is hereby outlined.

2.1 Funding and Financial Resources

Financial constraints are a major hurdle for NCFs. It hinders their competitiveness and ability to secure a market share in the infrastructure sector (Nsubuga-Mugoa, 2019). Research shows that limited financial resources, lack of innovative activities, and ineffective credit systems are significant challenges to adopting new concepts in NCFs (Martins *et al*., 2019). Furthermore, construction SMEs such as the NCFs often fail to recognize the benefits of Knowledge Management (KM) due to resource constraints, leading to poor financial resource management and a reluctance to invest in KM activities (Adu *et al*., 2020).

2.2 Budget Limitations

To stay competitive in the construction market, NCFs need to focus on innovativeness and competitive aggressiveness, which are key components of knowledge management (Adu *et al*., 2020). However, implementing these strategies comes at a cost, which is a major deterrent for cash-strapped NCFs. Limited budgets and allocations from management hinders their ability to invest in these critical policies (Yusof *et al*., 2019). The tendering process in Nigeria also puts NCFs at a disadvantage (Oladimeji, 2021) thereby reducing available budget-able funds. The NCI's tight schedules, slim profits, and complex procedures escalates the challenges faced by NCFs. While innovation is crucial in the industry, many firms hesitate to invest in it due to limited budget-able capital as a result of low profit margins (Yusof *et al*., 2019).

2.3 Tangible Expenditure

Implementing KM requires significant tangible investments to support strategies and processes. Research shows that knowledge infrastructure and process capabilities positively impact business performance (Elfar *et al*., 2017). The importance of information technology infrastructure in successful KM is increasingly recognized (Sani *et al*., 2019). Despite that NCFs invest in IT infrastructure, they often overlook systems that enhance KM processes such as: project/document management systems, and data mining infrastructure (Elfar *et al*., 2017).

2.4 Intangible Expenditure

To properly implement KM, there is need to constantly develop skills, competencies, and capabilities of the human resources to search for and exploit knowledge in the firms (Inkinen *et al*., 2017). Transforming explicit and tacit knowledge into intangible assets aligned with business demands require critical intellectual capital development which is tailored for the purpose (Oliva and Kotebe, 2019). Also, the process development will need to be optimized through the creation of rule books, procedure manuals, and definition of implementation processes (Elfar *et al*., 2017). Finally, KM capability must be intentional through skills development, motivation, and communication among professionals (Olanrewaju *et al*., 2019).

2.5 Cost of Knowledge

Construction is a knowledge intensive sector and for effective KM implementation, firms require timely information extraction, prompt sharing, and articulated data organisation to produce meaningful knowledge (Yan *et al*., 2020). Consequences of knowledge loss in construction is very dare, often leading to reworks, mistakes, and cost overruns (Olanrewaju *et al*., 2019). Therefore, cost of knowledge is important because when planned for, it fosters knowledge retention which prevents knowledge loss (Levallet and Chan, 2019). Implementation however requires knowledge workers, costs of producing code books or online storage to institutionalize the knowledge and ensure organisational memory (Yan *et al*., 2020).

2.6 Construction Project Cost

Key cost-based issues that could pose challenges on construction project include limited information at the cost estimate phase ((Yap and Skitmore, 2020), and frequent design and specification changes, causing cost-sensitive

variations (Habibi *et al*., 2018). Other cost-based factors include the recessive impact of the economy on material and *labour* costs (Habibi *et al*., 2018), diversion of project funds, including retention amount deductions (Adu *et al*., 2020), and material and *labour* cost fluctuations due to shortages or environmental/regulatory laws impacting project costs (Habibi *et al*., 2018).

3. Methodology

This study was carried out among NCFs registered with the Bureau of Public Procurement (BPP) in the civil-works category for transportation infrastructure. The work category comprises contractors in the sections for roads, highways streets, bridges, ports, parks, road tunnel, rail mass transit and waterways. While the unit of measurement is the NCFs, each firm selected was contacted directly to supply a knowledge worker within the firm to respond to a structured questionnaire for the study. The firms sampled are small and medium sized indigenous firms conforming to the micro, small and medium sized enterprises categorization of Small and Medium Enterprises Development Agency of Nigeria (SMEDAN, 2021). This category of firms where selected for the study because they are vulnerable to stunted growth due to competition from larger firms. Emphasis was laid on their active participation in the sector as main or sub-contractors.

The research was conducted by thorough examination of relevant literature to identify cost-based factors. This was followed by the administration of a structured questionnaire to the NCFs selected. A total population of 1714 was received from BPP. In order to obtain the sample size, the Krejcie and Morgan table for determining sample size was employed (Bukhari, 2021). A sample size of 315 was deduced from the population. To address response rate apathy in research 50% response threshold was employed (Saunders *et al*., 2019), therefore, dividing the initial size by 50% derived a figure of 630 and this number of questionnaires were distributed. A Systematic Random Sampling (SRS) was employed to generate random numbers from the population (Saunders *et al*., 2019).

The questionnaire used has three sections, the first examined the quality of respondents to ensure they meet the quality of knowledge workers required. The second section examined the organisation and their activities within the sector. The third sections were constructed to elicit responses to determine the more significant cost-based factors using a 5-point Likert scale. From the 630 questionnaires sent out, 252 was returned and only 247 was suitable for analysis. This represents 40% response rate and translates to about 78.1% of the sample size.

The data set had six (6) unobserved factors (constructs) and forty-eight (48) observed variables (indicators). Due to the rather large variables measuring the factors, factor analysis was employed to reduce the variables that measured the constructs. Principal Component Analysis (PCA) was employed to extract components using the varimax rotation with Kaiser normalization in IBM SPSS 23 Statistic (Kumar, 2020). The influential components were identified from the value of the extracted eigen values that are ≥ 1, and the rotated communality ≥ 3 (Hair *et al*., 2020). To accept model fit in PCA, and being an exploratory study with constructs showing limited evidence of their previous exploration in literature, the Kaiser–Meyer–Olkin (KMO) test and Measure of Sample Adequacy (MSA) was conducted to meet a KMO measures that are ≥ 0.6, and MSA values were acceptable at ≥ 0.5 (Hair *et al*., 2020). Finally, test for sphericity values of $p < 0.005$ indicated adequate correlations (Saunders *et al*., 2019).

After the PCA, 20 variable components were extracted that measured the 6 factors. These components were renamed, and transformed. The transformed data was extracted and used to arrive at the Relative Importance Index (RII). Importance levels are classified as follows (Hair *et al*., 2020): High (H) with values between $0.8 \leq RII \leq 1$; High-Medium (H–M) with RII values between $0.6 \leq RII \leq 0.8$; Medium (M) with RII values between $0.4 \leq RII \leq 0.6$; Medium-Low (M-L) with RII values between $0.2 \leq RII \leq 0.4$; and Low (L) with RII values between $0 \leq RI \leq 0.2$.

Average communalities were calculated for each component to ascertain the strength of each factor. For interpretation in this study, communalities ≥ 0.8 is termed excellent, 0.7-0.79 is termed strong, 0.6-0.69 is referred to as moderate, 0.5-0.59 is referred to as fair, while < 0.5 is referred to as poor (Hair *et al*., 2020).

4. Results and Discussion of Findings

4.1 Characteristics of Respondents

The study sampled NCFs registered with BPP in transport infrastructure. Their various expertise as registered are in roads/highway/bridges (54.3%); airport/park/terminal (25.1%); seaports and waterways (10.1%); and rail mass transit (10.5%). The firms were actively engaged, with about 40% handling 6-10 projects in 5 years and 25% handling 10-20 projects. About 80% of the firms had over 10 years' experience in the NCI. Respondents were experienced professionals with 56% aged 36-50 and 30% with over 20 years' industry experience while 50% has 10-20 years' experience. Similarly, the professional representation was diverse with Architects (17.8%); Quantity Surveyors (29.6%); Builders (10.9%); Civil Engineers (31.6%); and Services Engineers (10.2%) all represented. All professionals held affiliations with their respective institutions, with over 70% holding additional degrees. This demographic profile indicates that high-quality firms and professionals participated in the study.

4.2 Principal Component Analysis of Cost-based Factors.

Six constructs were subjected to factor reduction. They included funding and financial resources (7 variables), budget limitations (6 variables), tangible expenditure (6 variables), intangible expenditure (9 variables), cost of knowledge (6 variables), and construction project cost (14 variables). The communalities for each variable and the average communality for each component were calculated and used to compute the communality strength of the constructs. All KMO summaries measured ≥ 0.6 for each construct, while the statistical significance of each construct is also adequate. The factor reduction produced 20 variables measuring 6 constructs. The new components extracted has funding and financial resources having 3 variables, budget limitations having 3 variables, tangible expenditure having 3 variables, intangible expenditure having 4 variables, cost of knowledge having 3 variables, and construction project cost having 4 variables. The extracted components are presented in addition to the strengths of the computed communalities in Table 1 below.

Table 1: Communality Strength of Extracted Components and Constructs

Extracted Components	Average h_2 (Var)	Average h_2 (Fac.)	Remarks
Funding and Financial Resources*		0.72	Strong validity
Funding constraints and economic capital management	0.92		
Capital charge and resource assignment to KM processes	0.59		
Cost of enterprise and organisational debt financing	0.66		
Budget Limitations*		0.74	Strong validity
Budgeting allotment to project tender prices	0.78		
Costing innovative investment in KM process	0.70		
Budgeting for KM strategy adoption	0.73		
Tangible Expenditure*		0.77	Strong validity
Document management methods and systems	0.81		
Knowledge and informatics infrastructure	0.77		
Knowledge process and software capacity	0.74		
Intangible Expenditure*		0.77	Strong validity
Capacity building and organisation reorientation	0.72		
Organisational KM capacity	0.84		
knowledge repositories and communication network	0.76		
Organisational learning and knowledge sharing capacity	0.75		
Cost of Knowledge*		0.76	Strong validity
Knowledge codification management	0.71		
Knowledge creation cost	0.74		
Data security	0.84		
Construction Project Cost*		0.73	Strong validity
Project related risk (predictable)	0.80		
Project related risk (unpredictable)	0.65		
Project information and characteristics	0.72		
Client influenced cost factors	0.74		

h_2 = Communality; * = Constructs; Var = Variable; Fac = Factor

3.3 Importance Levels of Cost-based Factors

The renamed components were further analysed to extract the perception of importance of the constructs they measure. The Relative Importance Index (RII) is used to determine the perception of NCFs on the strength of each component. Specifically, RII was employed in this research because it helped to further simplify the data through assignment of numerical weighting of the factors, making it easier to analyze and compare (Kahraman *et al*., 2020). By assigning numerical weighting, NCFs can prioritize the factors based on their relative importance, thereby, facilitating decision-making (Sahin, 2021). The RII detailing the Importance Levels of the variables and the factors is presented in Table 2.

Table 2: Importance Level of Cost-based Factors for KM in NCF

Factors	RII	Rank	Importance Level (IL)
Funding and Financial Resources	0.8259	5	High Impotance Level
Budget Limitations	0.9134	2	High Impotance Level
Tangible Expenditure	0.9309	1	High Impotance Level

Intangible Expenditure	0.9067	3	High Impotance Level
Cost of Knowlegde	0.9015	4	High Impotance Level
Construction Project Cost	0.8184	6	High Impotance Level

3.4 Discussion of Findings

While previous studies had recognized organisational factors such as structure of the firm, support from management, and organisational culture as important factors when adopting KM (Singh and Pradhan, 2024), this study has identified cost-based factors that requires attention in the firm. Findings from this study revealed that cost-based factors exist in the NCI that must be considered when adopting innovative methods such as a CKM or in the deployment of KM cost-based models. The study justified existing literature in many instances on the existence of cost related impediments to KM deployment (Elfar *et al*., 2017; Habibi *et al*., 2018; Olanrewaju *et al*., 2019; Sani *et al*., 2019; Yan *et al*., 2020; Yusof *et al*., 2019). Also, it has practical implications in the NCI by providing a guide for NCFs when taking cost-conscious decision for CKM adoption. All the extracted components produced average communalities above 0.7 for the factors, which indicates a very strong variable representation within the factors and strong validity measures. Notably, the results showed all cost-based factors are of high importance levels.

Providing infrastructure for KM adoption has been well documented in literature (Elfar *et al*., 2017). Infrastructure and collaborative systems have always been highlighted as key technological considerations (Sani *et al*., 2019). It is not surprising that tangible expenditure has the highest importance index (0.93) and strong validity (0.77). Similarly, budget limitations are the second highest cost-based factor with an importance level of 0.91 and strong validity of 0.74. Yusof *et al*. (2019) argued that NCFs do not budget for innovations, therefore, this study confirms that the adoption and implementation of new concepts requires the creation of budget heads for adoption of new concepts such as CKM. The third most important factor is intangible expenditure (0.91) with strong validity of 0.77. Yan *et al*. (2020) explains that knowledge refers to meaningful information content assimilated for use. This finding supports literature as human resources, particularly time for knowledge sharing and training have been documented as essential for effective KM implementation (Singh and Pradhan, 2024).

Cost of Knowledge is the fourth more important factor with importance index of 0.90 and a strong validity of 0.76. Inaccurate resource estimates, resource shortages, lack of experience in cost-based decision making, and faults have significant impact on project performance (Yap *et al*., 2022). To optimise cost performance, both personalisation and codification knowledge-sharing systems should be implemented appropriately, while proper attention must be paid to the issues of capturing, storing, and transferring knowledge in the construction industry. Funding/Financial Resources (0.83) also with high importance levels and validity (0.72) is the fifth in line of cost-based factors. NCFs align with the believe that allocating resources to cost-based factors is the critical need required to implement CKM. The logic in this is that available funds should be allocated to ventures that can improve the organisations market share (Nsubuga-Mugoa, 2019). Finally, Construction Project Cost with a high importance level of 0.82 and strong validity of 0.73 is the last factor. This particular finding supports the assumptions that project estimation must consider the overheads needed to implement innovations such as CKM.

4. Conclusion

Cost-based factors for CKM adoption are tangible expenditure, budget limitations, intangible expenditure, cost of knowledge, funding/financial resources, and construction project cost. Venturing into the innovative field of CKM by NCFs requires knowledge on the cost-based factors for cost-conscious decision making. This study has provided background knowledge into the cost-based factors' importance for decisions when adopting cost-based KM models. This study is vital to NCFs because it bridged the knowledge gap of cost-based factors in the NCI for enhanced competitiveness and cost-performance.

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Influence of mobile social media applications on performance of construction project stakeholders in Nigeria.

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Abstract
The construction industry is also known to be very traditional when it comes to the adoption of innovations in processes and organisation, which is corroborated by the fact that it is among the least digitised industries. This study aimed to investigate the impact of mobile social media applications on the performance of construction project stakeholders in Abuja, Nigeria, with the goal of enhancing their overall performance. A quantitative research approach was thus employed, with the use of a questionnaire to collect data from two hundred and seven (112) respondents made up of construction stakeholders. The data was analysed using frequency count, percentage, and mean item score. The findings revealed that Twitter and Tumblr (MIS = 3.67 and 3.67, respectively) are the most important microblog mobile social media applications. It was therefore concluded that mobile social media applications influence the performance of construction project stakeholders. It was recommended that, given that mobile social media applications significantly impact the performance of construction project stakeholders, it is crucial to increase awareness and sensitization about the importance of adopting these applications among construction project stakeholders in Abuja.

Keywords: Applications; Construction; Mobile Social Media Performance; Project Stakeholders

1. Introduction

Performance of construction projects in Nigeria has been a significant concern due to challenges of cost overrun, time overrun, poor quality of work, incidence of building collapse, non-conformance with health and safety regulations, and dissatisfaction of stakeholders in realising project outcomes (Lobo and Abid, 2020).

Digital technology for communication and collaboration is often seen as an important managerial tool, and project managers are left with the increasingly important task of finding proper ways to harness ICT collaboration tools for the involvement of project stakeholders (Meneiluik and Nikiforov, 2022).

Rustholkarhu *et al.* (2022) contended that within a construction company, strategic information sharing is one of the most important parts that influence successful project delivery. However, the industry is challenged with continuous site relocation problems, which make it difficult to maintain an onsite social media network or an intranet that connects all the internal stakeholders (Koolen *et al.,* 2019). The construction project's performance and the public's perception of a particular company are crucial factors (Lannon and Walsh, 2020). Because of the construction industry's uniqueness, such as continuous site re-location, ad hoc project-team-based work, workplace safety concerns, and patchy offices, the use and integration of social media pose a significant challenge (Lobo and Abid, 2020).

While the performance of a construction project in terms of cost and time quality is influenced by the performance of the project stakeholder in terms of innovation, productivity, adaptability, team collaboration, and so forth, the performance of the stakeholders (contractors, subcontractors, project managers, and suppliers) is influenced by the techniques and tools employed throughout the running of the project (Lanon and Walsh, 2020; Ebekozien *et al.*, 2023). However, many construction organisations in Nigeria have yet to explore the promising benefits of social media applications for enhancing the performance of stakeholders in construction projects, and this may be attributed to a lack of understanding of the benefits of social media applications for enhancing the performance of construction stakeholders in construction projects (Meneiluik and Nikiforov, 2022).

It is against this backdrop that this research seeks to provide answers to the main research question, ''What social media applications could influence the performance of construction project stakeholders in Abuja, Nigeria''.

2. Mobile Social Media Applications for Construction Projects

Social media according to Mutua (2013), has emerged as a tool for bringing people together. It has been able to attract people of various groups which are one of the realities of the 21st century any right-thinking individual

would want to wish away easily. A myriad of social media platforms exists in serving various purposes. Notable amongst the application and use of these tools and their relevance to project management suffice (Grahl, 2015, Scott, 2014, SEOPressor, 2015). mobile social media applications for construction projects publishing application includes, sharing application, social networks, discuss applications, planning application , event organizer applications, live casting, advice, buzz monitoring application, career applications, crowd sourcing applications and multiplayer games applications

2. Methodology

This study adopted the survey design approach which is rooted in the quantitative research method by administering structured questionnaires to respondents. For the purpose of this study, the targeted population is total of 520 stakeholders of construction projects in Abuja. These stakeholders include contractors, project managers, subcontractors, suppliers and consultants. For the purpose of this study, a population size of 520 was subjected to the Krecie and Morgan Table for calculating sample size at a 5% limit of error and a 95% confidence level (Krecie and Morgan, 1970). The value of 520 was reduced to 271, which is the minimum number of questionnaires to be distributed. As a result, this study has a sample size of 217. For the purpose of this study, stratified sampling techniques was adopted where each stakeholder was grouped as a stratum, and then sampled at random. This guarantees equal representation of each member in the strata. The data for this research was collected using a well-structured questionnaire. Data analysis involves making sense out of the numerical values obtained during data collection (Cassium, 2014). Respondent information was analysed using frequencies and percentages.

3. Data Analysis and Discussion of Results

3.1 Mobile social media applications for construction projects

Respondents indicated their views on a range of mobile social media applications for construction projects. This application was grouped into thirteen categories: microblogs, publishing, sharing, social networks, discussing, planning, event organisers, live casting, advice, buzz monitoring, careers, crowdsourcing, and multiplayer games, as presented in Tables 1 – 13.

3.2 Microblogs application

The results of the analysis from Table 1 revealed Six microblogs mobile social media applications. Twitter and Tumblr (MIS = 3.67 and 3.67, respectively) are the most important microblog mobile social media applications. The microblog mobile social media application with the lowest ranking is PLURK (MIS = 3.21). On average, all the identified microblogs mobile social media applications are rated fairly important (average MIS = 3.46). This study supports the study by Grahl (2015) and Scott (2014), where it was stated that Microblogging also keeps customers informed about the longer content on your website. Examples are Twitter, Tumblr, Plazes, Twitpic, Jaiku, and PLURK.

Table 1: Microblogs application for construction projects

Microblogs	**Mean Score**	**Rank**	**Decision**
Twitter	3.67	1st	Important
Tumblr	3.67	1st	Important
Twitpic	3.42	3rd	Fairly Important
Plazes	3.42	3rd	Fairly Important
Jaiku	3.35	5th	Fairly Important
PLURK	3.21	6th	Fairly Important
Average mean score of Microblogs	***3.46***		Fairly Important

Source: Author's field survey (2024).

3.3 Publishing application

The results of the analysis from Table 2 revealed Four publishing mobile social media applications. Joomla and Drupal (MIS = 3.64 and 3.42, respectively) are the most important publishing mobile social media applications. The publishing mobile social media application with the lowest ranking is SharePoint (MIS = 3.25). On average, all the identified Publishing mobile social media applications are rated fairly important (average MIS = 3.39). A publishing application helps users create, manage, and distribute content across various platforms. Examples are SharePoint, Joomla, Drupal, and WordPress. This classification aligns with that of (Harrin, 2010).

Table 2: Publishing application for construction projects

Publishing	Mean Score	Rank	Decision
Joomla	3.64	1st	Important
Drupal	3.42	2nd	Fairly Important
WordPress	3.28	3rd	Fairly Important
SharePoint	3.25	4th	Fairly Important
Average mean score of Publishing	***3.39***		Fairly Important

Source: Author's field survey (2024).

3.4 Sharing application

The results of the analysis from Table 3 revealed Six sharing mobile social media applications. Flickr and Instagram (MIS = 3.85 and 3.75, respectively) are the most important sharing mobile social media applications. The sharing mobile social media application with the lowest ranking is YouTube (MIS = 3.21). On average, all the identified sharing mobile social media applications are rated important (average MIS = 3.59). Sharing applications are tools designed to help users distribute content, files, or information across various platforms and with multiple recipients. Examples are YouTube, Dropbox, Slideshare, Flickr, CrowdSpot, and Instagram.

Table 3: Sharing application for construction projects

Sharing	Mean Score	Rank	Decision
Flickr,	3.85	1st	Important
Instagram	3.75	2nd	Important
CrowdStorm	3.60	3rd	Important
Slideshare,	3.60	3rd	Important
Dropbox,	3.57	5th	Important
YouTube,	3.21	6th	Fairly Important
Average mean score of Sharing	**3.59**		**Important**

Source: Author's field survey (2024).

3.5 Social Networks application

The results of the analysis from Table 4 revealed Six social networks mobile social media applications. LinkedIn and Facebook (MIS = 3.85 and 3.75, respectively) are the most important social networks mobile social media applications. The social networks mobile social media application with the lowest ranking is Yammer (MIS = 3.17). On average, all the identified social networks mobile social media applications are rated fairly important (average MIS = 3.35). These applications facilitate communication and community building through various features and tools. This classification aligns with that of (Troukens ,2012).

Table 4: Social Networks applications for construction projects

Social Networks	Mean Score	Rank	Decision
LinkedIn	3.57	1st	Important
Facebook	3.50	2nd	Important
MySpace	3.35	3rd	Fairly Important
hi5	3.32	4th	Fairly Important
Ning	3.21	5th	Fairly Important
Yammer	3.17	6th	Fairly Important
Average mean score of Social Networks	**3.35**		**Fairly Important**

Source: Author's field survey (2024).

3.6 Discuss applications

The results of the analysis from Table 5 revealed Four discuss mobile social media applications. Skype and Google Talk (MIS = 3.82 and 3.25, respectively) are the most important Discuss mobile social media applications. The Discuss mobile social media application with the lowest ranking is Yahoo Messenger (MIS = 3.17). On average, all the identified Discuss mobile social media applications are rated fairly important (average MIS = 3.35). Discussion applications, also known as online forums or discussion boards, are platforms designed to facilitate conversations and information exchange on a wide range of topics. This classification aligns with that of (Zaher *et al*., 2018).

Table 5: Discuss applications for construction projects

Discuss	Mean Score	Rank	Decision
Skype	3.82	1st	Important
Google Talk	3.25	2nd	Fairly Important
MSN	3.17	3rd	Fairly Important
Yahoo Messenger	3.10	4th	Fairly Important
Average mean score of Discuss	**3.33**		**Fairly Important**

Source: Author's field survey (2024).

3.7 Planning applications

The results of the analysis from Table 6 revealed Five planning mobile social media applications. Huddle and Team Box (MIS = 3.35 and 3.32 respectively) are the most important planning mobile social media applications. The planning mobile social media application with the lowest ranking is ZOHO Projects (MIS = 3.03). On average, all the identified planning mobile social media applications are rated fairly important (average MIS = 3.21). These applications facilitate organisation, collaboration, and productivity. Examples are Project Manager.com, ZoHo Projects, Basecamp, Huddle, and TeamBox. This classification aligns with that of (Zaher *et al.,* 2018).

Table 6: Planning applications for construction projects

Planning	Mean Score	Rank	Decision
Huddle	3.35	1st	Important
TeamBox	3.32	2nd	Fairly Important
Basecamp	3.25	3rd	Fairly Important
Project Manager.com	3.10	4th	Fairly Important
ZOHO Projects	3.03	5th	Fairly Important
Average mean score of Planning	**3.21**		**Fairly Important**

Source: Author's field survey (2024).

3.8 Event organizer applications

The results of the analysis from Table 7 revealed four event organiser mobile social media applications. Doodle and Meetup (MIS = 3.60 and 3.57 respectively) are the most important event organiser mobile social media applications. The event organiser mobile social media application with the lowest ranking is Eventbrite (MIS = 3.21). On average, all the identified event organiser mobile social media applications are rated fairly important (average MIS = 3.21). Event organiser applications are specialised tools designed to help individuals, teams, and organisations plan, manage, and execute events efficiently.

Table 7: Event organizer applications for construction projects

Event Organiser	Mean Score	Rank	Decision
Doodle	3.60	1st	Important
Meetup	3.57	2nd	Important
Eventful	3.50	3rd	Important
EventBrite	3.21	4th	Fairly Important
Average mean score of Event Organiser	***3.47***		***Fairly Important***

Source: Author's field survey (2024).

3.9 Live casting application

The results of the analysis from Table 8 revealed three live casting mobile social media applications. Yahoo Live!qik and Justin.tv (MIS = 3.28 and 3.25 respectively) are the most important live casting mobile social media applications. The live casting mobile social media application with the lowest ranking is Upstream.tv (MIS = 3.21). On average, all the identified live casting mobile social media applications are rated fairly important (average MIS = 3.24). These applications are used for various purposes, including gaming, entertainment, education, and business. Examples are Yahoo Live!, Justin.tv, and Upstream.tv. This classification aligns with that of (Grahl, 2015, Scott, 2014).

Table 8: Live casting application for construction projects

Event Organiser	Mean Score	Rank	Decision
Yahoo Live!qik	3.28	1st	Fairly Important
Justin.tv	3.25	2nd	Fairly Important
Upstream.tv	3.21	3rd	Fairly Important
Average mean score of Live Casting	**3.24**		**Fairly Important**

Source: Author's field survey (2024).

3.10 Advice applications

The results of the analysis from Table 9 revealed four advice mobile social media applications. TripAdvisor and Customer Lobby (MIS = 3.46 and 3.42 respectively) are the most important Advice mobile social media applications. TheAdvice mobile social media application with the lowest ranking is yelp (MIS = 3.25). On average, all the identified Advice mobile social media applications are rated fairly important (average MIS = 3.37). These apps can cover a wide range of areas, including personal development, mental health, career advice, relationship counselling, and more. Examples are Trp Advisor, Epinions, Yelp, and Customer. This classification aligns with that of Lobby (Dolan,2013).

Table 9: Advice applications s for construction projects

Advice	Mean Score	Rank	Decision
TripAdvisor	3.46	1st	Fairly Important
Customer Lobby	3.42	2nd	Fairly Important
Epinions	3.35	3rd	Fairly Important
yelp	3.25	4th	Fairly Important
Average mean score of Advice	**3.37**		**Fairly Important**

Source: Author's field survey (2024).

3.11 Buzz monitoring applications

The results of the analysis from Table 10 revealed three Buzz Monitoring mobile social media applications. Nielsen Buzz Metrics and Alterian SM2 (MIS = 3.42 and 3.25 respectively) are the most important Buzz Monitoring mobile social media applications. The Buzz Monitoring mobile social media application with the lowest ranking is Sysomos (MIS = 3.10). On average, all the identified Buzz Monitoring mobile social media applications are rated fairly important (average MIS = 3.25). These apps can cover a wide range of areas, including personal development, mental health, career advice, relationship counselling, and more. Examples are Trp Advisor, Epinions, Yelp, and Customer Lobby. This classification aligns with that of (Dolan,2013).

Table 10: Buzz monitoring applications for construction projects

Buzz Monitoring	Mean Score	Rank	Decision
Nielsen Buzz Metrics	3.42	1st	Fairly Important
Alterian SM2	3.25	2nd	Fairly Important
Sysomos	3.10	3rd	Fairly Important
Average mean score of Buzz Monitoring	**3.25**		**Fairly Important**

Source: Author's field survey (2024).

3.12 Career applications

The results of the analysis from Table 11 revealed four Career mobile social media applications. BCentral and Monster (MIS = 3.14 and 3.07 respectively) are the most important Career mobile social media applications. The Career mobile social media application with the lowest ranking is Career Builder (MIS = 3.00). On average, all the identified Career mobile social media applications are rated fairly important (average MIS = 3.07). These applications offer a range of features, from job listings and networking opportunities to resume building and career advice. Examples are Monster, Central, Career Builder, and Step Stone. This classification aligns with that of (Troukens, 2012)

Table 11: Career applications for construction projects

Career	Mean Score	Rank	Decision
BCentral	3.14	1st	Fairly Important
Monster	3.07	2nd	Fairly Important
Step Stone	3.07	3rd	Fairly Important
Career Builder	3.00	4th	Fairly Important
Average mean score of Career	***3.07***		***Fairly Important***

Source: Author's field survey (2024).

3.13 Crowd Sourcing applications

The results of the analysis from Table 12 revealed three Crowd Sourcing social media applications. Test Topcoder and Crowd Spring (MIS = 3.25 and 3.14 respectively) are the most important Crowd Sourcing mobile social media applications. The Crowd Sourcing mobile social media application with the lowest ranking is Innocentive (MIS = 3.14). On average, all the identified Crowd Sourcing mobile social media applications are rated fairly important (average MIS = 3.17). These applications are used for a variety of purposes, including innovation, data collection, problem-solving, and content generation. Examples are Crowd Spring, Innocentive, Test, and Topcoder. This classification aligns with that of Dolan (Kanagarajoo, 2021).

Table 12: Crowd Sourcing applications for construction projects

Crowd Sourcing	Mean Score	Rank	Decision
Test Topcoder	3.25	1st	Fairly Important
Crowd Spring	3.14	2nd	Fairly Important
Innocentive	3.14	3rd	Fairly Important
Average mean score of Crowd Sourcing	**3.17**		**Fairly Important**

Source: Author's field survey (2024).

3.14 Multiplayer games applications

The results of the analysis from Table 13 revealed Six Multiplayer Games social media applications. Lord of The Rings online and War Craft (MIS = 2.25 and 2.28 respectively) are the most important Multiplayer Games mobile social media applications. The Multiplayer Games mobile social media application with the lowest ranking is Zynga (MIS = 2.07). On average, all the identified Multiplayer Games mobile social media applications are rated less important (average MIS = 3.17). These applications encompass a broad range of genres, from competitive sports and strategy games to cooperative adventures and social simulations. Examples are Zynga, CrowdPark, Farmville, Second Life, WarCraft, and Lord of the Rings online. This classification aligns with that of Dolan (2013); Ngai *et al.* (2015).

Table 13: Multiplayer games applications for construction projects

Multiplayer Games	Mean Score	Rank	Decision
Lord of The Rings online	2.35	1st	Less Important
War Craft	2.28	2nd	Less Important
Second Life	2.25	3rd	Less Important
Farmville	2.17	4th	Less Important
CrowdPark	2.14	5th	Less Important
Zynga	2.07	6th	Less Important
Average mean score of Multiplayer Games	**2.21**		**Less Important**

Source: Author's field survey (2024).

The same argument is true for the classification proposed by Ngai *et al.* (2015) in their review of the available literature on SM technologies. Their study provided only limited examples of SM tools related to media sharing sites, blogs and microblogs, social bookmarking sites, virtual online communities and social networking sites. They did not provide an extensive list of SM tools associated with each category.

4. Conclusion and Recommendations

The study found that mobile social media applications for construction projects are fairly important, while multiplayer games are less important. Consequently, the study concludes that various mobile social media applications, including microblogs, publishing sharing, social networks, discussions, planning, event organisers, live casting, advice, buzz monitoring, careers, crowdsourcing, and multiplayer games, significantly impact the performance of stakeholders in construction projects in Nigeria.

In the light of the findings and conclusions of this study, the following recommendations were made:

1.Various organisations are utilising social media application construction. It is crucial for each stakeholder to create social media tools that their consumers and the public frequently use.

2.Given that mobile social media applications significantly impact the performance of construction project stakeholders, it is crucial to increase awareness and sensitization about the importance of adopting these applications among construction project stakeholders in Abuja.

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Impact of lean construction approach on improving health and safety in construction projects in Kaduna State

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Abstract

Workplace safety is an important aspect of everyday life for every employee, irrespective of the industry they are employed in. Globally, workers suffer from workplace illness and accidents leading to serious injuries and death every day as they go about their jobs. The study examined the impact of lean construction approach to health and safety improvement in construction projects with the view of improving safety in construction projects in Kaduna. A quantitative research approach was adopted. The population for the study was comprised of professionals from construction firms and consulting firms in Kaduna (architects, builders, civil engineers, service engineers, quantity surveyors, estate valuers, and town planners). A simple random sampling technique was adopted. A structured questionnaire was used to collect the data. The analysis of the data was done using descriptive statistics such as percentages, frequency counts, and mean item score (MIS), as well as inferential statistics which included analysis (FA) and Linear regression analysis. One hundred and twenty-seven (127) questionnaires were distributed and one hundred and fourteen (114) were retrived. The findings also revealed that getting the right education is important for implementing lean construction tools and principles smoothly (MIS = 4.67) and that top management needs to be fully on board with the ideas (MIS = 4.53) were the most significant critical success factors necessary to overcome the barriers. The study therefore concludes that lean construction techniques have a significant impact on improving health and safety on construction projects. It was recommended that construction professionals must implement proactive measures such as necessary knowledge and skills required to achieve a smooth and full implementation of lean construction principles and tools the top management must be fully involved in the implementation of the concepts. to mitigate obstacles that hinder the implementation of the lean construction approach for enhancing health and safety in construction projects.

Keywords: Impact, Construction, Health and Safety, Lean, Projects

1. Introduction

The construction industry is often associated with high-risk environments, characterized by frequent accidents, injuries, and fatalities (Ahmed *et al.,* 2018). Despite advances in technology and safety regulations, many construction projects continue to face significant challenges in ensuring the health and safety of workers. Traditional construction methods, with their fragmented processes and inefficiencies, often exacerbate these risks (Demirkesen, 2020). Consequently, there is an urgent need to explore innovative strategies that can simultaneously improve project performance while enhancing worker safety. Construction workers are 3–4 times more likely than other workers to die from accidents at work however, in the developing world, the risks associated with construction work may be 6 times greater. (Edward *et al.,* 2022). According to Walter (2018), the death and injury rate from construction is very high and alarmingly continues to rise. Lean construction, an approach derived from lean manufacturing principles, focuses on reducing waste, optimizing processes, and improving collaboration within construction projects (Moaveni *et al.,* 2019). While lean construction is widely recognized for its potential to enhance project efficiency, its impact on health and safety outcomes has been underexplored. The core philosophy of lean emphasizing continuous improvement, minimizing waste, and fostering a culture of collaboration suggests that it may positively influence health and safety conditions by reducing hazardous working environments, improving communication, and preventing incidents (Uddin *et al.,* 2020). Hence, the industry has been considered the most hazardous industry in many parts of the world (Nadhim *et al*., 2016). More than two decades of research on lean principles and their application in the construction industry have shown some success. But the application of lean in the construction project is still in the initial stages in developing countries of the world Nigeria inclusive. The research problem, therefore, centers on understanding the extent to which lean construction principles and practices can improve health and safety standards in construction projects. Specifically, there is a need to investigate how the implementation of lean methodologies affects accident rates, worker well-being, and compliance with

safety regulations. For this reason, this current study assessed the application of the lean construction approach to health and safety improvement in construction projects in Kaduna State.

2. Literature review

Impact of Lean Construction Approach on Improving Health and Safety in Construction Projects.

Communication is a source of motivation in Lean construction projects, where a collaborative environment is created through Lean philosophy and Lean tools such as the Last Planner System. At the same time, communication helps to increase construction safety (Edmondson, 2018). Carmeli and Gittell (2009) implied that high-quality relationships are significantly related with construction safety. For the management of relations among team members, Lean leadership plays an important role.

Lean leadership helps to implement Lean principles, enhance communication and collaboration, promote culture of continuous improvement (Sadikoglu, *et al.,* 2020). Team leader behaviour is also an antecedent to construction safety and Lean leadership has potential to promote construction safety (Cauwelier *et al.,* 2016). Schöttle *et al.,* (2019) investigated the inclusiveness during decision making process through a case study in a Lean construction project. They proposed that choosing by advantages (CBA) method promotes inclusiveness, avoids group thinking, and develops construction safety.

Problem-solving is another important aspect of Lean culture. In Lean philosophy, root cause analysis helps to tackle problems at the root before they turn into mistakes and continuous improvement helps to sustain the improvement. Similarly, a psychologically safe work environment helps to reduce workarounds, which are temporary solutions to problems. Teams with high construction safety analyse problems and improve the processes to prevent them to occur again rather than relying on workarounds (Edmondson, 2018). Continuous improvement is a cornerstone in Lean philosophy that helps to consider the room for improvement (Liker and Convis, 2011).

Considering a psychologically safe environment, sharing and discussing new ideas may help to achieve better ways of implementation leading to continuous improvement. Hence, one might conclude that psychologically safe employees can be motivated to adopt Lean concepts and apply tools and techniques for better performance. In that way of thinking, Lean thinking and construction safety can be considered as mutually supporting concepts.

In Lean construction, people oftentimes act with self-confidence knowing that the responsibility is shared in case of success and failure. This is possible with no blame culture, where responsibility is shared among team members and team members feel safe about disclosing their ideas without the fear of being judged. This also coincides with some characteristics of a psychologically safe work environment, mentioned by Edmondson (2018). Error reporting and feeling safe to speak about mistakes help to learn from mistakes. Removing factors causing fear enhances learning and cooperation (Edmondson, 2018). Hence, it can be stated that the environment created by Lean philosophy helps to increase construction safety.

Value creation and waste elimination are the main objectives of Lean construction. Waste is identified as anything that does not create value. Along with seven wastes of Ohno, (2019) namely "waiting, moving, transporting, inventory, over-processing, overproduction, defective production", loss of human potential was also considered as waste (Macomber and Howell, 2004). "Not listening" and "not speaking" were identified as two great wastes by Macomber and Howell (2004).

In Lean culture, value is considered to be created primarily by employees. Considering the view of Lean in terms of human potential, value creation, and waste elimination can be associated with construction safety. Given this background, the essentials of Lean construction are emphasized. On the other hand, traditional construction projects oftentimes struggle with poor communication and collaboration, teams with a lack of problem-solving skills, and low respect for people.

Koskela, *et al.* (2020) implied that conventional project management in construction fails to create value for the customer since it does not rely on a transformation-flow-value framework. Love, *et al*. (2018) further mentioned that successful safety management is strongly related to reducing rework, which is possible through early identification and elimination of errors. This becomes easier when communication channels are open between team members and adopting a 'no blame' culture by the organization.

3. Methodology

This study looks at the barriers to the application of lean construction techniques to improve health and safety in construction projects. It does this by using a quantitative method based on a survey of industry professionals. The use of structured questionnaires was adopted to collect data from professionals based on a five-point Likert scale format. The first section (Section A) of the questionnaire collected data relating to the profiles of the professionals to be considered for the study. The remaining issues relating to the objectives of the study were addressed. Two parts of the questionnaire covering the research goals are included to elicit answers from respondents in the study

area. One hundred and twenty-seven (127) questionnaires were distributed and one hundred and fourteen (114) were retrived. After that, the data was imported into SPSS for analysis to assess its reliability. A reliability test was conducted to validate the research questionnaire. Therefore, the research questionnaire as well as the data it is measuring are reliable. The collected data was examined using descriptive analysis.

4. Data Analysis and Discussion of Results

4.1 Critical Success Factors Necessary to Overcome the Barriers

Table 1 reveals that the 2 critical success factors necessary to overcome the barriers to the application of the lean construction approach to improve health and safety in construction projects identified in the study are considered 'Extremely Important 'by the respondents, while the remaining 7 critical success factors necessary to overcome the barriers were deemed 'Very Important by the respondents.

Table 1: Critical Success Factors Necessary to Overcome the Barriers

SN	Critical Success Factors Necessary to Overcome the Barriers	MIS	S.D	Rank	Decision
1	Education: Necessary knowledge and skills required to achieve a smooth and full implementation of lean construction principles and tools	4.67	.47028	1st	Extremely Important
2	the top management must be fully involved in the implementation of the concepts.	4.53	.50097	2nd	Extremely Important
3	Total belief by site team and supply chain	4.41	.64918	3rd	Very Important
4	Simplify the language of lean construction	4.35	.66688	3rd	Very Important
5	The organisation should ensure that the fear built in the staff due to misconceptions and misunderstandings of lean construction practices is cleared from their minds.	4.33	.57479	5th	Very Important
6	Enlightenment on benefits of lean construction practice and need for change	4.32	.65845	6th	Very Important
7	Construction industry should get clients to firmly demand a lean construction approach to managing their projects	4.29	.62301	7th	Very Important
8	The organisation should ensure that the fear built in the staff due to misconceptions and misunderstandings of lean construction practices is cleared from their minds.	3.79	.81120	7th	Very Important
9	Robust Planning	3.71	.85934	9th	Very Important
10	Persistence in order to achieve a sustainable lean construction practice	3.57	.84030	10th	Very Important
	Average MIS	***4.19***			Very Important

The first five critical success factors necessary to overcome the barriers deemed very important by the respondents to improve health and safety in construction projects are: Getting the right education is important for implementing lean construction tools and principles smoothly (MIS = 4.67); top management needs to be fully on board with the ideas (MIS = 4.53); the site team needs to fully believe in them; and making the language of lean construction easier to understand (MIS = 4.41 and 4.35, respectively). The organisation should ensure that the fear built in the staff due to misconceptions and misunderstandings of lean construction practices is cleared from their minds. with an MIS value of 4.33.

Furthermore, the following critical success factors necessary to overcome the barriers to the application of the lean construction approach were deemed "less important" by the respondents: The organisation should ensure that the fear built in the staff due to misconceptions and misunderstandings of lean construction practices is cleared from their minds through robust planning and persistence in order to achieve a sustainable lean construction practice (MIS = 3.79, 3.71, and 3.57) ranked 9th and 10th, respectively. The study found that critical success factors were needed to get around the problems that made it hard to use the lean construction method to improve health and safety on construction projects. These factors were seen as very important (average MIS = 4.19). In addition, all nine critical success factors necessary to overcome the barriers identified in the study recorded a standard deviation of less than one, indicating the existence of agreement between responses. This study's findings are in line with those

According to Bashir *et al.* (2015) and SaRHAh (2011), organisations should engage their staff in a learning process to acquire all the necessary knowledge and skills required to achieve a smooth and full implementation of lean construction principles and tools. Kawish (2017) suggested that the workers should be enlightened on the need for change from the traditional practice and should be made to understand the difference between lean and non-lean practices. They should be well informed about how they can comply with the demands of lean practices. This strategy could help in addressing challenges like difficulties in changing the working culture, misconceptions about lean, and a lack of cooperation from employees.

3.2 Impact of Lean Construction Approach on Improving Health and Safety in Construction Projects

Table 2 displays the results of the simple linear regression analysis conducted to test the impact of the lean construction approach on improving health and safety in construction projects.

Table 2: Impact of Lean Construction Approach on Improving Health and Safety in Construction Projects

	Variables		Observation		Inferences
SN	**X**	**Y**	**T value**	**P value**	**Remark**
		(Constant)	3.04	0.00	
1	Improving health and safety on construction projects	Last Planner System.	2.07	0.04	SS
2	improving health and safety on construction projects	Daily huddle meetings	0.54	0.58	NS
3	improving health and safety on construction projects	Fail-safe quality and safety	1.98	0.05	SS
4	improving health and safety on construction projects	5S process (visual workplace)	-0.15	0.88	NS
5	improving health and safety on construction projects	Visual management.	3.38	0.00	SS
6	improving health and safety on construction projects	First-run studies	-1.24	0.21	NS
7	improving health and safety on construction projects	Concurrent design	0.25	0.80	NS
8	improving health and safety on construction projects	Just-in-time	3.45	0.01	SS
9	improving health and safety on construction projects	Kaizen	2.33	0.02	SS
10	improving health and safety on construction projects	Supply chain management	-4.10	0.00	SS
11	improving health and safety on construction projects	Total production maintenance	1.31	0.19	NS
12	improving health and safety on construction projects	Design for buildability	2.06	0.04	SS
		R	0.543		
		R Square	0.295		
		Adjusted R Square	0.219		

Note: T value = P value= Probability value; SS=statistically significant; NS=Not significant.

The findings revealed that the model is statistically significant, with p values < 0.05 and R2 values of 29.2%. This implies that any change in the lean construction approach of the Last Planner system, daily huddle meetings, fail-safe quality and safety, the 5S process (visual workplace), etc. would lead to a corresponding change in improving health and safety in construction projects. Only five out of the twelve lean construction approaches were statistically significant: daily huddle meetings, the 5S process (visual workplace), first-run studies, concurrent design, and total production maintenance because they had a p value above 0.05. This study's findings are in line with those Carmeli and Gittell (2009) implied that high-quality relationships are significantly related to construction safety. For the management of relations among team members, lean leadership plays an important role.

4.0 Conclusion and Recommendation

This study examines the application of the lean construction approach to health and safety improvement in construction projects with the view of promoting safety in construction projects in Kaduna. On average, all the

barriers to the application of the lean construction approach to improve health and safety in construction projects are very significant. The study found that critical success factors were needed to get around the problems that made it hard to use the lean construction method to improve health and safety on construction projects. These factors were seen as very important. In addition, all nine critical success factors necessary to overcome the barriers identified in the study recorded a standard deviation of less than one, indicating the existence of agreement between responses. The study therefore concludes that lean construction techniques have a significant impact on improving health and safety on construction projects. In the light of the findings and conclusion of this study, the following recommendations. The construction professional must implement proactive measures to mitigate obstacles that hinder the implementation of the lean construction approach for enhancing health and safety in construction projects. This is particularly crucial in addressing barriers such as the "insufficient education and training required to apply LC techniques for safety enhancement" and the "lack of knowledge in applying LC techniques for safety improvement," along with other barriers.

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Analysing the physical condition of Buildings: A Case Study of an Institution of learning in Nigeria

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Abstract

Buildings depreciate with time and gradually perform less than they are expected. This is a concern for building owners and users. Research on deprecation of building tends to focus on identifying or categorising defects. However, investigations that examine the condition of public buildings that inhabit large and frequent users is limited. The aim of this research is to analyse the physical condition of a public buildings in an institution of learning. This study adopts a case study approach involving physical observations and the condition rating of three buildings in an institution of learning in Nigeria. The results of the analysis showed that there were several defects on the wall, floors, roof, electrical and mechanical services. The results on the condition of office buildings showed average condition index values indicating that the buildings were in moderate condition with the *labour*atory in a better condition with an average condition rating of 0.58 and the offices with an average condition rating of 0.52 and the classes with an average condition rating of 0.44. The study argues that improving the condition or state of a building would lead to enhanced building performance.

Keywords: buildings, condition, building condition index, defects, building performance

1. Introduction

Buildings slowly depreciate over time and gradually perform less than they are required (Olubajo *et al.* 2024; Silva and de Brito, 2021). This is a concern for building owners and users who need or use current information about the physical condition of buildings they inhabit to avoid problems with poor performing buildings such as building failure, accidents and fatalities. One established way to gain knowledge or information about a building or the performance of a structure is by examining the condition of the building fabric, elements, and services to determine maintenance needs. This is because the condition of a building reflects the state or performance of the building and a low performing building is usually not safe for occupants. This shows that knowledge on the condition of building per time is important for decision making and this raises questions on the type of depreciation or defects that develop in buildings that usually inhabits large volume of people over time.

Two main themes dominate the discussions on the depreciation of buildings in the literature. Some studies focus on identifying or categorising the types of defects in buildings (Olubajo *et al.* 2024; Waziri, 2016). Other studies focus on the maintenance approach in handling the depreciation of buildings (Motawa and Almarshad, 2013). However, investigations that examine or analyse the condition of public buildings such as hospitals or schools that inhabit large number of frequent users are limited. Therefore, the aim of this study is to examine the physical condition of buildings in an institution in Nigeria. The section that follows reviews literature on the aspects of the condition of a building such as defects, performance and maintenance.

2. Literature Review

2.1 Building Defects

The construction industry is one of the largest contributors to the economic development of a country, but dealing with major challenges such as building defects can affect project cost, duration and stakeholder relationships. Thus, to reduce the adverse effects, identification of defects in the early stages of the construction is essential (Pamera and Gurmu, 2020). Building defects are categorized as structural and non-structural defects. Structural defect refers to any defect in a structural element of a building that is attributable to defective design, faulty workmanship or use of inappropriate materials, and a combination of these. Whereas a non-structural defect in building can be described as a defect in a non-structural element of the building as a result of defective residential building work (Waziri, 2016). These defect types usually occur in building parts such as roofs, walls, floors, ceiling, toilets, doors and windows. Other common building defects such as cracks, peeling paint, rising dampness, defective plaster rendering usually occur on walls (Wen and Mydin, 2013). Defects that directly affect the performance of structures are caused by poor design or construction (Alomari 2022). Structural defect usually occurs when something goes wrong with

the design that will affect its strength and stability. It is therefore important to understand the material properties, behavior the design process and the static or dynamic forces acting on building (Jamaluddin *et al.* 2017).
According to Ayininuola and Olalusi (2004) wall cracks, foundation settlement and buckling of column are the most common building defects in Nigeria. Defects in building façades affect the structural integrity of buildings and degrade external appearance and those type of defect can be managed during maintenance (Lee *et al.* 2020). A building defect occurs when the building loses its ability to perform its function. Building defect can be categorized as physical defect (Pamera and Gurmu, 2020). Examples of physical defect are strength and performance failures due to the inability of the building to function as expected by the established acceptable limit suggested by standard codes (Jamaluddin *et al.* 2017). Alomari (2022) classified defects into eight categories according to the causes of their occurrence such as: poor performance, cracked objects, abrasion, separation, improper fitting missing mission, surface appearance, and water issue. The first step in resolving any building defect is by diagnosing correctly through inspection of the cause buildings defect (Alomari 2022).

2.2 Building Performance

In recent times, the construction industry has been placing higher demands on quality, reduced risk and performance (De Almeida *et al.* 2015). This is because building performance plays a major role in the expectations expressed by owners and occupants and their fulfilment by designers and building operators (Augenbroe and Park 2005). Building performance indicators and characteristic involves the measurement and assessment along with management of energy, lighting, thermal comfort, operational processes and maintenance according to the interests of building's owners, operators, and occupants (Ahmed *et al*. 2011). Performance-based buildings strengthen the decision-making capacity of the various stakeholders and participants in the building sector (Lützkendorf and Lorenz 2006).

2.3 Building Maintenance

Buildings are essential and regular maintenance is required for a building to function optimally and accommodate the activities for which they are constructed for (Ogunoh *et al*. 2018). Building maintenance can be defined as activities or services provided in order to preserve, protect and restore a building structure after completion or after any repair or replacement to current standards to enable it to serve its intended functions throughout its entire lifespan without upsetting its original features (Olarewaju and Abdul-Aziz 2014).
According to Au-Yong *et al.* (2014) building maintenance is the combination of technical and administrative actions to ensure the items and elements of a building are in an acceptable standard to perform their required functions. Making decisions for the maintenance of a building requires the integration of various types of information and knowledge created by different members of construction professionals such as: maintenance records, work orders, causes and knock-on effects of failures, etc. Failing to capture and use this information/knowledge results in significant costs due to ineffective decisions (Motawa and Almarshad 2013).
Furthermore, literature has categorised the maintenance of buildings into two main categories namely: preventive or corrective maintenance (Stenström *et al.* 2016). A preventive maintenance is concerned about the routine maintenance plan, while, a corrective maintenance is concerned about the reactive maintenance in response to a cause of failure or break down (Motawa and Almarshad 2013). The cost of maintaining a building can reach or outweigh the initial cost of a new building when maintenance considerations is not incorporated during the design phase (Okuntade 2014). Therefore, design or construction decisions have a significant effect on the cost of maintenance. This shows that maintenance should not be a passive action or plan. Rather, maintenance should be planned ahead, and organised dynamically to achieve the best value (Olarewaju and Abdul-Aziz 2014).

2.4 Building Condition Survey or Assessment and Tools

The condition of a building is likely to change over time as the physical and operational environments presses on the building fabric and elements (Silva and de Brito 2021). This shows that regular and continuous examination of the physical condition of building is therefore required. This is in order to develop current or up-to-date information on the condition of building that is required for maintenance work (Abbott *et al*. 2007). Therefore, it is important for heads of organisations and maintenance managers of public buildings to gain knowledge regularly by monitoring the condition of their buildings to avoid defects that can lead to the failure of buildings (Yacob *et al*. 2016).
A thorough analysis of the condition of a building is a complex and technical task, requiring knowledge, time and equipment. In some countries the condition of a building is analysed on the basis of diagnosis the extent of deterioration in the building elements (de Oliveira *et al.* 2008). A condition analysis of a building is one stage in the building management system that supports effective and efficient improvement and maintenance of a building (Linggar *et al*. 2019). This analysis is the first part of a process in developing a guideline for decision making in the

planning and implementing future maintenance, and the results of effective condition assessments can be used to predict the extent of damage (Linggar *et al.* 2019).

The analysis of building condition is important in evaluating building quality, and to indicate building quality, assessed buildings must be rated (Ani *et al.* 2014). One reason for assessing or analysing the condition of a building is to identify building defects (Olubajo *et al*. 2024).

Analysing the physical condition of a building or building assessment is a tool for evaluating the performance of buildings to facilitate long-term maintenance expectations. According to Yacob *et al.* (2019) condition assessment or survey is a process that involves inspecting and reporting the physical condition and functional performance of building, infrastructure systems and components (Yacob *et al*. 2019). This shows that without condition surveys, there will be insufficient or no information to carry out repair works on buildings to deal with defects (Yacob *et al.* 2019).

Furthermore, a condition survey or assessment can be regarded as an important safety measure. According to Arya *et al.* (2007), these measures are generally carried out in two levels namely: preliminary and detailed. These levels of condition assessment or analysis provide a systematic a process for getting information in order to project repair, renewal, or replacement needs that will preserve the building fabric or elements (Yacob *et al.* 2019). This indicates that building condition surveys are very important to supports decision making that is critical for maintenance work and activities.

One approach in literature in analysing the condition of a building is the building condition index method – BCI. This approach is method designed to a quantitatively and uniformly compare and monitor groups of comparable facilities over time. Once a building Condition survey has been carried out, data obtained by this process is analysed and translated into a condition value or an index coined the building Condition Index (BCI). This building condition index (BCI) is an index number that indicates the current condition of an asset measured relative to its as-new condition (Chemweno *et al*., 2017).

3. Research Method

This study adopts a case study approach involving physical observations on the condition of several buildings in an institution of learning in Auchi, Edo state, Nigeria. The decision to analyse buildings in this public institution is because there are several buildings in this institution of learning with potential maintenance needs that usually inhabits large volume of people. Therefore, analysing the physical condition of buildings in this institution offers valuable information that is useful in addressing defects and improve the building's performance.

Three buildings in the institution of learning were selected for a condition analysis namely: academic buildings, administrative buildings, lecture halls and *labour*atories buildings. The decision to focus on these three buildings in this institution of learning is because they are the oldest buildings in the institution and knowledge on the physical condition of these buildings can to prevent potential fatalities, enhance maintenance/repair works that will create a conducive environment for learning.

The condition analysis or survey will involve site visits, visual or physical observations and inspection of the buildings, facilities, and equipment to obtain data on the defects of the building elements or areas that require improvement in maintenance practices. The study adopts a building condition index (BCI) to analyse the condition of the buildings. BCI= asset current condition/as new condition. Average BCI= element total observed rating/total number of elements.

4. Results

Table 1: Building condition index for the Labouratory buildings

SN	ELEMENT/COMPONENT	OBSERVED RATING	BUILDING CONDITION INDEX	CONDITION INDEX	CONDITION
1	Floor	55	0.57	3	Fair
2	Walls	49.4	0.52	3	Fair
3	Roof	90	0.94	5	Excellent
4	Ceiling	47.2	0.49	2	Poor
5	Doors/ windows	40	0.42	2	Poor
6	Electrical services	80	0.84	4	V.good
7	Mechanical services	42.7	0.45	2	Poor
8	External surrounding	39.4	0.41	2	Poor
	Average condition rating	55.3	0.58	3	Fair

Table 1 shows the average condition rating of the lab, a total number of 8 labs were surveyed and their individual condition rating calculated before their average rating calculated to determine the overall condition of the labs. The result showed the lab is in a moderate condition with an average condition rating of 0.58.

Table 2: Building condition index for the classroom building

SN	ELEMENT/COMPONENT	OBSERVE RATING	BUILDING CONDITION INDEX	CONDITION INDEX	CONDITION STATUS
1	Floor	43.3	0.45	2	poor
2	Walls	32	0.33	2	poor
3	Roof	90	094	5	Excellent
4	Ceiling	39	0.41	2	poor
5	Doors/ windows	31	0.32	2	poor
6	Electrical services	32.3	0.34	2	poor
7	Mechanical services	32.3	0.34	2	poor
8	External surrounding	40.3	0.42	2	poor
	Average condition rating	42.1	0.44	2	poor

Table 2 shows the average condition rating of the classes, a total number of 20 classes were surveyed and their individual condition rating calculated before their average rating calculated to determine the overall condition of the classes. The result showed that the average condition rating of the classes is in a poor condition with an average condition of 0.44.

Table 3: Building condition index for the Office buildings

SN	ELEMENT/COMPONENT	OBSERVE RATING	BUILDING CONDITION INDEX	CONDITION INDEX	CONDITION STATUS
1	Floor	60	0.63	3	fair
2	Walls	50	0.52	3	fair
3	Roof	90	0.94	5	Excellent
4	Ceiling	48.3	0.50	3	fair
5	Doors/ windows	39.2	0.41	2	poor
6	Electrical services	45	0.47	2	poor
7	Mechanical services	35.8	0.37	2	poor
8	External surrounding	30	0.31	2	poor
	Average condition rating	49.7	0.52	3	fair

Table 3 shows the average condition rating of the offices, a total number of 10 offices were surveyed and their individual condition rating calculated before their average rating calculated to determine the overall condition of the offices. The result showed that the offices are in a moderate condition with an average condition rating of 0.52

Picture 1: Broken chair

Picture 2: Faded paint and holes

Picture 3: Faded paint and holes on wall

Picture 4: Damaged ceiling

Picture 5: Exposed wire and faded paint

The picture in figure 1 shows form of defect in the mechanical services which are chairs and tables observed mostly in the classes and labs. The picture indicates poorly use and misuse by the students. The picture in figures 2, 3 and 4 shows some of the nature of defect that was observed in the *labour*atories, classes and offices. The picture in figure 2 indicates faded paint in external surrounding ceilings that were observed close to the classes and lab, indicating gradual decay of the concrete ceiling paint. The picture in figure 3 shows hole in the walls that were observe mostly in classes and lab and this is cause due to misuse by the student and also differed maintenance that were not carried out. The picture in figure 4 indicates broken ceiling abettors and the ceiling are not align which indicate that maintenance work needs to be carried out in most of the ceiling in the classes and lab. The picture in figure 5 indicates poorly connected wires for a socket that is exposed without a control switch in some of the labs and classes. This surface wiring depicts unsafe electrical wiring and connections. The picture in figure 5 also indicate faded painting which is likely due to poor workmanship of use of inferior materials, figure 5 also indicate that the lab and classes require maintenance in form of painting. The findings suggest that the component is in moderate condition. An important issue emerging from these findings is that the component requires maintenance work mainly in the classes and lab.

The results from table 1, 2 and 3, show some similarities and differences in the physical condition of the *labour*atory and classroom building in the engineering section. This is due to the fact it is mostly used by students, while the offices are in better condition. There is a similarity between the offices, class and lab in the mechanical component as all facilities don't have fire extinguisher, waste base and fire alarm. The result from table 1 and 3 also show that the general description of the classes and lab are very similar and this is due to the fact that their nature of defect are almost same. This is mostly due to misuse by the larger population of people i.e., the students as also observed in Javiri *et al*. (2018) study as the damages were observed in institutional buildings components due to depreciation of some component were as the result of increased human activities (student) who are mainly occupant of facility. This can be seen from the pictures taken during the survey and also from the building condition index. The average BCI for the classes, lab and offices are 0.44, 0.52 and 0.58 which clearly indicates that the facility and component are in a fair condition but require maintenance. The BCI clearly shows that the classes, lab and offices lack maintenance in most of the component which is required to make most of the component function well as also clearly stated by Linggar *et al.* (2019) that maintenance is required to restore the quality and performance of degraded buildings and its component in other to enable them perform Effectively and efficiently in both quality and economy.

5. Discussion

The study analysed the similarities and difference between the condition of the three buildings. The study did not find a significant difference between the classes, offices and *labour*atory building. Evidence presented from the condition analysis indicated that the average condition rating of the *labour*atory shows that the floor component is in an average condition with deteriorated surfaces that require attention and worn-out finishes that requires maintenance. The wall component has minor defects such as cracks, peeling, cobwebs and dust stains. The services are functional but need attention, the roof component is as new, the ceiling has potential problems (such as holes, cobwebs and dust stain), the electrical service components are a good condition and does not require any major maintenance. The mechanical services have significant backlog such as there are no fire alarms, no fire extinguisher

and maintenance work exist. It was observed that the *labour*atory is in moderate condition with some worn finishes requires maintenance and also deferred maintenance works exists.

The average condition rating of the classes indicates that the floor components are in a moderate condition with some deteriorated surfaces that require attention. The services are functional but failing often and the wall component are badly deteriorated with potential structural problems such as horizontal cracks, peeling and cobweb stain and papers on the wall, The roof components is in an excellent condition, however, the ceiling components are in a bad condition. The services are functional but failing often and require maintenance. The study observed potential problems (such as holes, cobwebs and dust stain) in the window and doors that are in a bad condition and require significant attention. The electrical components failed frequently as the services are functional but fails often, it has potential problems (damaged fans and bulbs, exposed wires). They were significant backlog and require maintenance works, the mechanical services components are in poor condition with worn out chairs, tables and board, no fire extinguisher and no fire alarm. The average rating shows that asset in poor condition, services are functional but needs maintenance, deteriorated surfaces require significant attention.

The average condition rating of the offices shows that the floor component are in moderate condition of components, the Services are functional but need attention and also Worn finishes requires maintenance, the wall are in average condition with worn finishes and some major defects (cracks, peeling, cobweb and dust stain), Services are functional but requires attention, The roof components are in excellent condition as the components is as new, the ceiling component are in average condition of component, with minor defects (such as holes, cobwebs and dust stain). The door and windows are in poor condition of component with defects (faded doors and windows are cracked). The electrical component is functional but fails often with potential problems (damaged fans and bulbs, exposed wires). Overall, the study rates the buildings in moderate condition with worn finishes that require maintenance, services are functional but needs maintenance and deferred maintenance work.

6. Conclusion

This study aimed at analysing the physical condition of several buildings in an institution of learning. Three buildings were selected in the public institution namely: the classrooms, offices and *labour*atories. The study adopted the building condition index approach to calculate the average condition of the building, components, facilities and amenities. The study analysed the similarities and difference between the condition of the three buildings using their average condition rating that was calculated. The analysis also focused on investigating the nature and extent of defect in component and amenities. The results showed that the physical condition of the classroom buildings is in very poor condition with an average condition rating of 0.44; the *labour*atory building and offices are in a fair condition with average condition of 0.52 and 0.58 respectively. The study also found that the facility is safe but require maintenance. The study is limited to the elements and components in the three buildings and the study recommends that the condition of more buildings in public institutions are investigated more often to facilitate effective maintenance that will aid adequate learning and conducive environment for the student and occupant. The study recommends that routine inspection should be highly encouraged to rescue some facilities that gives warning before final failure and as well as detecting danger. The study argues that improving the condition or state of buildings would lead to enhanced building performance and facilitate effective maintenance.

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Integration of Passive Fire Prevention Strategies in the Design of a Shopping Mall in Abuja

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Abstract

Fire safety in shopping mall design has been the subject of a recent study to identify the factors within the design process, The most damaging, expensive, and disruptive sources of damage to any building is fire, which primarily occurs in shopping centres in Nigeria. Shopping center fires have caused billions of naira in property damage and resulted in premature fatalities, which negatively impacts victims. This study investigates the integration of passive fire prevention strategies in the architectural design of shopping malls in Abuja, Nigeria. A mixed-methods approach was used, combining quantitative surveys (n=300) and qualitative case studies of four prominent malls: Jabi Lake Mall, Ceddi Plaza, Shoprite Lugbe/Lugbe Mall, and Ikeja City Mall. The findings reveal that only 10.63% of malls have fire-resistant escape routes, emphasizing the need for enhanced regulatory compliance and awareness. These results indicate a pressing need for stricter enforcement of fire safety regulations and the incorporation of essential passive fire prevention elements in mall designs. In conclusion, the study recommends that architects and policymakers prioritize the integration of passive fire prevention strategies in shopping mall designs. Furthermore, enhancing safety awareness among mall operators and occupants is crucial for fostering a culture of preparedness, ultimately leading to safer shopping environments.

Keywords: architectural design, fire prevention, safety, shopping mall, risk assessment

1. Introduction

Shopping center fires have caused billions of naira in property damage and resulted in premature deaths, which negatively impacts victims, their families, and the country as a whole on both psychological and financial levels (Bayo & Kayii, 2020). The most damaging, expensive, and disruptive sources of damage to any building is fire, which primarily occurs in shopping centers in Nigeria. However, fire is not a random occurrence; it is often caused by human activity. In commercial and industrial buildings across the globe, fire is thought to be the primary cause of fatalities and property loss Due to the huge number of fire-related losses that occur globally, researchers experts must keep looking for new prevention measures (Arowolo TA *et al*., 2021). According to previous research on shopping mall fires, human factors include careless use of electrical appliances, smoking and the careless disposal of cigarette stumps, gas leaks from gas cylinders, improper fuel storage, overloading electrical outlets, defective electrical wiring, unauthorized connections of electricity, and a general lack of awareness of safety. These factors are thought to be the most common causes of fires. The aim of this research is to identify and incorporate appropriate passive fire prevention measures that align with the architectural and functional requirements of shopping malls in Abuja. Assessing their architectural and functional requirements. It identifies key elements for safety enhancement and reduces fire hazards, and proposes guidelines for implementing these measures in the design and construction of new malls in Abuja.

There is certain design that could work well together to support the building's overall goals. With the help of the larger design team, architects typically oversee the relationships between the design objectives, giving them priority and determining the best possible design solution (Rathnayake *et al*., 2020). The many functional and aesthetic elements required to meet the demands of stakeholders and clients as well as adherence to building codes and regulations are taken into consideration by architects when making design decisions (Reisinger *et al*., 2021).

2. Literature Review

Passive fire prevention strategies in building design are critical to enhancing occupant safety, minimizing property damage, and ensuring the structural integrity of buildings during fire incidents. Passive fire prevention strategies are crucial in mitigating fire risks in buildings and structures. Unlike active fire protection systems, which require manual or automatic intervention to suppress fires, passive fire protection (PFP) involves the use of building materials and design techniques to prevent the spread of fire and smoke. This literature review explores the concept of passive fire protection in commercial settings, particularly shopping malls. It further examines existing studies

on the challenges and effectiveness of these strategies in commercial architecture by synthesizing this knowledge, the review aims to highlight the importance of incorporating passive fire prevention in Abuja's shopping mall designs for improved safety.

2.1 Overview of Shopping Malls

According to (Hameli, 2018), shopping malls are significant retail establishments that are essential to the retail distribution system. Purchasing goods or services, either with cash or other means, is an essential part of daily life for people everywhere. Allowing people to purchase products and services while meeting social needs is the fundamental goal (Lim, 2022). The social element of earliest days markets was crucial, as they evolved into a hub for communal gatherings and the enjoyable conclusion of weeks' worth of *labour*. But as urban patterns became more sophisticated and detached, this social element progressively faded(van Eck *et al*., 2022). Shopping centres were developed as the heart of commerce in large cities, often located near government and entertainment centres, helping to shape the urban fabric (Varol & Özçelik, 2022). Shopping centers were developed as the hub of activity in large cities, situated near administrative and recreational facilities, to serve as the hub of city life (Kirk, 2023). Although a store's primary goal is profit through the sale of products or services, retail strategies and consumer behavior are rapidly evolving to adapt to new societal norms. The planning and selling strategies of shops stress these changes, and new innovations need to be monitored closely.

2.2 Classification of Shopping Mall

The three types of shopping malls are General-purpose centers, Community centers, and Neighbourhood centers according to the (ICSC) International Council of Shopping Centers (Deborah, 2022).

1. General-purpose centers, which have a gross leasable area exceeding 800,000 square feet, are larger and provide more possibilities than regional centers.
2. Community centers are smaller and have a broad selection of services and general products, often including fashion.
3. Neighbourhood centers have a gross leasable space of 30,000 to 125,000 square feet and are usually constructed in residential neighbourhood s. Convenience stores, often known as arcades or shopping plazas, are outdoor retail spaces that have a number of shops arranged in a row.

2.3 Fire

Fire and the theory of its emergence are inseparably connected. According to this belief, fire is an uncontrolled fire that is outside the reach and desire of humans (Morgan *et al*., 2020). At a specific temperature, a fuel and oxygen combine to form fire, which produces flame, sound, and light. As a result of uncontrollably contacting fuel, oxygen, and heat, fire is a natural situation. Among other things, fires result in losses to persons, property, and production.

1. Loss of Life: Either directly or indirectly, fire can result in casualties.
2. Reduction in productivity: The production process will be hampered by a fire, and it may even cease altogether. The projected value of the loss will be five to fifty times greater than the direct loss.
3. Disruption of Business Due to the loss of productivity and the destruction of property caused by the fire, a market or shopping center burning down severely disrupted commercial operations.
4. Losses in Society: A number of fire victims suffered as a result of the fire, losing everything they owned, ruining their lives, and hurting their families. There are barriers in social activities as well, which lowers welfare

2.4 Fire Prevention Measures in Buildings

A fire outbreak in a constructed facility poses risks to people and their property, which is why numerous efforts have been made to mitigate the risks associated with building fires (Kelly *et al*., 2021). Fire safety measures include integrated design features, fire detection and alarm systems, and fire extinguishing installations. According to (Mohan *et al*., 2021), all fire safety regulations may be expressed in terms of a few essential design elements, including the number of staircases, journey distance, or fire resistance period. In order to prevent fatalities in the event of a fire in high-rise buildings, suggested sprinkler systems, fire-safe elevators, specifically designed additional staircases for fire fighters, and in-person and personal instructions.

According to UK regulatory guidance, escape signs such as exit, fire exit, and emergency exit are necessary for guiding people toward escape routes in larger, more complicated buildings Other preventive strategies were revealed by (Mohamed *et al*., 2020)and included documenting, planning, informing, instructing, and training; fire detection and warning signs; signs and notices; and passive and structural fire protection.

Standardized protocols included preventing fire outbreaks, educating management and employees, carrying out emergency procedures, giving safety instructions, maintaining fire protection equipment, and cooperating with fire authorities. Maintaining fire safety records is another crucial aspect of these practices (Amasi, 2021).

Overview of Passive Fire Prevention Strategies

Fire-Resistant Materials: The use of fire-resistant materials such as concrete, gypsum, and fire-rated glass is fundamental in passive fire protection. These materials can withstand high temperatures and prevent the structural integrity of buildings from being compromised (Zhang, 2023).

Compartmentalization: This strategy involves dividing a building into fire-resistant compartments to contain fires within a limited area. Fire doors, walls, and floors are designed to resist fire and smoke, thereby preventing the spread to other parts of the building (Kodur *et al*., 2020).

Firestopping: Firestopping involves sealing openings and joints in fire-rated walls and floors to prevent the passage of fire and smoke. This includes the use of fire-resistant sealants, sprays, and intumescent materials (Al-Hajj *et al*., 2022).

Structural Fire Protection: Protecting the structural elements of a building, such as steel beams and columns, with fire-resistant coatings or encasements helps maintain the building's stability during a fire.

Smoke Control Systems: While primarily an active system, integrating smoke control measures such as smoke barriers and ventilation systems can complement passive strategies by managing smoke movement and improving visibility during evacuation.

2.5 Challenges in Implementation

The effective implementation of passive fire prevention measures in shopping mall designs faces several significant challenges, which can undermine the safety of these commercial spaces.

Lack of Awareness Among Developers: Many developers may not fully understand the importance of passive fire prevention or the specific measures that should be incorporated into their projects. This lack of awareness can lead to inadequate planning and design, resulting in shopping malls that do not meet essential fire safety standards (Qin *et al*., 2022). Developers may prioritize other aspects of the project, such as aesthetics or functionality, without recognizing the critical role that fire safety plays in protecting occupants and property.

Insufficient Training for Architects: Architects play a crucial role in integrating fire safety measures into building designs. However, many may not receive adequate training on the latest fire safety regulations and best practices for passive fire prevention. This gap in knowledge can lead to designs that overlook essential safety features, such as fire-resistant materials, proper exit placements, and effective fire compartmentalization. Without proper training, architects may struggle to balance safety with other design considerations, potentially compromising the overall effectiveness of fire prevention strategies.

Financial Constraints: Budget limitations are a common challenge in the construction industry, and they often lead to decisions that prioritize cost savings over safety. Developers may opt for cheaper materials or cut corners in design to stay within budget, which can result in inadequate fire safety measures. This financial pressure can discourage the adoption of higher-quality, fire-resistant materials or the implementation of comprehensive fire safety designs, ultimately increasing the risk of fire incidents in shopping malls.

2.6 Training and Knowledge of Passive Fire Safety Measures

In order to prepare building occupants for the occurrence of a fire, training can be provided through workshops, seminars, and short courses. Security personnel and store owners should participate in frequent fire drills and receive training on firefighting equipment. Building planning and construction must be finished on time in order to guarantee that new fire safety measures are installed correctly. Fire outbreaks can be avoided by unlocking escape staircases and fixing exposed electrical fixtures and wiring. Replace combustible materials with fire-resistant ones or treat them with fire retardants if they are present, especially on the first and ground floors. Fire blankets and other fire safety measures should be included in ground and second level spaces. It is best to employ cementitious coatings and intumescent paints for fire resistance and to provide residents enough time to escape. In places where fire spread resistance is not present, fire-rated windows and doors can be fitted. It is necessary to address an

abandoned elevator shaft in order to stop the fire from spreading to further floors. Those with the necessary qualifications should offer a fire safety training course.

3. Methodology

Data collection for this research was conducted using both primary and secondary sources. Data was gathered from a variety of sources, including observations, interviews, questionnaires, and a review of the literature. The research employed a descriptive method to collect and analyze data. Direct observations also accorded the researchers the opportunity to get first-hand information on compliance with fire safety measures. Purposeful sampling is a procedure in which researchers carefully select respondents and locations to better understand the central phenomenon (Palinkas *et al*., 2015). This was adopted to help the researcher collect pertinent data from the case studies as related to the subject under research; the case studies were chosen based on the criteria of shopping mall in Abuja. 4 shopping mall buildings were selected to be used as case studies for this research in Abuja, Nigeria. A sample size of 300 hundred questionnaires were distributed to targeted and 207 valid respond was received from selected shopping malls occupants in the case study shopping mall buildings. Descriptive studies aim to observe, describe, and document situations as they naturally occur. Statistical tools such as the mean were applied to quantify the level of fire safety measures in terms of community safety, procedures, and awareness.

4. Result and Discussion

4.1 Selection Criteria for Case Studies

The facilities were chosen for this project because they provide information on the research area being studied. Because it was important to focus on particular categories research population, the purposive sampling technique was employed to gather these case studies. The analysis of the researcher was used to select the case study. considering the significance of the proposed location of an Abuja shopping centre. The data gathering comes from Nigeria shopping malls. The following shopping mall buildings (case studies) were examined:

- Jabi Lake Mall
- Ceddi Plaza
- Shoprite Lugbe /Lugbe mall
- Ikeja City Mall

4.2 Selection Criteria for Case Studies

The findings presented in Table 4.2 provide insight into the study's relationship to the integration of passive fire prevention measures in Abuja's shopping malls. It is important to take into account how different passive fire prevention elements fit into the architectural and functional specifications of shopping malls. You can examine and talk about the outcomes as follows:

Key; • = Available; - = Not Available

Table 4.1: Passive Fire Safety Measures

Name of Shopping mall	Jabi Lake Mall	Ceddi Plaza	Ikeja City Mall	Shoprite Lugbe /Lugbe mall
Emergency Staircases	•	•	•	•
Emergency Exits	•	•	•	•
Clear Distance Behind Exits	•	•	•	-
Fire Assembly Points	•	_	•	-

Source: Author's work, (2024)

The study finds that emergency staircases are present in all four shopping centers in Abuja: Shoprite Lugbe/Lugbe Mall, Jabi Lake Mall, Ceddi Plaza, and Ikeja City Mall. These staircases are typically included into the mall's architecture. But the lack of emergency exits at Shoprite Lugbe/Lugbe Mall points to a possible issue that might be fixed. Shoprite Lugbe/Lugbe Mall lacks clear distances behind exits, but Jabi Lake Mall, Ceddi Plaza, and Ikeja City Mall do. Ceddi Plaza and Shoprite Lugbe/Lugbe Mall lack fire assembly points, whereas Jabi Lake Mall and Ikeja City Mall do. These elements are crucial for planning the secure post-evacuation assembly of residents. According to the study, in order to provide complete fire safety, all malls should have fire assembly points, emergency exits, and clear

space behind exits. It may be necessary to amend policies or guidelines to require these characteristics in all malls, new and old.

4.3 Current Passive Fire Prevention Measures

An overview of the passive fire prevention measures currently in place in Abuja retail malls may be found in the provided figure 4.3 below. Finding out how effectively existing designs adhere to safety regulations and pinpointing areas in need of improvement are crucial objectives for the assessment of these measures.

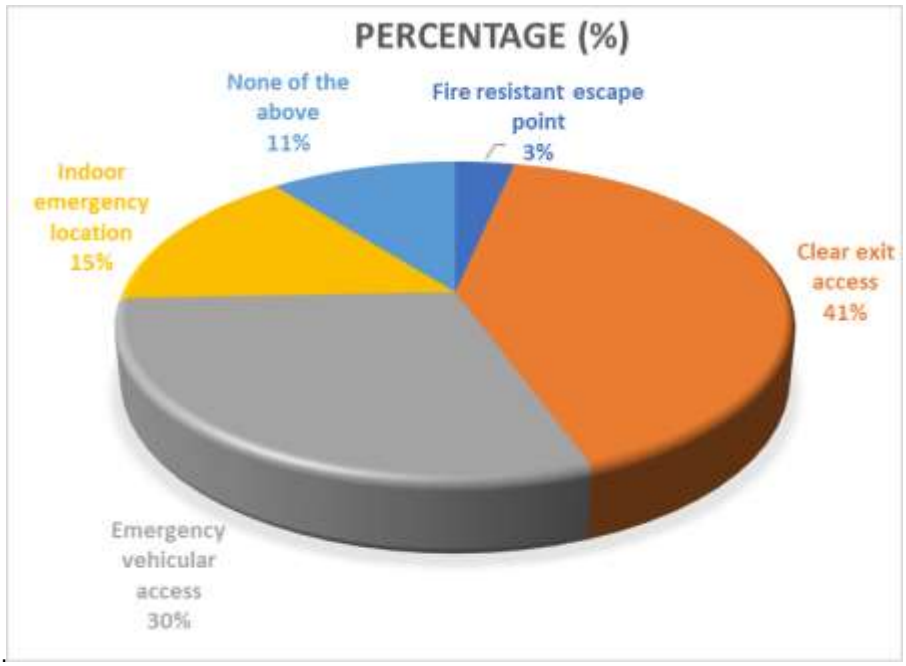

Figure 4.1: Current Passive Fire Prevention Measures

The analysis finds a significant gap in Abuja shopping malls' fire safety regulations. The fact that just 10.63% of malls have fire-resistant escape routes suggests that building standards requiring these elements need to be strictly enforced. The most commonly seen metric, found in 41.06% of malls, is clear exit access. This suggests that even though a sizable percentage of malls have taken action to guarantee clear departure pathways, many have not yet done so to a sufficient degree. Less than one-third of malls have provisions for fire engines and other emergency vehicles to enter the grounds promptly and effectively. Emergency vehicular access is observed in 29.95% of malls. This precaution is essential for enabling first responders to quickly arrive at and handle fire emergencies.

The study highlights how crucial it is to provide emergency vehicle access at the design stage in order to satisfy fire safety functional requirements. In 14.98% of malls, indoor emergency spots such as designated safe zones or refuge areas are noted. These locations could be crucial in the event of a fire. A lack of sufficient internal safety zones in many malls may be indicated by the low frequency of indoor emergency spots, which could be crucial in the event of a fire. The study's conclusion that 3.38% of malls lack any of the passive fire prevention measures that have been observed highlights the pressing necessity of thorough fire safety design and implementation.

5. Conclusions

In order to improve safety and reduce the hazards connected with fire occurrences, shopping malls must incorporate passive fire protection methods into their design. According to this report, shopping center fires in Abuja, Nigeria, have tragically resulted in lives and severe property loss, highlighting the urgent need for efficient fire prevention measures. The analysis of fire safety measures in shopping malls in Abuja reveals a critical gap in compliance with established fire safety regulations. The findings indicate that only 10.63% of malls have fire-resistant escape routes, and 14.98% provide designated indoor emergency areas. This lack of adequate safety measures not only endangers lives but also highlights the urgent need for stricter enforcement of fire safety standards. The current situation underscores the necessity for immediate action to enhance the safety of these commercial spaces. These results highlight the need for stricter enforcement of fire safety regulations and for comprehensive passive fire prevention measures to be incorporated into the architectural design process. Architects may design safer spaces that save people and property by giving priority to elements like fire-resistant

materials, obvious escape routes, and designated safe zones. Policymakers should strengthen building codes to mandate fire-resistant materials and clear escape routes, alongside regular compliance audits. Enhanced training programs for mall management and staff are essential to ensure preparedness through fire safety training and drills. Public awareness campaigns should educate shoppers on fire safety measures and compliance importance. Future research should investigate the effectiveness of various fire safety measures and explore technological innovations, such as smart fire detection systems. By implementing these recommendations, stakeholders can improve fire safety in shopping malls, protecting lives and property while fostering a culture of safety awareness within the community, ultimately enhancing the overall shopping experience.

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An Evaluation of the Determinants Causing Variation in Residential Property Rental Values in Minna, Niger State, Nigeria

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Abstract

Fire safety in shopping mall design has been the subject of a recent study to identify the factors within the design process, The most damaging, expensive, and disruptive sources of damage to any building is fire, which primarily occurs in shopping centres in Nigeria. Shopping center fires have caused billions of naira in property damage and resulted in premature fatalities, which negatively impacts victims. This study investigates the integration of passive fire prevention strategies in the architectural design of shopping malls in Abuja, Nigeria. A mixed-methods approach was used, combining quantitative surveys (n=300) and qualitative case studies of four prominent malls: Jabi Lake Mall, Ceddi Plaza, Shoprite Lugbe/Lugbe Mall, and Ikeja City Mall. The findings reveal that only 10.63% of malls have fire-resistant escape routes, emphasizing the need for enhanced regulatory compliance and awareness. These results indicate a pressing need for stricter enforcement of fire safety regulations and the incorporation of essential passive fire prevention elements in mall designs. In conclusion, the study recommends that architects and policymakers prioritize the integration of passive fire prevention strategies in shopping mall designs. Furthermore, enhancing safety awareness among mall operators and occupants is crucial for fostering a culture of preparedness, ultimately leading to safer shopping environments.

Keywords: architectural design, fire prevention, safety, shopping mall, risk assessment

1. Introduction

Residential dwelling symbolizes one of the most basic needs of human beings and it has a profound impact on the health, welfare, and productivity of individuals (Julius, 2010). More so, not only a house is an essential need of human beings but it is also an object of investment as well as a means of storing wealth.

This has resulted in people buying houses and those who cannot afford to buy do rent to satisfy their needs hence, the creation of the residential property market. Unlike every other commodity market, the property market is not centralized as the market for a particular property is located where the property is situated. As a result of the lack of a centralized market for real properties, property values usually vary irrespective of the similarity level of such properties (Udoekanem, 2015).

The rate of variation in residential property rental values in Minna is visible which may be due to so many reasons and many more determinants that this study will assess. Using Minna, Niger State as a case study will, therefore, reveal or help to establish the relationship between property values and the determinants that result in variation of rental values in Minna and its environs.

Referring further to Minna, the residential property market is rapidly growing and this is not far-fetched from the fact that the population of the city is growing by the day as a result of many factors which may include among others the situation of tertiary institutions (Federal University of Technology Minna both Bosso and Gidan kwanu campuses, College of Education Minna, School of Midwifery Minna, New Gate University Minna); branches of top commercial banks; and being close to the Federal Capital Territory. Residential property rental values vary within and across the various neighbourhoods of the Minna metropolis. A typical example of the variation in residential property rental value in Minna can be observed in properties located within the neighbourhood of the various tertiary institutions in the city.

Against this background, the researcher examines the various determinants responsible for variation in residential property rental values in Minna.

2. The Study Area

Minna lies at latitude 9° 33' N and 9° 45'N and longitude 6° 34' E and 6° 42'E. The town has a mean annual rainfall of 1334mm (52 inches) taken from an exceptionally long record of 54 years. Minna is a town of migrants. Nine in ten of the household heads in the town have migrated to the town from elsewhere. Work is the main attraction. Without the migrant population, the skilled services and trades, for instance, would not be able to function (DAP Niger State, 2007).

2.1 Population

The 2006 census states that the population is 3,954,772, comprising 2,004,350 males and 1,950,422 females. These represent the proportional share of 51.5% for males and 48.5% for females. As opposed to a national annual growth rate of 3.2%, Niger State is growing at 3.4% annually and is a peaceful State reputable for its hospitality and good neighbourliness.

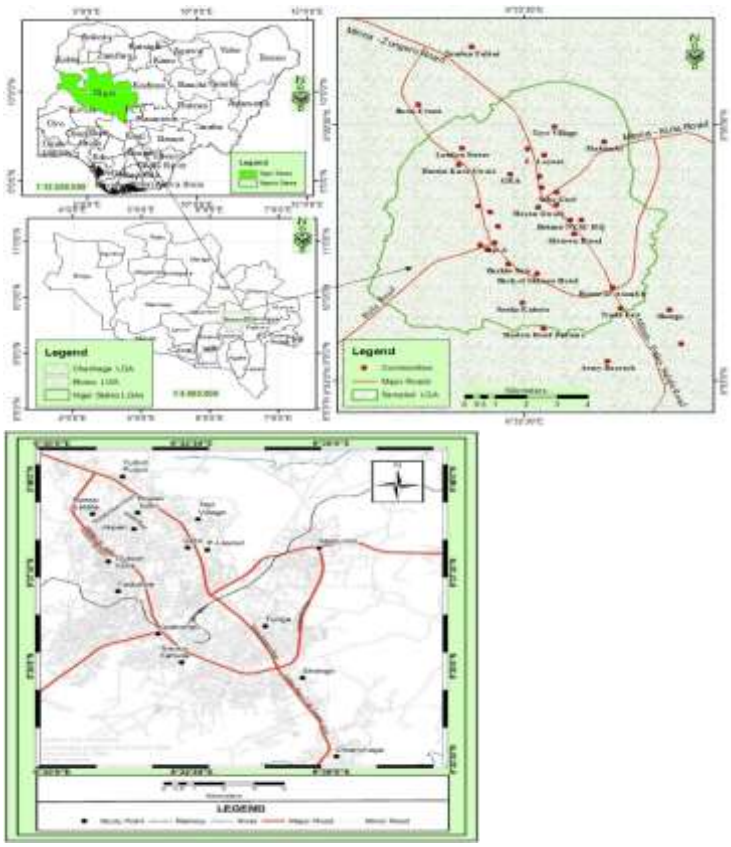

Figure 1: Nigeria Showing Niger State, Minna and the Residential Neighbourhoods.

3. Conceptual Framework

In the past, real estate was perceived as a legacy a parent bequeaths to their children. However, with the understanding that real estate investment is characterized by capital appreciation and boasts a good hedge against inflation, the real estate market is becoming more popular and important (Igbinosa, 2011). More so, the residential property market represents one of the most important sub-sectors of the real estate industry (Anthony, 2012). The demand for residential accommodation is on the increase as a result of the ever-growing human population. This increase has caused rental growth and variation over the years and has ultimately led to the enticing nature of residential Property investment and the consequent attraction of investors, public and private, to residential property investment (Olalere, 2016).

However, rent determination in Nigeria has often been left basically to the choice of the owner who fixes rent based on his estimation of what his house should command as per rental value (Kemiki *et al*., 2014).

4. Materials and Methods

This study utilized both primary and secondary sources of data. The primary data comprise rental data of residential properties in the study area across the neighbourhoods. These include annual data on rental trends for residential

properties under study for 2013-2023 and their specific characteristics, the rental growth rate, and factors that cause variations in rental values.

4.1 Population and Sample Frame for the Study

The target population for this study consists of residential properties in the Minna metropolis that are strictly for investment and can generate income for the property owner in the form of rent and are said to have income-earning potential or rent, tenants of residential properties and all firms of registered Estate Surveyors and Valuers in Minna, Niger State that manages residential properties. The number of registered Estate Surveyors and Valuers firms was obtained from the directory of Estate Surveyors and Valuers Registration Board of Nigeria (ESVABON) register.

4.2 Sampling Technique and Sample Size

Primary data for the study were collected through field surveys. These stages included the selection of Estate Surveying and Valuation firms involved in the management of residential properties and the selection of tenants of residential property types such as two-bedroom and three-bedroom flats for data collection. The number of registered firms of Estate Surveyors and Valuers in Minna is 12, the figure was obtained through the information provided in the current Directory of the Nigerian institution of Estate Surveyors and Valuers. Thus, all the 12 registered firms of Estate Surveyors and Valuers involved in residential property management were selected for data collection. In selecting residential properties used for this study, the study area was delineated into sections. These sections were identified as two-bedroom and three-bedroom flats for rental purposes. A total of fifteen neighbourhoods were selected which constitutes the neighbourhood with high demand for two and three bedrooms. Thus, a total of 250 residential properties across the 15 neighbourhoods in Minna were selected for the study.

5. Results and Discussion

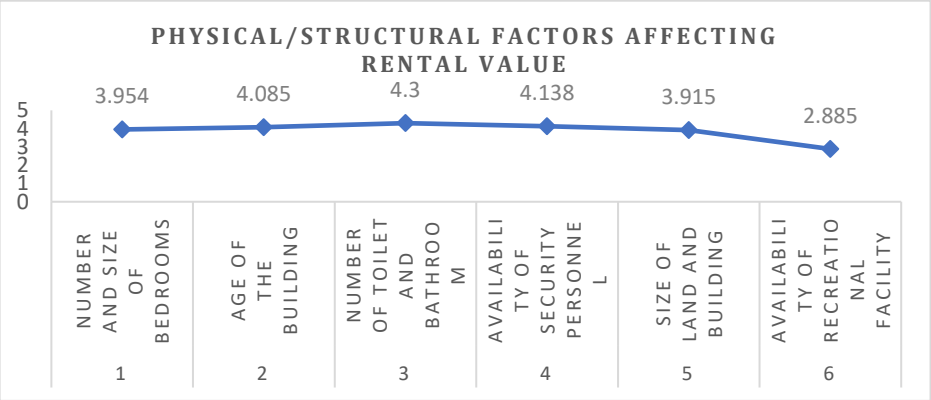

Figure 2: Physical/ Structural Factors Responsible for Rental Variation

Analysis of physical/structural factors affecting residential property rental values showed that the number of toilets and bathrooms indicated by a relative importance index of 4.300 on the RII scale is the most important factor affecting value. This is closely followed by the Age of the Building an RII of 4.085 as well as the size of land and building with a RII of 3.954. Moreover, the availability of security personnel and recreational facilities has the minimum RII of 3.915 and 2.885 respectively meaning they have less influence on residential property value in the study area.

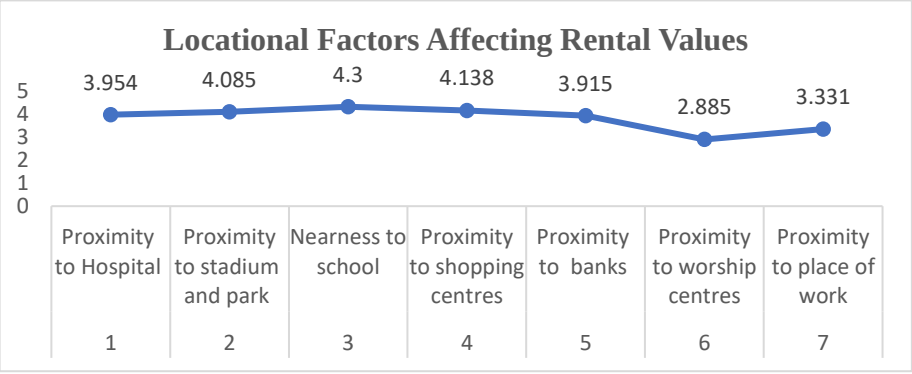

Figure 3: Locational Factors Responsible for Rental Variation

The analysis showed that proximity or nearness to school whether tertiary or secondary ranked highest among the listed locational factors affecting property value. This is closely followed by nearness to shopping centres and markets while nearness to the banks raked lowest on the relative importance index scale. It would be noted that nearness to the place of work is ranked higher in the RII scale than nearness to worship centres and this is because there are a lot of civil servants within or around the study area that reside in the neighbourhood.

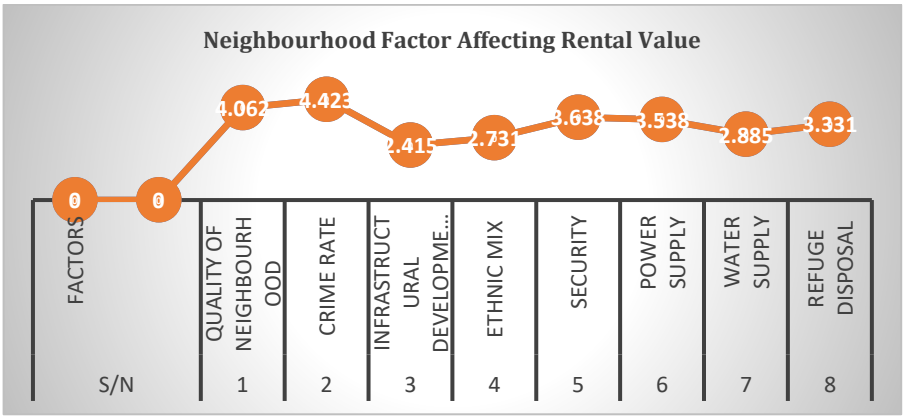

Figure 4: Neighbourhood Factors Responsible for Rental Variation

Analysis of responses about neighbourhood factors affecting residential property value revealed that the crime rate with an RII of 4.423 is the most important neighbourhood factor influencing property values followed by the quality of the neighbourhood (Estate plan and quality designs) with an RII of 4.062. Ethnic mix and owners/renters mix, infrastructural development are of less influence on property values when compared to others in this category. Most residents of the Estate are attracted to the security of the area not only because of the level of infrastructure development with RII of 2.415 such as road and drainages as well as good estate plans and quality designs.

Table 1: Dominant Factors Influencing Rental Variation in the Study Area

S/N	Name of Neighbourhood	Factors Influencing property values in the study area
1	Tudun-Fulani	Number of toilets and bathrooms, number of bedrooms, condition of the building, direct access to tarred road, quality of neighbourhood and size of the building.
2	Bosso Town	Presence of tertiary institutions, banks, public offices, etc., condition of the building, and size of the building
3	Bosso Estate	Quality of neighbourhood, number of bedrooms, and size of the building
4	Jikpan	Presence of tertiary institutions, banks, public offices, etc., condition of the building and number of bedrooms.
5	GRA	Direct access to tarred road, number of bedrooms and size of the building.
6	F-layout	Direct access to tarred road, size of the building, and quality of neighbourhood.
7	Dutsen Kura	Number of bedrooms, condition of the building and number of toilets and bathrooms.
8	Fadikpe	Number of bedrooms, condition of the building and number of toilets and bathrooms.
9	Maitumbi	Condition of the building, size of the building and direct access to tarred road.
10	Tayi village	Quality of neighbourhood, direct access to tarred road, stable electricity supply, and presence of tertiary institutions, banks, public offices, etc.
11	Kpakungu	Number of bedrooms, number of toilets and bathrooms and condition of the building.
12	Sauka-kahuta	Condition of the building, number of bedrooms and size of the building.

13	Tunga	Quality of neighbourhood, condition of the building and number of bedrooms.
14	Shango	Number of bedrooms, condition of the building, adequate water supply, number of toilets and bedrooms and size of the building.
15	Chanchaga	Adequate water supply, quality of neighbourhood and condition of the building.

Table 1 indicates the dominant factors common to all the fifteen(15) locations studied, and these factors are; the number of bedrooms, number of toilets and bathrooms, size of the buildings, condition of the buildings, quality of neighbourhood and direct access to tarred roads were found to be ranked uppermost while other factors such as proximity to recreational facilities, availability of day and night watch security, stable electricity among others played a significant role in the choice of residential accommodation but not as much as the other factors identified as the uppermost.

5. Conclusion

In conclusion, the research indicates that there is variation in residential property rental values in Minna, Nigeria. These variations are attributed primarily to factors that determine residential property rental values of which the condition of the building, size of the building, number of bedrooms, number of toilets and bathrooms, quality of the neighbourhood, presence of tertiary institutions, banks and public offices proved to be the dominants factors. The study also indicates that the various factors relating to the physical, location and neighbourhood characteristics of residential property which determine the rental values of residential property influence tenants' choice of accommodation in the various neighbourhoods across the study area and consequently determine variation in residential property rental values in the study area.

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Systematic Literature Review on Application of Cashew Nut Shell Liquid to Construction Industry

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Abstract

Cashew Nut Shell Liquid (CNSL) is a versatile material that can be easily adaptable to all areas of science. It can be easily polymerized and having a phenolic ability makes its application very easy. Alas, few have researched it in the construction industry in African countries. After a systematic literature review, and using the Scopus database, it was discovered that 33 articles have been published from all disciplines on CNSL from Africa since 1940 and only 11 articles have something related to construction (though not in Built Environment) in 84 years. Indians have published over 381 articles and Nigerians have published only 25 articles over the years despite the abundant availability of this raw material in Nigeria. This review concluded by showing this wide research gap in Nigeria Africa and the construction field.

Keywords: Anacardic Acid, Cardanol, Cardol, CNSL

1. Introduction

Cashew nutshell liquid is a by-product of the cashew nut processing industry and has been used in virtually all areas of science. Cashew nut shell liquid is a reddish brown viscous liquid located within the honeycomb structure or spongy- mesocarp of the shell of cashew nuts obtained from a cashew tree called botanically Anacardium occidentale Linn. It is an alkyl phenolic liquid and obtained as a reddish brown, viscous, vesicant liquid (Lochab, *et. al.,* 2014). Due to the phenolic nature and different degrees of unsaturation in the side chain, cashew nut shell liquid offers a reaction place at both the aromatic ring and side chain, which makes it a suitable raw material for a variety of reactions (Mahanwar & Kale, 1996). There are four major constituents of cashew nut shell liquid, they are; Anacardic acid (6-pentadecenyl salicylic acid), Cardanol (3-pentadecenyl phenol), Cardol (5-pentadecenylresorcinol) and 2 methyl Cardol (2-methyl, 5-pentadecenyl resorcinol) (Lubi & Tachil, 2000; Bhunia, *et. al.,* 2000). However, Taiwo (2015) said it contains some minor compounds. According to the data published by the Food and Agriculture Organisation of the United Nations (FAO) in the year 2000 on cashew production in Africa, from 1961 to 2000, Nigeria reached a record high of 176,000 tonnes of cashew production in the year 2000, and second highest producer in the world behind only India (Jason, 2004); four other African countries made the first ten. They are; Guinea, Benin, Cote d'Ivoire, and Tanzania.

In another publication by the Food and Agriculture Organisation of the United Nations statistic Department (FAOSTAT) on cashew production in some African Countries, between the years 2000 to 2012, Nigeria became the highest producer in Africa with about 836,500 tons per year and overtaken India in the world production of cashew and maintained the second highest producer globally, behind Vietnam. However, this figure contradicts the production figure published by Africa Cashew Alliance (ACA) and Red River Food Incorporated, published in 2012, where Nigeria stood at 90,000 and 85,000 tonnes per year respectively, maintaining 7th position in the world production. (Adeigbe, *et. al.,* 2015). Despite this information and the abundant availability of this raw material in Africa and most especially Nigeria, there is still very little research and application of this raw material in Nigeria and Africa at large.

Further, several areas of science have used this raw material. For instance, Kanehashi *et al.,* (2015) researched the anti-bacterial activity of cashew nut shell liquid. The effect of each degree of unsaturation of anarchic acid content of cashew nut shell liquid on the anti-oxidant, anti- fungal, antichlorine sterase activities and toxicity had been investigated by Morais *et. al.*, (2017). Moreira *et. al.,* (2018) studied cardanol methacrylate-epoxy synthesized from

cashew nutshell liquid by epoxidation and said it is suitable for acid-resistant treatment for dentine hypersensitivity. Adeleke *et al.*, (2021) carried out a study on the anti-pesticide activity of cashew nutshell liquid. In Engineering, cardanol from cashew nut shell liquid was synthesized to obtain a phosphorylated compound which had been reported by Lomonac *et. al.,* (2012) as a compound that has anti-oxidant ability to increase the thermal instability of biodiesel. The study by Mwangi *et.al.,* (2013) showed that cashew nutshell liquid has a better fuel based on energy when compared with conventional fuel from liquid and solid content. Further, distilled technical cashew nutshell liquid was used as biodiesel and an additive to stabilize triglyceride biofuel in diesel (Sanjeeva *et. al.,* 2014). Trans esterification process of cashew nutshell liquid to obtain a biofuel has also been reported (Baskar *et. al.,* 2020) and Suresh *et. al.,* (2020) researched the performance and emission characteristics of diesel engines consisting of cardanol-based hybrid biodiesel blends.

In Construction, little research has been done compared to other areas of science. Bhatia & Patel (2016) investigated the effect of cashew nutshell liquid used as an admixture with fly ash as a partial replacement of cement. Mansuri et. al., (2017) investigated the corrosive resistance of reinforced concrete having cashew nutshell liquid resin to concrete showing good corrosion resistance. Cashew nutshell liquid resin as an admixture to composite fibre has been reported by Kumar & Babu (2019). All these researches were done by non-African countries despite the availability of the raw material in Africa and if done in Africa it is not in construction. Therefore, this article will expose a wide gap in research on cashew nutshell liquid in construction most especially in Africa using a systematic literature review.

2. Review Methodology

A systematic review involves the use of literature as a facilitator by answering some salient questions and identifying research gaps and areas where further researches are required or proposing a new method (Khan *et. al.* 2020). In this review, an attempt is made to evaluate the amount of literature on cashew nutshell liquid available on the Scopus database, identify the number of journals published in the construction industry and other disciplines, and the amount published by Africans and Nigerians in Particular. In other to achieve the aim of the review, a literature review was done from the year 1940 to 2024, 1940 was the first year when cashew nutshell liquid was published to this current year. However, for easy analysis, the first 30 years were divided into decades while the remaining years were taken as one. PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) (Chen & Zheng 2019) was used to evaluate the qualitative review while bibliometric analysis was used for the quantitative review. The subject area where cashew nutshell liquid was used was examined and how African countries have been studying this product from the anacardeae family. There are four stages of PRISMA, they are; identification, screening, eligibility and inclusion as listed in figure 1. The information obtained will be our basis for qualitative review where inference was made.

2.1 Literature Search

Literature published on cashew nutshell liquid was extracted from the Scopus database (this includes all published materials in all journals in the Scopus database) and screened until the volume was reduced for easy reference. As of 05/7/2024, the keyword "Cashew Nutshell liquid" was searched on the Scopus database, and 881 documents popped up in the Scopus database relating to the search criteria without a filter. The search was reduced to decades as explained earlier (Table 1). This was it is until 1994 when publication on the subject matter started increasing in geometry until now. When the search was filtered, from 2014-2024, about 516 documents appeared, 2004-2014, 251 documents appeared, from 1994-2004, 96 documents appeared and from 1994 below, 72 documents were published on cashew nutshell liquid making a total of 881 documents

Table 1: Breakdown of documents retrieve from scopus data base

S/N	Years	Number of Documents Received
1	2014-2024	516
2	2004-2014	251
3	1994-2004	96
4	1994 below	72
	Total	**881**

2.2 Identification

Typing all the above search criteria at once will give no document. This is understandable because the Scopus database is a computer database using artificial intelligence, it was looking for information on documents having all

the search criteria. Therefore, the search criteria were narrowed down to only “cashew nutshell liquid”. Using this search criterion, 881 documents were retrieved.

2.3 Screening

The retrieved documents were thoroughly screened to enhance the quality of this literature review with the aid of the Scopus database. The documents were screened only for articles, conferences, reviews, letters, and book chapters. 118 documents were removed and 763 documents were retrieved. A further screening was done on the languages. Languages such as Spanish, Portuguese, French, German, and Chinese were removed. This is because the author can only under English. 737 documents were retrieved leading to further removal of 26 documents.

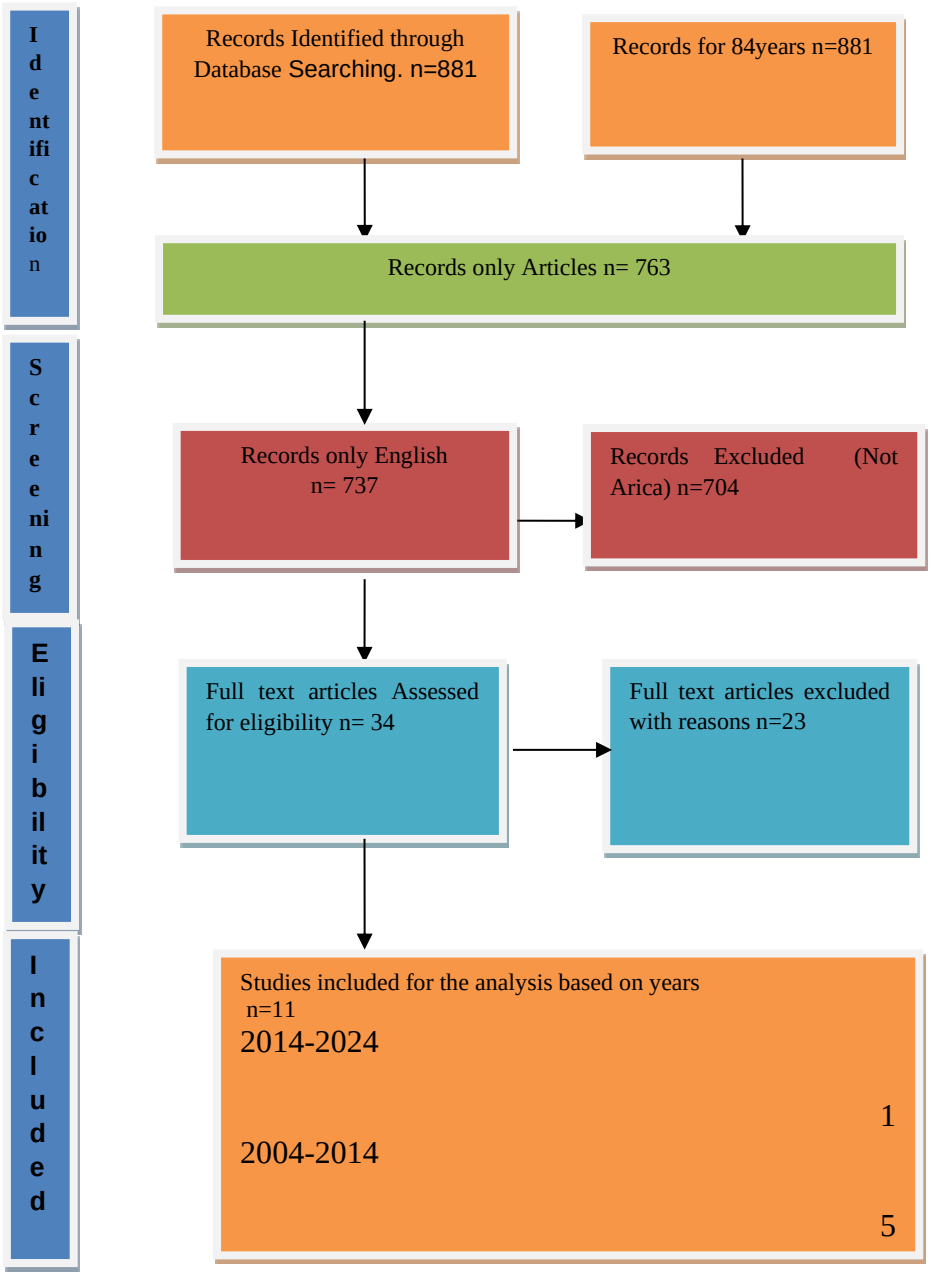

Figure 1: PRISMA 2009 flow Diagram (Chen & Zheng 2019)

2.4 Eligibility

The seven hundred and thirty-seven documents retrieved after screening are still too much requiring further trimming. The countries of publication were also screened since only African countries are the aim of this systematic

literature review. Countries removed were India, Brazil, the United States of America, the United Kingdom, China, France, Italy, Japan, Canada, and Colombia. This led to the elimination of 704 documents (Figure 1), and 33 articles were retrieved (Table 2). In addition, some of these documents were not in construction, therefore documents retrieved were imported to Excel and further screening was done to assess the eligibility criterion. This led to the removal of 23 documents.

2.5 Inclusion

Eleven (11) articles were included in this literature review for further analysis. These Eleven (11) included were break down in the Table 3.

Table 2: Articless Eligible for analysis

Years	Articles Eligible
2014-2024	18
2004-2014	9
1994-2004	5
1994 below	1
Total	**33**

Table 3: Articless Included for analysis

Years	Articles Included
2014-2024	1
2004-2014	5
1994-2004	4
1994 below	1
Total	**11**

3. Result and discussion

3.1 Articles on CNSL based on countries

After qualitative analysis using PRISMA, 11 kinds of literature were published on construction-related material where CNSL was used as raw material (Figure 2). The breakdown showed that only three African countries had published on CNSL as construction material. Nigerians have published more articles among the three African countries with six (6) articles, four (4) articles, and one (1) from Ethiopia (Figure 3). The breakdown showed that Nigerians have published only six (6) articles from 1940 to 2024 according to the data available on the Scopus database. This is very small when compared to countries like India. According to Figure 3, Nigerians have published more articles on CNSL among the African countries. Nigerians have published twenty-five articles (25) between the same periods. A total of 60 articles have been published so far on CNSL by African countries. However, when compared to the publications on cashew nutshell liquid from around the world between these years (Figure 4), Nigeria stood in 9th position and was the only African country on the list. Despite the FAO data (Jason, 2004) that showed African countries have five countries among the first ten highest producers of this natural material. This shows the level we value some natural resources abundantly available to us.

Interesting to know that Indians have published 381 articles within this period and Brazilians have published 190 articles available on the Scopus database. India and Brazil were among the leading producers but Nigeria is ahead of Brazil as the leading producer of cashews. The indices showed from 1940 to 2024, Indians have published over 1500% journals more than Nigerians while Brazilians have published 760% articles more. Figures and tables should be originals or sharp prints; they must be well readable without enlarging with the zoom. Illustrations will be in colour in the electronic version and black and white in case of printed version. The authors must make sure that the figures are legible and understandable in greyscale mode. Avoid referencing your text to coloured items in the figures. All these means will be lost after the printing and will create misunderstanding to the reader.

Figures and tables should preferably be placed either at the top or at the bottom of the page. Please do not render tables as pictures, not use small font size in the tables. Please do not use too small font sizes in the pictures. These reduce the legibility severely, resulting in poor reader experience.

3.2 Citations on CNSL

Bisanda (1993) from Tanzania, the first author from Africa to publish on the use of CNSL in producing construction material has the highest citation with 41 citations (Figure 5). Other authors have less than 10 citations. The article by Tiamiyu & Ibitoye (2012) on the Effect of clay addition on service properties of a developed OPF-CNSL-

formaldehyde roofing material from Nigeria came joint second with Mubofu *et. al.* (2011) from Tanzania with their article on 'The activity of invertase immobilized on cashew nut shell liquid-templated large pore silica hybrids'.

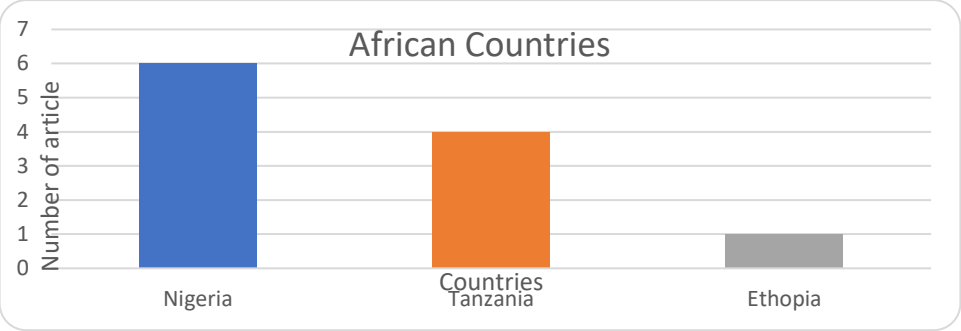

Figure 2: Articles where CNSL was used as construction material from africa

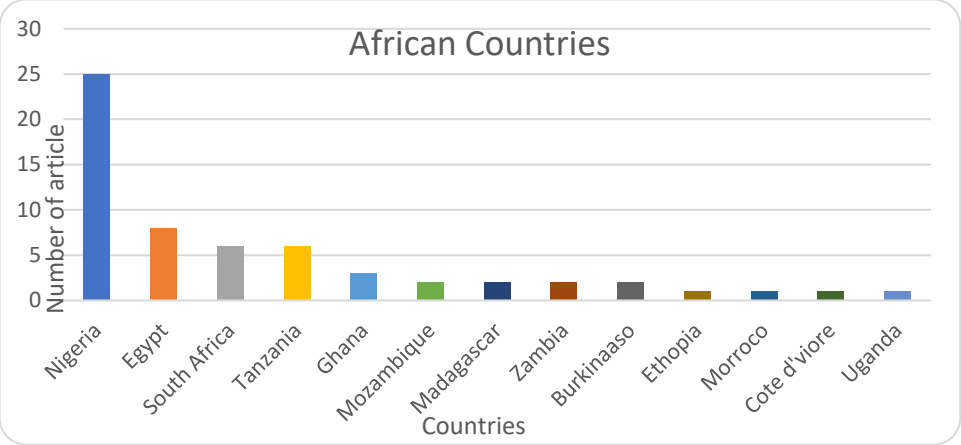

Figure 3: Articles on CNSL from africa

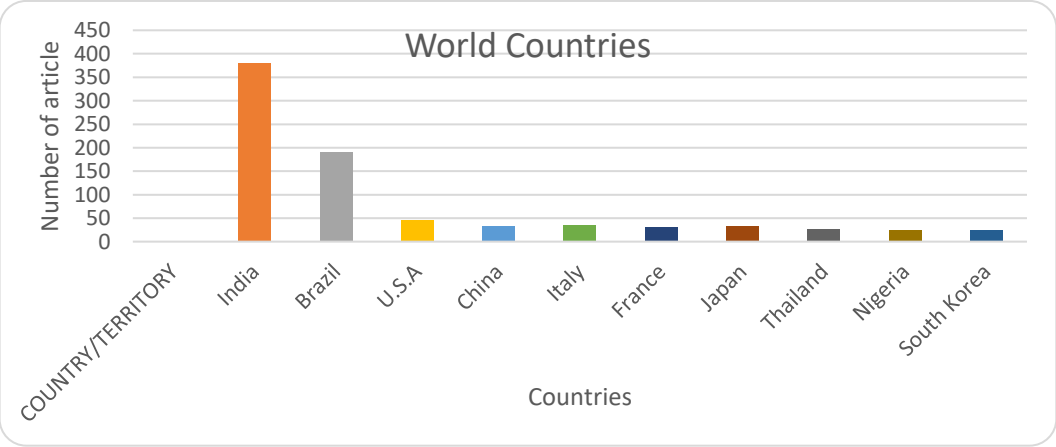

Figure 4: Articles on CNSL from countries in the world

This showed the level of visibility of African authors. However, among the authors that has published on CNSL from Africa, the duo of Akinhanmi *et. al.* (2008) and Sawadogo *et. al.* (2018) from Nigeria and Burkina Faso has the first and second position with 92 and 80 citations respectively (Figure 6).

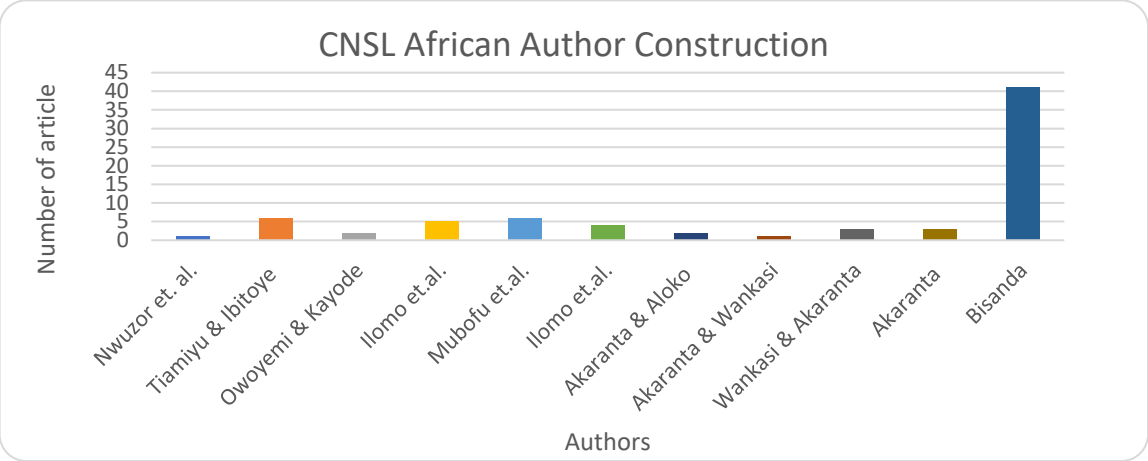

Figure 5: Articles on CNSL as Construction Material from African Authors

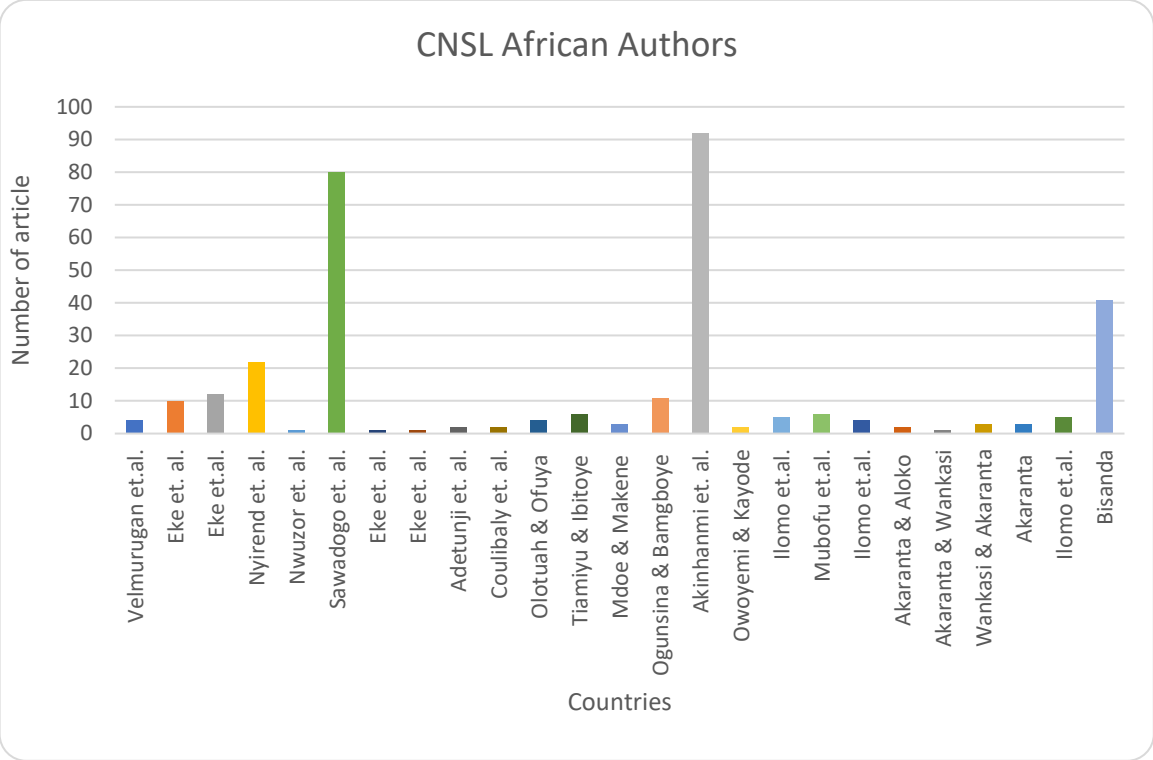

Figure 6: Articles on CNSL from African Authors

3.3 Publications by Different Subject Areas

The subject area that has published more articles on CNSL in Africa is chemistry followed by Engineering (not Construction), although among this some have used CNSL in the production of construction material. Physics, Computer Science, and Wood have published at least one (1) article each about 2% of the African publication on CNSL (Figure 7). In the world, Chemistry and Materials subjects area have published more, occupying the first and second position, with 363 and 361 articles respectively contributing about 21% of each of the publications on cashew nutshell liquid (Figure 8).

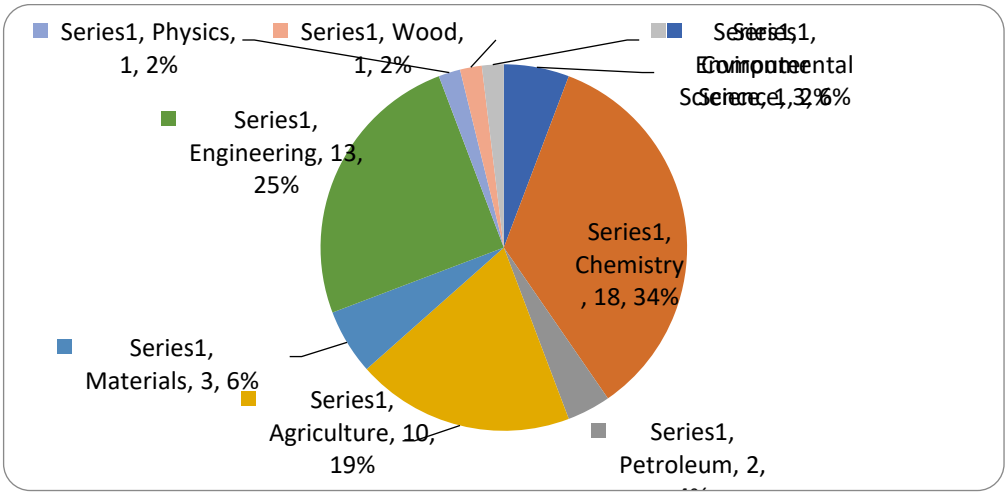

Figure 7: Articles on CNSL by subject area from africa

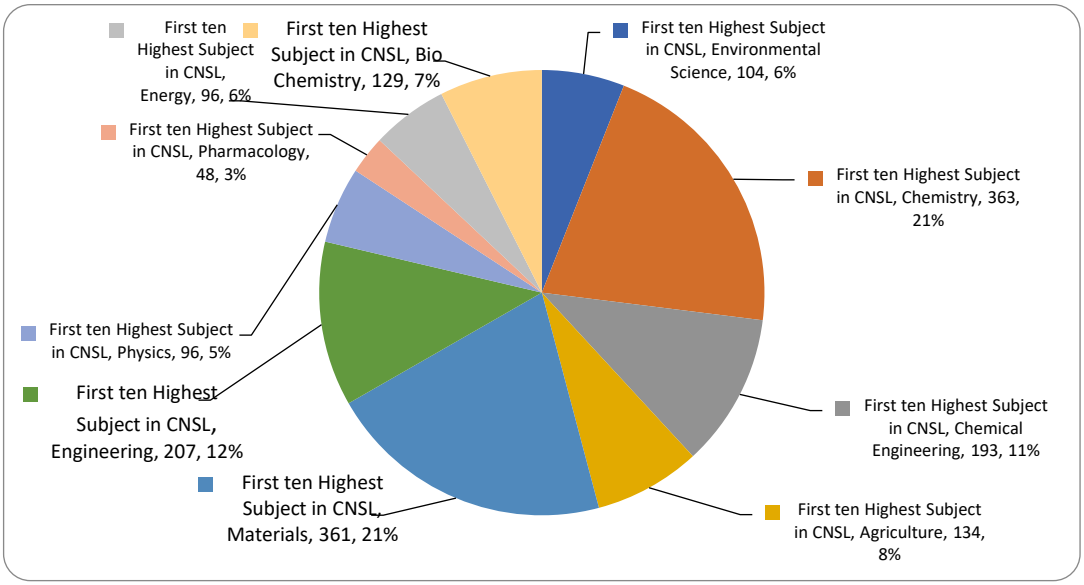

Figure 8: Articles on CNSL by subject area

4. Conclusions

In Conclusion, after a systematic literature review of articles in the Scopus database on cashew nutshell liquid, Nigerians have published 25 times, in Africa 33 times, and globally 881 times. In construction-related fields, only 11 articles have been published in 84 years. This article has evidently shown the underutilization of Cashew Nut Shell Liquid in Nigeria, Africa, and the construction industry. This is based on research output on this construction material. The number of research articles on a material determines how well a material is utilized. Nigeria and Africa have utilized this material 2.5% and 3.75% times when compared to the world. This is a wide gap requiring more interest.

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Assessment of Fire Safety Measures for a Student Hostel: A Review

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Abstract

Student hostels are high-occupancy environments that present unique fire safety challenges, making it crucial to assess and improve fire protection measures to ensure occupant safety. Despite existing regulations, incidents of fire in student accommodations persist, often resulting in significant risks to life and property. This systematic review aims to evaluate current fire safety measures implemented in student hostels, identify gaps in existing practices, and recommend enhancements to reduce fire-related risks.

A systematic literature search was conducted across multiple databases, including PubMed, Scopus, and Google Scholar, focusing on studies published between 2000 and 2024. The search criteria included keywords such as "fire safety," "student accommodation," "fire prevention," and "emergency preparedness." Articles were selected based on relevance, methodological quality, and their focus on fire safety protocols, evacuation strategies, detection systems, and occupant behavior. Data were synthesized using thematic analysis, with findings categorized into prevention, detection, response, and occupant preparedness measures. The results indicate that while fire detection systems and emergency response plans are typically in place, significant gaps exist in occupant training, maintenance of fire safety equipment, and the integration of modern fire suppression technologies. Additionally, a lack of awareness and preparedness among students contributes to increased vulnerability during fire incidents. This review recommends a comprehensive approach to fire safety that includes regular fire drills, enhanced training programs for occupants, improved maintenance protocols, and the adoption of advanced technologies such as smart fire detection systems. Implementing these measures can significantly reduce fire risks in student hostels and improve overall safety outcomes.

Keywords: Assessment, Fire Safety Measures, Hostel, Student , Systematic Review

1. Introduction

Fire safety is a critical concern in residential buildings, particularly in student hostels where a large number of individuals live in close proximity. The hazards connected to fire accidents in such hotels might be terrible, maybe resulting in death, injuries, or major property damage (Cvetković *et al*., 2022). The limited and often packed character of student hostels combined with tenants' lack of knowledge of safety procedures increases the susceptibility to fire-related risks (Glauberman, 2018). Recent fire events in student residences all over different nations have highlighted the necessity of strong fire safety precautions and exposed areas of weakness in current fire safety standards. Globally, residential building fire safety rules seek to lower fire hazards by means of preventative and protective actions. Fire alarms, smoke detectors, sprinkler systems, fire extinguishers, and well designated emergency exits (Yatim, *et al.* 2020) are among these. Minimising the effect of fires also depends critically on regular fire safety exercises, enough signs, and fire-resistant materials (Kodur *et al.,* 2020). Notwithstanding these rules, there are typically differences in fire safety compliance across student hostels that might be related to building age, available funds, or management methods (Agyekum *et al.,* 2016). A significant gap in the literature is the lack of attention to regional disparities in fire safety regulations and practices. Fire safety standards can vary widely by region, influenced by local regulations, building codes, and resource availability(Obida and Aminu, 2023). For instance, hostels in countries with stringent fire safety codes may still experience fire incidents due to non-compliance, while those in regions with less stringent regulations may lack basic safety infrastructure altogether (Abass *et al.,* 2022). This disparity indicates a need for region-specific analyses to identify best practices and adapt fire safety strategies according to local contexts.The problem is further compounded by inconsistent occupant training and limited integration of advanced fire safety technologies, such as smart fire detection systems and automated suppression devices. The existing literature often fails to account for how these technologies could be applied in the context of student accommodations. Additionally, there is a lack of comprehensive studies that assess the effectiveness of fire safety education programs in improving occupant preparedness, an area critical to reducing

the impact of fires when they do occur (Asare ,2022 ; Oyekola 2021, Bamigbola, 2020). This review addresses these gaps by systematically examining fire safety measures specifically for student hostels, identifying regional disparities in fire safety practices, and evaluating the role of occupant preparedness in mitigating fire risks. The findings aim to provide actionable recommendations for improving fire safety in student accommodations, ultimately enhancing the protection of life and property. Therefore, a comprehensive study is required to evaluate the efficiency of present fire safety policies in student hostels and to point out areas needing development. With an aim of assessing their suitability, efficacy, and conformity with accepted criteria, this research aims to systematically evaluate the body of current literature on fire safety precautions in student hostels. The review is to provide a thorough evaluation that may guide policy and improve fire safety procedures in student housing by means of analysis of research from several areas and comparison of many safety measures. This work is organised as follows: With an eye on student hostels, Section 2 will go over pertinent material on fire safety precautions in residential structures. Section 3 will go over the search technique and criteria for choosing papers utilised in the systematic review. Section 4 will show the outcomes of the review along with common safety precautions, areas of implementation lacking, limits in current research, and will address the consequences. Section 6 will lastly conclude the work with an overview of important results and recommendations for further studies

2. Literature Review

2.1 Fire Safety Measures in Residential Buildings

Preventing fire outbreaks, reducing their effect, and guaranteeing occupant safety depend on residential building fire safety policies (Zhang, 2023). The most often used devices are establishing early warning systems for inhabitants, such as fire alarms and smoke detectors. By warning residents to escape quickly, these devices may greatly lower mortality (Shokouhi *et al.,* 2019). Additional crucial steps include fire extinguishers, which trained people may use to put out minor flames, and automated sprinkler systems, which assist to confine fires before they spread. Essential parts of fire safety are emergency exits and evacuation strategies. Clear signs pointing to accessible evacuation routes and emergency exits help citizens find safety during a fire (Cvetković *et al.,* 2022). Apart from that, frequent fire drills are very essential for getting inhabitants ready for an emergency as they familiarise them with evacuation protocols and assist to spot any escape path obstructions.

2.2 Previous Studies on Fire Safety in Hostels

Several studies have emphasised the relevance of fire safety in residential settings, with a special emphasis on high-occupancy structures like student hostels (Olawoyin, 2018; Wardani *et al.,* 2018; Adama *et al.* 2019; Heinbach and Aziz, 2022; Zhang, 2023). According to research, many student accommodations encounter issues due to out-of-date fire safety equipment, inadequate maintenance of existing systems, and insufficient resident training. For example, a research done in the United Kingdom discovered that over 30% of assessed student hostels lacked proper fire detection systems, and many inhabitants were ignorant of evacuation procedures owing to the lack of frequent fire drills (Onyekwere *et al*., 2024). According to research conducted in developing countries, economic restrictions and insufficient enforcement of fire safety standards often impede the adoption of fire safety measures in student hostels. For example, study in Nigeria found that many student hostels lacked essential fire safety equipment such as fire extinguishers and alarms, increasing the danger of a fire (Osunsanmi *et al*., 2020). In contrast, nations such as Japan and the United States place a greater focus on complete fire safety measures, including the use of sophisticated technology such as heat and flame detection systems, which provide a better degree of protection (Huo *et al*. 2016).

2.3 Regulations and Standards

Fire safety regulations for residential buildings, including student hostels, differ greatly across regions, but the majority are guided by international standards established by organisations such as the National Fire Protection Association (NFPA) and the International Organisation for Standardisation (ISO) (Meacham and McNamee, 2020). These regulations generally apply to the design and installation of fire detection and suppression systems, emergency lights, fire doors, and evacuation protocols. In Europe, the European Standard EN 54 establishes standards for fire detection and alarm systems, guaranteeing that they are dependable and effective in an emergency (Asigiri *et al.,* 2021). Similarly, the United States adheres to the NFPA rules, which require the installation of fire alarms and sprinklers in dorms and other high-occupancy structures. While these laws provide a framework for guaranteeing fire safety, compliance is not always assured, particularly in older buildings or privately operated hostels where replacing infrastructure may be prohibitively expensive (Asigiri *et al.,* 2021).

2.4 Gaps in Current Fire Safety Measures

Despite the presence of regulations that are many studies have shown gaps in the present fire safety procedures in student dormitories. Fire alarms and sprinklers are not always adequately maintained, which may cause system failures during crises. Furthermore, a lack of fire safety education among students is a reoccurring problem, with many inhabitants uninformed of the proper use of fire extinguishers or the placement of emergency exits. Another major source of worry is the difference in fire safety procedures between older and contemporary hostels. Older buildings may not have been designed with contemporary fire safety requirements in mind, necessitating significant renovation to meet current norms. In contrast, newly constructed or recently renovated hostels are often outfitted with cutting-edge fire safety technology and follow more strictly to international safety regulations.

2.5 Use of Advanced Fire Safety Technologies

Recent advances in fire prevention technologies have showed promise in improving the security of student housing. Modern hostels are incorporating innovations such as intelligent fire alarm systems that employ algorithms to discern between false alarms and true fires, as well as thermal imaging cameras that detect heat buildup before a fire begins (Mróz *et al*., 2016). However, these technologies are not yet widely used owing to their high cost and a lack of understanding among hostel managers. The research demonstrates the need for more thorough and standardised methods to fire safety in student dormitories. While legislation and technology exist, their uneven implementation across areas and kinds of lodging demonstrates the need for systematic changes (Heinbach and Aziz, 2023). This systematic research attempts to close the gap by evaluating the existing level of fire safety precautions in student hostels and making suggestions for improving safety procedures.

3. Methods

A systmatic review was chosen as the methodological approach to comprehensively assess fire safety measures in student hostels. This approach enables the collection, synthesis, and evaluation of existing research on the topic in a structured and reproducible manner. The goal is to identify the effectiveness, strengths, and limitations of current fire safety practices in student accommodations, providing a well-rounded understanding that can inform policy and practical improvements.

3.1 Inclusion and Exclusion Criteria

To ensure that the review focused on relevant and high-quality studies, the following criteria were established for the selection of articles:

Inclusion Criteria:

1. Studies published within the last 24 years to capture the most recent fire safety practices and standards.
2. Research focused on fire safety in residential buildings, specifically student hostels, dormitories, or similar high-occupancy accommodations.
3. Articles that assessed fire safety measures such as fire alarms, sprinklers, emergency exits, fire drills, and fire safety training.
4. Studies published in peer-reviewed journals or reputable conference proceedings.

Exclusion Criteria:

1. Studies not written in English, due to language limitations.
2. Research that focused on fire safety in non-residential settings (e.g., industrial or commercial buildings).
3. Articles without empirical data or practical assessments of fire safety measures.
4. Publications that only discussed fire safety regulations without evaluating their implementation or effectiveness.

3.2 Search Strategy

A systematic literature search was performed across databases such as PubMed, Scopus, and Google Scholar, targeting peer-reviewed articles published between 2000 and 2024. The decision to include studies from the last 24 years was based on the evolution of fire safety standards and technology over this period, which saw significant advancements in detection systems, suppression technologies, and emergency preparedness strategies. Including studies over this time frame allows for a comprehensive analysis of how fire safety measures in student hostels have evolved and identifies persisting gaps despite regulatory advancements.

The search utilized keywords such as "fire safety," "student accommodation," "fire prevention," "emergency preparedness," and "regional fire safety regulations." Articles were selected if they focused on fire safety measures

in student accommodations, addressed occupant training and preparedness, or discussed fire safety technologies and regulatory frameworks. Studies were excluded if they solely focused on general residential fire safety without specific implications for student hostels.

3.3 Thematic Analysis

Thematic analysis was used to synthesize the findings from the selected studies, with themes identified based on common aspects of fire safety measures. The analysis followed these steps:

1. **Data Extraction:** Information related to various fire safety measures (e.g., detection systems, suppression devices, emergency response strategies, and occupant training) was extracted from the selected articles. Each study was categorized by its geographical focus to facilitate regional comparisons.
2. **Theme Identification:** The extracted data were grouped into four main themes: fire prevention measures, detection systems, emergency response protocols, and occupant preparedness. These themes were chosen because they represent the critical components of an effective fire safety strategy.
3. **Regional Comparison:** For each theme, studies were compared across regions to identify disparities in fire safety measures. Detection systems (e.g., smoke detectors, heat sensors) and their coverage levels were compared to see if some regions had higher compliance or adopted more advanced technologies. The frequency and quality of fire drills and training programs were also analyzed to determine variations in occupant preparedness across different countries.
4. **Evaluation of Effectiveness:** Each identified fire safety measure was assessed in terms of its reported effectiveness in preventing incidents or reducing casualties. Factors such as compliance with local fire codes, availability of resources, and occupant engagement were considered. This analysis aimed to uncover which measures were more successful in certain regions and why.

3.4 Justification for Regional Analysis

Regional disparities in fire safety measures can significantly affect the overall safety of student hostels. For example, hostels in countries with advanced fire safety regulations might exhibit higher levels of compliance, but may still face challenges in occupant preparedness due to cultural factors or turnover rates. Conversely, regions with less stringent fire safety regulations might lack basic detection and suppression technologies, leading to increased risks. By comparing fire safety measures across regions, the review seeks to identify not only best practices but also adaptable strategies that account for local contexts. This approach provides a more nuanced understanding of fire safety in student accommodations and facilitates tailored recommendations for enhancing protection measures.

4. Results and discussion

4.1 Overview of Selected Studies

The systematic review included a total of 35 studies that met the inclusion criteria, published between 2010 and 2024. The studies were geographically diverse, covering fire safety measures in student hostels from various regions, including North America (25%), Europe (30%), Asia (20%), Africa (15%), and other regions (10%). The types of accommodations studied included university dormitories, private hostels, and boarding schools, with a range of building ages from newly constructed to over 50 years old. The selected studies assessed different aspects of fire safety, such as fire detection systems, suppression equipment, emergency evacuation procedures, fire drills, and fire safety training. While some studies provided comprehensive assessments of all these measures, others focused specifically on one or two aspects. This diversity of focus allowed for a broad evaluation of fire safety measures in various contexts.

4.2 Common Fire Safety Measures Implemented

The review identified several fire safety measures commonly implemented in student hostels. These measures could be grouped into four main categories: fire detection, fire suppression, emergency evacuation, and resident education.

1. Fire Detection Systems

Almost all studies found smoke detectors and fire alarms in student dormitories, with various degrees of coverage. For example, in Europe and North America, most hostels have fire detection systems that cover individual rooms, corridors, and communal spaces. However, research from Africa and parts of Asia found gaps in the installation of these systems, with some hostels having alarms in communal areas but not in individual rooms. While not as widespread as smoke detectors, some contemporary hostels, notably in the United States and Japan, include heat detection systems that trigger when the temperature surpasses a set level. These devices were often used in combination with smoke detectors to decrease false alerts.

2. Fire Suppression Equipment

Sprinkler systems were discovered to be more widespread in hostels constructed or rebuilt in the previous 24 years, especially in nations with stringent fire safety standards such as the United States, Canada, and the United Kingdom. Older hostels in underdeveloped countries sometimes lacked such systems owing to the expensive installation and maintenance expenses. All studies indicated the availability of fire extinguishers, although their adequacy and maintenance varied. Some investigations found that, although extinguishers were there, their accessibility was restricted owing to poor placement or obstacles, and in some instances, they had not been tested on a regular basis for functioning.

3. Emergency Evacuation Procedures

The research discovered that emergency exits were usually present but were not always well marked or maintained. Several investigations, especially those done in older hostels, found problems with obstructed exits, confusing signs, and small stairwells that might impede escape during a fire. Regular fire drills were more usual at hostels located in countries with strict fire safety rules, such as the United States, the United Kingdom, or Australia. However, in many hostels across Asia and Africa, fire drills were sporadic or nonexistent, and students were often unaware with evacuation methods.

4. Fire Safety Education and Training

According to the analysis, only around 40% of the hostels evaluated offered official fire safety training to its inhabitants. Hostels that did provide training often did it as part of the new student orientation or during yearly safety weeks. According to studies conducted in developing nations, there is a dearth of fire safety education programs, leaving many pupils unprepared for emergency scenarios. Some hostels established fire safety awareness initiatives, which included the distribution of instructional leaflets and the placement of fire safety instructions in rooms. However, the success of these programs varied since not all pupils read or recalled the material presented.

4.1 Gaps and Limitations in Fire Safety Measures

The review identified several gaps and limitations in the fire safety measures implemented in student hostels:

Fire safety procedures varied significantly among locations and kinds of lodgings. Comprehensive fire safety measures were more consistently implemented in high-income nations, but financial limits and regulatory enforcement concerns often hampered implementation in low-income countries. Many investigations found that the fire detection and suppression technology in older dormitories was antiquated or badly maintained, decreasing its efficacy. Due to inadequate maintenance, alarms sometimes failed to activate during exercises. In hostels with proper fire safety equipment, a crucial gap emerged: tenants lacked fire safety instruction. This problem was most evident in hostels that did not hold regular fire drills, leaving inhabitants unable to react efficiently in the case of a fire. Several investigations found that emergency exits were obstructed or that evacuation paths were too narrow to handle huge crowds. This presents a considerable danger during evacuation, particularly in older buildings with small stairs or out-of-date architecture. The systematic research finds considerable differences in the fire safety measures applied in student dormitories among regions. Higher-income nations, such as the United States, the United Kingdom, and Japan, implemented more extensive fire safety measures, including the widespread use of smoke detectors, sprinklers, and frequent fire drills. This contrasts significantly with hostels in low-income areas, where fire safety precautions are sometimes uneven, owing mostly to budget restrictions, a lack of regulation, and older building infrastructures that do not meet current safety requirements. The analysis also found that newer hostels, regardless of geographic location, tended to include more modern fire safety measures, such as integrated smoke and heat detection systems and automatic sprinklers. These modern lodgings were more likely to meet or surpass international fire safety regulations, as contrast to older hostels where retrofitting may be prohibitively expensive. In many situations, fire safety renovations for older structures were confined to simple measures such as adding fire extinguishers, which may not be enough in more severe fire scenarios.

4.2 Implications for Policy and Practice

The findings from this review underscore the need for more uniform fire safety regulations that account for the unique risks associated with student hostels. Many hostels still do not meet minimum fire safety standards, particularly in regions with less stringent regulatory environments. To address this, governments and regulatory bodies could:

1. Uniform fire safety regulations should be enforced for all student hostels, regardless of the building's age. This may include mandatory installation of fire detection systems, regular maintenance of fire suppression equipment, and updating evacuation routes to meet modern safety standards.

2. Retrofitting older buildings can be costly, and some hostel operators may lack the resources to implement necessary safety improvements. Subsidies, grants, or low-interest loans could be offered to encourage compliance with fire safety regulations.
3. Even in hostels equipped with the latest fire safety technology, residents may be unprepared to act during a fire if they lack proper training. Policies requiring regular fire drills and fire safety education programs can significantly improve residents' preparedness for emergencies.

5. Conclusions

This systematic review reveals significant disparities in the implementation and effectiveness of fire safety measures across student hostels worldwide. While advancements in fire detection systems and emergency response strategies are evident in many regions, there remain considerable gaps in occupant training, equipment maintenance, and the adoption of modern fire safety technologies. The findings underscore the need for a more comprehensive and uniform approach to fire safety that goes beyond compliance with minimum regulatory standards to address the unique risks posed by high-occupancy student accommodations. There is considerable variation in the types of detection systems used, ranging from basic smoke alarms to sophisticated smart detectors and automated suppression systems. Regions with advanced regulations often mandate higher levels of coverage and more robust equipment, yet these technologies are not uniformly adopted, especially in developing regions. Occupant preparedness is a critical yet underdeveloped area of fire safety in student hostels. The review highlights a general lack of regular fire drills and comprehensive fire safety training programs, particularly in countries where fire regulations are less stringent. This increases the vulnerability of students during fire incidents, given their varied levels of awareness and preparedness. There are significant differences in fire safety practices across regions, reflecting disparities in regulatory standards, resource availability, and cultural attitudes toward fire safety. Countries with stringent regulations tend to have better-equipped hostels, but compliance issues persist. In contrast, hostels in regions with less strict standards often lack basic fire safety infrastructure.

6. Recommendations

To enhance fire safety in student hostels, the following actionable recommendations are proposed for policymakers and hostel administrators:

1. Policymakers should work towards establishing global minimum standards for fire safety in student accommodations, similar to guidelines set by organizations such as the National Fire Protection Association (NFPA) or International Code Council (ICC). Standardized regulations could include mandatory installation of smoke detectors and fire extinguishers, routine safety inspections, and enforcement of fire-resistive building materials.
2. Hostel administrators should implement regular fire safety training and drills for students and staff, with an emphasis on practical evacuation procedures. Training programs should be culturally adapted to address different levels of fire safety awareness and should include instruction on using fire safety equipment.
3. Governments and hostel owners should encourage the adoption of smart fire detection and suppression systems that can provide real-time alerts and enable quicker response times. Investing in automated fire suppression devices, such as sprinklers with built-in smoke detectors, can significantly reduce fire risks and casualties.

Further research is needed to fill gaps in the existing literature and improve fire safety outcomes for student hostels:

1. More studies should examine fire safety measures in student hostels in developing regions, where regulations and resource availability differ significantly from high-income countries. This research can inform region-specific recommendations and help to tailor fire safety strategies to local needs.
2. Investigate the impact of various fire safety training methods on occupant behavior during emergencies. Studies comparing different types of training, such as hands-on drills versus online modules, could identify the most effective approaches to improving fire safety awareness.

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Assessment of the Effectiveness and Accessibility of National Housing Fund Scheme in Providing Affordable Housing in Niger State, Nigeria

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Abstract

The National Housing Fund Scheme was established primarily to address the constraint to the mobilization of long term funds for housing development and to ensure every Nigerian has access to housing loans easily at affordable interest rates. The study critically evaluated the effectiveness and the accessibility of the National Housing Fund (NHF) scheme in providing affordable housing to civil servants in Niger State. The main objectives of the study were to determine the effectiveness and accessibility of the NHF, evaluate the extent to which the NHF has provided loans to mortgage institutions for on-lending to contributors, and to establish how government policies enhance housing affordability for civil servants in Niger State. The study adopted survey research method and the sample size comprised 100 civil servants. Descriptive statistics were used to analyse the data collected. The study revealed that there is an inability for civil servants to access loans for the acquisition or development of shelters despite the increase in the cash pool. Poor management of the funds, lack of communication, bureaucratic delays, insufficient number of developed mass housing estates, and corruption in the process of housing loan approval and disbursement are factors constraining the accessibility of NHF by contributors in Niger State. The NHF accessibility to contributors and the adequateness of housing did not significantly correlate ($p > 0.05$; $r = 0.523$). According to this, contributors' ability to use the NHF will be greatly impacted by the availability of adequate housing. It is imperative that, policies that prioritize the needs of people be developed and put into action in order to build yearly units of affordable mass housing for the purpose of national development.

Keywords: National Housing Fund, Bureaucratic delays, Contributors, Housing Affordability, Niger state.

1. Introduction

Housing has been recognized as the second most important human requirement, after food (Opoko *et al*., 2016). It is also being recognised as a basic human need that is necessary to further facilitate harmonious interaction between the governed and their governments. However, despite the abundance of policies, programs, and methods outlined to address the housing gap, providing appropriate and good housing has proven to be an enormous challenge in majority developing Countries, including Nigeria (Oyalowo and Babawale, 2017).

Nigeria is one of the most rapidly urbanizing Nation in Africa (Farrel, 2018), and the percentage of Nigerians residing in urban areas has grown significantly over time (Central Bank of Nigeria, CBN, 2020). According to Malik and Wahid (2014), one of the main issues facing increasing urbanization is the supply of suitable housing for the general public, which has sparked debate about the most long-term and sustainable ways to stop undesirable development. As of 2016, the Federal Mortgage Bank of Nigeria (FMBN) estimated that there was a 17–20 million housing unit gap, with a potential cost of ₦6 trillion (US$16 billion) and an annual unit deficit rise of 900,000 (CAHF, 2017).

Like in other developing Nations, the FMBN which is Nigeria's housing institutions face a number of challenges which impede this institution from operating effectively. Inadequate output, substandard housing, and high housing costs are the results of these contextual and organizational difficulties.

The most perplexing problem currently facing Nigerian workers is the salary/minimum wage issue, which has a significant impact on civil and public servants' ability to become homeowners. However, other demographic factors may also be influencing their ability to obtain a home on the open market (Ofor *et al*., 2019). Concerns about land acquisition, high building material costs, low salaries, interest rates on mortgages, poorly established mortgage loan programs and loan inaccessibility, managerial bottlenecks, expensive construction approval plans, difficulty obtaining a Certificate of Occupancy on land (C of O), high professional fees, issues with environmental, social, and physical characteristics, statutory administration, infrastructure development, and control through government housing agencies are all closely related to the issue of civil servants' homeownership (Ibuoye, 2021). This raises a research question: what impact has the National Housing Fund (NHF) scheme had on reducing housing inadequacy

in Nigeria since its inception? This study, which focuses on housing development for civil servant in Niger state, assessed the effectiveness and accessibility of NHF plan in promoting affordable housing in Nigeria based on this assumption.

2. Research Methodology

2.1 Research Study Area

Niger state is located in the North-Central part of Nigeria with its capital city called Minna. According to Adeline and Eme (2015), the state has an estimated population of 3,950,249. Majority of the population are made up of public servants, farmers, business owners, and civil servants; the main ethnic groups are the Gbagyi, Nupe, Hausa, and Fulani. The state has attractions like stunning scenery, animal parks, water dams, flora and fauna, and the vibrant local culture, making it a potential destination for both domestic and foreign tourists. But access to affordable housing has become the major factor constraining the development of the state, therefore there is need for the government to make housing loan accessible to civil servant to encourage house ownership.

2.2 Research Design and Study Population

The study adopted descriptive survey research method since the objective is to provide an accurate snapshot of the people's opinions collected through survey. The researcher decided on the study's sample size after considering the resources required to complete the research into account. The technique used was cluster sampling. One hundred (100) civil servants who make contribution to the National Housing Fund scheme (NHF) were included in the study. Fifteen (15) employees from Federal University of Technology Minna and the National Examination Council (NECO) offices constitutes part of the study population. The study also included ten (10) employees each from the following organizations: the Federal Polytechnic Bida, the Federal Medical Center Bida, the Joint Admission and Matriculation Board (JAMB) Minna state office, and the National Institute for Freshwater Fisheries Research (NIFFR). also included are (5) employees from Federal College of Freshwater Fisheries Technology New Bussa and Mainstream Energy Solutions Limited in Kainji, Niger State, Nigeria, and twenty-five (25) employees from the Niger State Secretariat Complex in Minna. The rationale behind this unique distribution of the study population is to capture both Federal and State Government employees and likewise to envelop the public and private sectors respectively in the National Housing Scheme program.

2.3 Questionnaire Administration and Data Collection procedure

The respondents were asked to complete a structured questionnaire that has closed-ended questions with five-point rating scales to indicate their level of agreement or disagreement. The respondents were required to provide their sociodemographic information, the researcher also ask them to show proof of deduction made on their salary for NHF contribution through their payslip and the updated NHF booklets to be sure they are part of the scheme. The researcher which is I and two (2) certified research assistants assisted in distributing the questionnaires to respondents and promptly collected the completed forms. This averted missing of the completed questionnaire copies and guaranteed a prompt return. A central stakeholders validation meeting was organised by the researcher via zoom to present the findings of the research work to the respondents to validate the information collected from them. Observations were made for corrections and additional contribution were made and all are capsulated in the final research work.

2.4 Data Analysis

The statistical software for social sciences (SPSS) version 24.0 was used for analyzing the data generated by the study instrument. This software was used because of its efficiency, accuracy and advanced capabilities. The Pearson Product Moment Correlation Coefficient (PPMCC) was used to assess the null hypothesis stated in the study for direct measurement of linear relationship. P value ≤ 0.05 was considered significance,

3. Results and Discussion

This study assesses the Niger State, Nigeria, national housing fund scheme's accessibility and effectiveness. Table 1. displays the sociodemographic variables of the respondents, which show that 46% of the respondents were female and 54% of the respondents were male. Given that both genders of respondents were included in the study, the results indicate that the study was not gender bias. The results also showed that men are naturally inclined to provide a comfortable home for their family, which explains why there are more men among the respondents. According to the questionnaire, 40% of respondents had a bachelor's degree, 35% had a master's degree, 12% said they had Higher National Diploma [HND], 7% had a Doctor of Philosophy [PhD] and 6% had Post graduate Diploma [PGD]. The results revealed that, considering their stated level of education, the respondents are well-read and worthy of their employment status. The study also showed that 32% of respondents had been working for their

employer for between 1 to 20 years, 11% had been working for more than 21 years, and 57% of respondents had provided their employer with productive services for between 1 to 10 years. The fact that each respondent has worked for a company for more than a year suggests that they all fulfil the requirements to be given access to any funding source in Nigeria, including the National Housing Fund (NHF). In addition, 68% of the respondents live in rented apartments, 12% are homeowners, 12% live in the homes of their paternal family members, and 8% are in staff quarters. According to the results, the majority of respondents (88%) do not own their own homes. This result is consistent with the research of Atamewan *et al*. (2017), which found that 83.7% of the sample did not own a personal residence.

All mean values were higher than the benchmark mean of 2.5, as indicated by the results in Table 2. This suggests that the participants concurred with the different assertions regarding constraints limiting Niger State contributors from accessing the National Housing Fund (NHF). The respondents unequivocally stated that Minna, Niger State, does not have enough mass housing estates that are either developed or in the process of being built. Findings also showed that contributors to the National Housing Fund (NHF) were still unable to obtain loans in order to obtain housing, even with an increase in the fund's overall pool. Further findings also revealed that a lack of communication has created frustration among contributors, who find themselves unable to effectively capitalize on the benefits that the scheme should provide.

An analysis of the findings reveals that donors find it difficult to access the National Housing Fund (NHF) and that it falls woefully short of their housing requirements (Table 3). The outcome also showed that none of the contributors could claim to have obtained all of their housing funds from the National Housing Fund (NHF) without the need for loans from financial lending institutions or cooperative societies. This result is comparable to that of Atamewan *et al*. (2017), who argued that although contributors do not have access to the housing fund, housing financing is essential to the delivery of sustainable housing. In addition, the National Housing Fund (NHF) has difficult and unreachable conditions, making it difficult for contributors to receive housing funds (Atamewan *et al*., 2017).

Table 4 analyzes the study question, which asks how much money the National Housing Fund (NHF) has loaned to mortgage institutions so they can then lend it to contributors in Niger State. According to the results, the National Housing Fund (NHF) has not been able to effectively mobilize funds to build affordable housing for contributors in Niger State or to guarantee a steady flow of loans to workers in Niger State for the construction, acquisition, and renovation of residential housing. Incentives for the capital market to invest in Niger State real estate development have also been lacking from the National Housing Fund (NHF). This result is consistent with the declarations made by Adejuwon and Fashina (2021), who stated that the NHF's incapacity to finance housing development is the root cause of Nigeria's housing shortfalls.

Policies like promoting public-private partnerships and low-cost housing schemes will greatly aid in the provision of affordable housing, according to the analysis of the research question on the level of government policy in enhancing housing affordability in Niger State, Nigeria (Table 5). This result is consistent with the recommendations made by Aidelokhai *et al*. (2022), who suggested that people-oriented policies be developed and put into place for the yearly construction of affordable mass housing units for national development, that the government guarantee the provision of high-quality infrastructure within housing estates to attract citizens, and that stakeholders and mortgage banks should push for the removal of onerous requirements for citizens to obtain housing loans and streamline the processes for the acquisition of the houses.

The national housing fund (NHF) accessibility by contributors in Niger State, Nigeria, and the adequateness of housing did not significantly correlate, according to Pearson's correlation analysis, which found $p>0.05$ and a correlation coefficient of 0.523 because the correlation coefficient(r) measures the strength and direction of the linear relationship between the two variables (positive and negative response of respondents). According to this, contributors' ability to use the National Housing Fund (NHF) will be greatly impacted by the availability of adequate housing.

Table 1: Sociodemographic variables of the respondents

Variables	Percentage (%)
Gender	
Male	54%
Female	46%
Educational Level	
Higher National Diploma (HND)	12%
Bachelor degree (BSc)	40%
Postgraduate Diploma (PGD)	6%
Master Degree (MSc)	35%
Doctor of Philosophy (PhD)	7%

Years of service	
1 - 10	57%
11- 20	32%
Above 21	11%
Housing Occupancy/Ownership Status	
Rented apartment	68%
Personal house	12%
Staff quarters	8%
Family house	12%

The demographics of the respondent can significantly influence their perspectives on national housing fund scheme through how they perceive the accessibility, benefits and challenges associated with the scheme base on their age, income level, educational background, employment statue and geographical location.

Table 2: Factors constraining the Accessibility of National Housing Fund (NHF) by Contributors in Niger State

S/N	Statements	SD 1	D 2	N 3	A 4	SA 5	$\bar{X}$	StD	Dec
1.	Non-remittance to NHF by state government	5 5%	10 10%	40 40%	25 25%	20 20%	3.45	0.95	Accepted
2.	National Housing Fund deductions of 2.5% from my salary is to meager to fund my housing need	15 15%	5 5%	15 15%	25 25%	40 40%	3.7	0.43	Accepted
3.	Poor management of the funds accumulated from contributors by Federal Mortgage Bank of Nigeria	10 10%	5 5%	25 25%	30 30%	30 30%	3.65	1.25	Accepted
4.	Lack of communication on the benefits of the scheme	5 5%	10 10%	15 15%	20 20%	50 50%	4	0.88	Accepted
5	Insufficient number of developed mass housing estates in Niger State	-	5 5%	5 5%	25 25%	65 65%	4.5	0.98	Accepted
6	Tortuous and long NHF loan application procedure as a result of bureaucratic delays.	10 10%	-	-	40 40%	50 50%	4.2	1.32	Accepted
7	Workers resort to third-party agencies to fast track the loan application at unofficial fees, thus, creating perception of corruption in the process of housing loan approval and disbursement	e	10 10%	20 20%	35 35%	30 30%	3.75	1.24	Accepted
8	Despite the increase in the total pool in the NHF, workers were still unable to get loans to get shelter	-	-	20 20%	30 30%	50 50%	4.3	1.17	Accepted
9	FMBN is not providing proper accounts of the funds to the intended beneficiaries of the NHF	5 5%	10 10%	20 20%	25 25%	40 40%	3.85	1.09	Accepted
10	These funds are kept somewhere and people who access them are the privileged few	5 5%	10 10%	15 15%	35 35%	35 35%	3.85	1.10	Accepted
	Grand Mean						3.93		

Key: SD = Strongly Disagreed, D =Disagreed N= Neutral, A = Agreed, SA = Strongly Agreed. $\bar{X}$=Mean and (Benchmark mean = 2.50)

Some of the major factors that affect's the accessibility of NHF in Niger state are lack of awareness and lack of proper dissemination of information, eligibility criteria, contribution requirements, and lengthy bureaucratic processes to mention but a few.

Table 3: Adequacy and Accessibility of National Housing Fund (NHF) by Contributors in Niger State, Nigeria.

S/N	Statements	SD 1	D 2	N 3	A 4	SA 5	$\bar{X}$	StD	Dec
1.	I was able to access the National Housing Fund for the purchase / construction of my house	43 43%	32 43%	15 15%	5 5%	5 5%	1.97	1.05	Rejected
2.	The National Housing Fund provided adequate funding to realisation of the purchase / construction of my house	57 57%	21 21%	18 18%	3 3%	1 1%	1.7	1.24	Rejected
3.	I solely sourced my housing fund from National Housing Fund without having to borrow from Co-operative societies or financial loan institutions	67 67%	16 16%	17 17%	-	-	1.5	1.29	Rejected
4.	I was able to access the National Housing Fund within a short period of time without undue influence	45 45%	29 29%	18 18%	6 6%	4 4%	2.01	0.98	Rejected
5	The National Housing Fund has provided adequate funding towards the construction of estates in Niger State to either government or private developers	40 40%	37 37%	23 23%	-	-	1.83	1.13	Rejected
	Grand Mean						1.80		

Key: SD = Strongly Disagreed, D =Disagreed N= Neutral, A = Agreed, SA = Strongly Agreed. $\bar{X}$=Mean and (Benchmark mean = 2.50).

Since this analysis is below the benchmark required it will means the national housing funds scheme has not been easily accessible by a high percentage of the contributing civil servants therefore it is ineffective.

Table 4 Extent to which the National Housing Fund (NHF) has Provided Loans to Mortgage Institutions for On-lending to Contributors in Niger State.

S/N	Statements	VLE 1	LE 2	ME 3	HE 4	VHE 5	$\bar{X}$	StD	Dec
1.	Facilitating the mobilisation of funds for the provision of houses for workers in Niger State at affordable prices	48 48%	27 27%	10 10%	10 10%	5 5%	1.97	0.92	Rejected
2.	Ensuring constant supply of loans to workers in Niger State for the purpose of building, purchasing and improvement of residential houses	50 50%	21 21%	19 19%	5 5%	5 5%	1.94	1.16	Rejected

3.	Providing incentives for the capital market to invest in property development in Niger State	25 25%	40 40%	10 10%	15 15%	10 10%	2.45	0.90	Rejected
4.	Encouraging the development of specific programmes that would ensure effective financing of housing development for low-income workers	28 28%	33 33%	20 20%	15 15%	4 4%	2.34	1.17	Rejected
5	Providing long-term loans to mortgage institutions for on lending to contributors to the National Housing Fund (NHF)	25 25%	35 35%	15 15%	5 5%	20 20%	2.6	0.96	Accepted
	Grand Mean						2.26		

Key: Very High Extent = VHE, High Extent = HE, Moderate Extent = ME, Low Extent = LE, Very Low Extent = VLE..
$\bar{X}$=Mean and (Benchmark mean = 2.50)

The analysis is rejected because it is below the required standard of the benchmark of 2.50 making it a non-feasible scheme.

Also, since the government fails to provide constant supply of loan to workers or mobilize funds for the provision of affordable houses in the state and also have not provided incentives to capital Market to invest in mass housing development the problem of accessing affordable housing in the state will continue to be in the increase. Providing long term loans to mortgage institutions is not enough as they make it difficult for civil servants to access it through rigorous bureaucratic laws.

Table 5 Level of Government Policy in Enhancing Housing Affordability in Niger State, Nigeria

S/N	Statements	VLL 1	LL 2	ML 3	HL 4	VHL 5	$\bar{X}$	StD	Dec
1.	The applicant must first be a contributor to the National Housing Fund (NHF) scheme for not less than 6months; this contribution is always 2.5% of the basic salary	5 5%	15 15%	5 5%	25 25%	50 50%	4	1.07	Accepted
2.	Applicant must apply through a registered primary mortgage institution where s/he has an account	5 5%	5 5%	13 13%	40 40%	37 37%	3.99	0.89	Accepted
3.	Qualified applicant can access the loans for building, buying and renovation of houses	18 18%	20 20%	20 20%	20 20%	22 22%	3.08	0.92	Accepted
4.	Public-private partnership in the provision of affordable housing	16 16%	4 4%	15 15%	34 34%	31 31%	3.6	0.80	Accepted
5	Federal Low Cost Housing Scheme	15 15%	10 10%	15 15%	35 35%	25 25%	3.45	0.61	Accepted
	Grand Mean						3.62		

Key: Very High Level =VHL, High Level =HL, Moderate Level = ML, Low Level = LL, Very Low Level = VLL $\bar{X}$=Mean and (Benchmark mean = 2.50)

4. Conclusion

It is possible to draw the conclusion that the availability and accessibility of the National Housing Fund Scheme in Niger State determines the delivery of affordable and sustainable mass housing. The expense of constructing a home in Nigeria amply demonstrates that it is out of reach for the majority of the population, and infrastructure development is necessary for the efficient provision of mass housing. Two of the National Housing Fund's biggest problems are bureaucratic bottlenecks and poor fund management (NHF).

5. Recommendations

Based on the findings and conclusion, the following recommendations were made:

To protect the National Housing Fund (NHF) from being mismanaged, an anti-corruption monitoring desk ought to be set up. Automating the National Housing Fund (NHF) loan application and monitoring procedure is another way to streamline the home-buying process while simultaneously fostering efficiency and openness.

To increase the net amount of contributions to the National Housing Fund (NHF), the Federal Mortgage Bank of Nigeria (FMBN) ought to launch a vigorous mobilization campaign. It is imperative that policies that prioritize the needs of people be developed and put into action in order to build yearly units of affordable mass housing for the purpose of national development.

6. Conclusion

The importance of housing to human existence cannot just be over emphasized. It is therefore very important for Government policies to be tailored towards addressing identified challenges in the National Housing Fund Scheme. Critical bureaucratic processes posing major bottlenecks to accessing National Housing Fund should be extremely relaxed if not eliminated, aggressive awareness on the importance of the Scheme should be created to the possible beneficiaries and cost efficiency should be enstrained to make housing affordable to the contributors.

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Assessment of Community Engagement and Stakeholder's Participation in Planning of Ojude Oba Festival in Ijebu Land

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Abstract

This study evaluates the level of community engagement and stakeholder participation in the planning and execution of the Ojude Oba Festival in Ijebu Land, Nigeria. The festival, which holds significant cultural importance, faces challenges in maintaining its authentic practices due to increasing commercialization and globalization. The research assessed community involvement, communication channels, and the inclusiveness of stakeholder participation, especially among groups like women, youth, and local entrepreneurs. A mixed-methods approach was employed, involving quantitative surveys and qualitative interviews with 134 stakeholders, with 111 valid responses analyzed. Results showed that while cultural and community groups were highly involved, while youth and environmental organizations were underrepresented. Communication relied heavily on formal meetings and digital platforms. The study also identified gaps in crowd control and environmental management. It concludes by recommending the creation of stakeholder committees, enhanced digital engagement, and more regular community consultations to preserve the festival's cultural value and promote socio-economic development in the region.

Key words: Community Engagement, Stakeholder Participation, Cultural Festival, Sustainability, Inclusiveness

1. Introduction

Tourism is a global phenomenon with significant economic, social, and cultural impacts worldwide. According to the World Tourism Organization (UNWTO, 2022), international tourist arrivals reached 1.5 billion in 2019, generating $1.7 trillion in export earnings. This highlights the immense economic influence of tourism. The sector comprises various forms, including leisure, business, medical, and cultural tourism, each catering to different traveler motivations.

Cultural tourism, in particular, promotes cultural exchange, heritage preservation, and sustainable development (Richards, 2018). It revolves around exploring a destination's cultural assets, such as historical sites, arts, cuisine, and festivals, fostering intercultural dialogue and contributing to cultural conservation. Nigeria, known for its cultural diversity, hosts numerous festivals that attract domestic and international tourists. These festivals showcase the traditions and values of the nation's ethnic groups (Esu *et al.,* 2020).

One such festival is the Ojude Oba Festival in Ijebu Ode, Ogun State, which celebrates the end of Eid al-Adha. It features a grand procession of chieftaincy groups and age grades, paying homage to the Awujale, the ruler of Ijebu Land (Adewumi *et al.,* 2018). The festival is not only a cultural spectacle but also a symbol of the Ijebu people's resilience and traditions.

Effective planning and stakeholder participation are essential for organizing such festivals. However, challenges such as limited stakeholder participation and a focus on monetary impacts have been highlighted (Ugor, 2018; Bakare *et al.,* 2021). Addressing these challenges is crucial for the sustainability of Nigeria's cultural festivals and the preservation of its cultural heritage.

2. Main Results

Table 1 present an analysis of the communication channels and mechanisms used, rated on a Likert scale from 1 (Not used) to 5 (Very frequently used). The findings indicate that formal meetings and online platforms are very frequently used (VQU) with a mean score of 5.00, as all 111 respondents rated it at 5. Informal meetings, on the other hand, are not used (NU) with a mean score of 1.10, predominantly rated at 1 by 100 respondents.

Traditional media is frequently used (FU), receiving a mean score of 3.49, with ratings predominantly at 3 and 4 by the respondents. Community consultations and the suggestion box are both rarely used (RU), with mean scores of 1.39 and 1.30 respectively, indicating limited engagement through these channels. These insights highlight the

predominant reliance on formal meetings and online platforms for communication, while other mechanisms like informal meetings, community consultations, and suggestion boxes are underutilized. Traditional media remains a significant communication channel, frequently employed by the respondents.

Table 1. Communication channels and mechanisms

Variable	1	2	3	4	5	N	Sum	Mean	Remark
Formal meetings	0	0	0	0	111	111	555	5.00	VQU
Informal meetings	100	11	0	0	0	111	122	1.10	NU
Online Platforms	0	0	0	0	111	111	555	5.00	VQU
Traditional media	0	0	57	54	0	111	387	3.49	FU
Community consultations	68	43	0	0	0	111	154	1.39	RU
Suggestion Box	78	33	0	0	0	111	144	1.30	RU

Table 2 present the analysis of spatial planning and management of festival venues, the findings reveals that 60% of respondents rate the spatial planning and venue management as good, with an additional 21% rating it as excellent. However, 19% consider it fair or poor, indicating room for improvement.

Table 2 Perspective on Spatial planning and venue management

Variable	Frequency	Percentage
1 (Poor)	7	6
2 (Fair)	14	13
3 (Good)	67	60
4 (Excellent)	23	21
Total	**111**	**100**

Table 3 reveals the findings on the most important stakeholder and planning groups, community leaders and the planning committee each account for 47 individuals, representing 42% of the population. 15 individuals or 14%, and tourism agencies by 2 individuals, accounting for 2%, identify cultural groups. Notably, no individuals identified local government officials as the most important stakeholder group.

Table 3. Most Important stakeholders and planning groups

Variables	Frequency	Percentage
Community leaders	47	42
Local government	0	0
Cultural groups	15	14
Tourism agencies	2	2
Planning committee	47	42
Total	111	100

Figure 1: Subgroup members captured during the festival

Figure 2: Leader of a male sub group and an important member of the planning unit captured during the festival

3. Conclusion

This research highlights the crucial role of inclusive and diverse approaches to community engagement and stakeholder participation in planning the Ojude Oba Festival. While the festival successfully preserves cultural heritage and fosters social engagement, there are still challenges related to the limited participation of underrepresented groups, inadequate communication strategies, and the need for improved decision-making processes. Ensuring balanced participation is essential for the festival's long-term sustainability. By including underrepresented groups such as youth and environmental organizations, diversifying communication channels, and increasing community involvement in budgeting and key decisions, the festival can enhance safety, efficiency, and environmental responsibility. These improvements will not only strengthen community relations but also create a more enriching experience for attendees. Furthermore, fostering collaboration with local residents and businesses and addressing power imbalances will help ensure equitable and inclusive participation, contributing to the festival's ongoing success. Continuous efforts in these areas will be required to maintain the positive relationships established and ensure the festival's future growth and sustainability.

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Strategies for achieving sustainability in supply chain management in construction projects in North Central, Nigeria

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Abstract

Sustainability in supply chain management (SCM) is crucial for construction projects as it impact the environment, society and economy. It focuses on reducing the governance impact of supply chain operation and minimises harm and improve efficiency. 'This paper examined strategies for achieving sustainability in supply chain management in construction projects in the North Central States of Nigeria. A total of 250 questionnaires were administered and 200 were retrieved and used for the analyses. Data was collected with the use of questionnaire distributed amongst respondents from construction industries, professionals, clients, contractor's, developers, subcontractors, wholesaler and retailers of construction materials. The descriptive statistic, involving the use of mean scores of each variable through the adoption of the 5-point Likert scale and Relative Importance Index, data was analysed to establish the significant factors in each of the constructs. Study showed that amongst several strategies for achieving sustainability in supply chain management, the Compliance with the strategy of sustainability in supply chain with a mean score of 3.38 and RII of 0.924 was identified as the most important strategies, followed by the good governance strategy with a mean score of 3.32 and RII value of 0.888 Having RII values greater than 0.5 implies that the variables have significant influences on the subject under consideration.

Keywords: Construction project, Management, Supply chain, Sustainability.

1. Introduction

Construction Industry (CI) contributes significantly to the economy of any nation and constitutes a large portion of the developmental plans of most nations. It accounts for close to 10% of the Gross Domestic Product (GDP) of developed nation and 6% of nations like Nigeria experiencing development (Omoraka, 2020). Supply Chain Management in the construction industry goes beyond only purchasing materials it also includes managing equipment, technology, human resources, and even regulatory compliance. Delivering projects on time and under budget requires making sure that each of these components is in line with project objectives. (Sroufe and Curkovic, 2019 (Sun *et al.,* 2019).

Sustainability refers to the ability to maintain or support a process, system or activity overtime without depleting natural resources or causing harm to social, economic and environmental conditions that enable humans to exist with nature in 'productive harmony' in the present and the future (Anwar, 2022). Sustainability develops innovative solutions to meet the needs of the present generations without compromising the ability of future generations to meet their own needs (Ayman *et al.*, 2021). The increasing awareness of sustainability worldwide and its contribution towards saving the environment, prospering economy and enhancing society called for the construction industry to think sustainable (Wibowo *et al.,* 2018; Anwar, 2022). It is against this background that this study intends to identify the strategies for achieving sustainability in supply chain management in construction projects. The geographical scope will cover North Central Geo-Political Zone in Nigeria which comprise of, Niger State, Kwara State, Kogi State, Nasarawa State, Benue State, Plateau State and Abuja, the Federal Capital Territory. These states have registered Professionals, Construction Industries and Manufacturing Industries, developer, wholesalers and retailers of construction materials. The North Central was selected in other to reduce the scope of the research work.

2. Literature Review

2.1 Overview of Sustainability and Supply Cain Management

The central theme of sustainability revolves around the tension between the increasing needs of the population and the degradation of Earth's resources and environment (Epstein *et al*., 2018). Sustainability refers to the ability to

maintain or support a process, system or activity overtime without depleting natural resources or causing harm to natural environment, social and economic. It involves the meeting the need of the present without compromising the ability of future generation to meet their own needs (Khan, 2017). Sustainable development helps companies extend their lifespan, enhance the planet's wellbeing, preserve the biosphere, support living beings, and protect and improve society (Khan ,2017). It entails the ability to preserve present and future resources, address challenges, maintain wellbeing, foster human participation, and uphold personal freedom. Sustainability necessitates that companies consider the social and environmental impact of their activities and daily operations (Epstein *et al*., 2018).

Sustainable supply chain management refers to the increasing awareness of environmental protection and social responsibility in every aspect of the supply chain (Das, 2018), and adhering to the concept of the sustainable development of people, nature, and society throughout the supply chain. Usually, scholars define sustainable supply chain management from the three dimensions of economy, environment, and society (Das ,2018). The economic aspects generally include profit, cost, profitability, consumer satisfaction, increased sales, and capital investment, the environmental aspects include green production, green design, green procurement, internal environmental management, green packaging, investment recovery and green transportation (Das ,2018; Lurthra and Mangla ,2018) and the social aspects include employee safety, employee benefits, community safety and welfare, and partner rights.

2.2 Strategies for Achieving Sustainability in Supply Chain Management

In recent years, the increasing environmental concerns have made the sustainability practices receive management attention. In the supply chain, ecological issues severely affect the value chain system, thus demanding the need for effective strategies and sustainability practices across the supply chain network. Therefore, today, numerous firms have adopted sustainable supply chain strategies (SSCSs) for improving ecological welfare. Given the articulation, the study shows that the firms' sustainability strategies reduce the environmental cost, thereby maximizing the social welfare with sustainable practices (Zandieh *et al*., 2018).

In particular, sustainable supply chain strategies assist the firms in attaining the sustainable triple-bottom-line dimension. In supply chain modeling, organizations' enduring plans and sustainable practices devote to improving the organizations' function. PeRHAps, understanding this multi-dimensional sustainability helps companies to support organizations' practices with a sustainability vision. The firms' sustainability strategies lead to the effective implementation of sustainable practices. (Luthra and Mangla, 2018).. Some identifies strategies for effective SSCM as reported by Luthra and Mangla (2018) and Ahmad *et al*. (2022) include:

Good governance strategy: Good governance is critical to long-term sustainability success, and this requires a robust structure that includes committed management, clear visions, directions, and positive influence (Luthra and Mangla,2018). Sustainability governance ensures its sustainability strategies and policies are in line throughout its business operations. This entails managing report processes, strengthening relationships with external stakeholders, and ensuring the overall accountability (Khan and Qureshi, 2020). With regards to SSCM, it is important that every stakeholder in the supply chain participates collaboratively in order for the strategy to be formalized (Luthra and Mangla,2018). Their participation translates into concrete action to be implemented and followed up. Governance, being a critical component of accountability, it is important to establish traceability and transparency towards its actions in sustainability. This gives rise to improved reputation, strengthened stakeholder's confidence and willingness to respond to changing external environments associated with contemporary construction activities (Ahmad *et al*., 2022).

Strategic supplier collaboration: In most supply chains, the concerned organizations hardly have control over resource, materials or quality, but this are usually achieved through collaborative efforts amongst stakeholders in the supply chain. By the development of collaboration amongst stakeholders, organization are able to manage risks and impacts created by their supply chain operations even as they capitalize of opportunities to create value. (Luthra and Mangla, 2018) To achieve a successful collaboration in a supply chain, all stakeholders must be strategically aligned, functionally engaged across parties involved, must have trust and effective communication, efficient/ organized governance and able to share information (Luthra and Mangla, 2018).

Circular strategy of waste reduction: Organizations can help reduce waste and ensure sustainability by incorporating circular economy initiatives into their supply chain (Khan and Qureshi, 2020). In a circular economy, materials are dissembled, channeled back to production, and reused as raw materials to create new, sellable products (Luthra and Mangla,2018). Thus, minimizing waste. In addition, it enables organizations to be less dependent on "virgin" raw materials and natural resources, allowing them to achieve sustainability goals while

gaining profits. Organizations must consider waste reduction at every stage, from product design to distribution, and consider efficient logistics journeys for returning products into the supply chain loop, including reverse logistics (Ahmad *et al*., 2022).

Eco-friendly sourcing strategy: An organisation can implement eco-friendly sourcing or sustainable practices by incorporating ethical policies with its sustainability goals throughout its supply chain (Khan and Qureshi, 2020). It includes materials sourcing, manufacturing, logistics, product design, and end-of-life product management. Organizations must find ways and solutions to implement eco-friendly sourcing and practices within their supply chain to gain a competitive advantage while still growing profit (Ahmad *et al*., 2022).

End-to-end supply chain visibility: End-to-end supply chain visibility in construction industries allows organizations to monitor and track various components and construction materials in transit, starting from the initial purchase of raw materials through the delivery of the project to end users (Ahmad *et al*., 2022). It involves careful and regular monitoring throughout the entire process. Organizations will then organize the data captured in a central database where organizations will use it to review, analyse and mine for actionable insights. Since this implementation requires a proactive approach to data management, organizations will require significant investment to support this digitalization and data management system. In a competitive global environment, visibility is crucial for organizations to make accurate, strategic business decisions and respond to necessary supply chain events that could impact profitability and customer experience (Hassan and Habib,2022).

Compliance with the strategy of sustainability: Sustainable supply chain work by setting consistent ethical and environmentally responsible standards and ensuring all relevant processes, actions, materials, and stakeholders comply with them (Zandieh *et al*., 2018). For this to work, benchmarks, policies, targets, and guidelines must be spelled out. It is then shared and agreed to among all stakeholders, including suppliers across the chain (Hassan and Habib,2022). It includes defining the social and environmental standards and evaluation criteria. Organizations must consider essential factors and processes that meets its sustainability goals and values when selecting strategic suppliers and ensuring they comply (Hassan and Habib,2022).

Digital Strategy for Efficient Operations: Incorporating digital technology is essential for efficient operations in this rapidly digitizing world. Organizations must understand how technology can assist, disrupt, or improve their supply chain operations (Hassan and Habib,2022). Identifying the right technologies that add value to the organization and supply chain operations can improve end-to-end visibility and increase transparency, accuracy, and efficiency. The extent and pace of implementing digital technologies are subject to crucial enablers; the capacity and environment and the capacity of trained employees to apply the technologies proficiently (Hassan and Habib,2022). Big data, advanced analytics, artificial intelligence (AI), mobile apps, block chain, and RFID technology are some digital technologies organizations can use. They can be interconnected to optimize their full benefits for an effective supply chain (Ahmad *et al*., 2022).

Transportation Optimization Strategy: Transportation is becoming more volatile in the supply chain, with increasing fuel prices affecting freight rates and impacting the overall supply chain (Hassan and Habib,2022). Organizations must find new solutions to minimize transportation costs and ensure transportation capacity to maintain a competitive edge. Optimizing the transport network may be complex, but it eliminates cost overruns, reduces fuel consumption, and creates fewer emissions. As a result, it reduces carbon footprint and eliminates other disruptions to the functioning supply chain. With the constant evolution and supply chain complexity, intelligent technologies in transportation operations can help organizations improve transportation efficiency by finding the best route based on real-time conditions and increasing energy efficiency. It also contributes to the overall process for organizations to stay competitive (Harouach *et al*., 2024).

3. Research Methodology

The study population include all selected relevant stakeholders in construction supply chain within the States in North Central Geopolitical Zone and Federal Capital Territory. Responses shall be sought from Construction industries, Manufacturing industries, professionals, clients, contractors, subcontractors, wholesaler and Retailers of construction materials in study area. A Stratified random sampling was used in selection of sample size to ensure all sub-groups in the study were involved, and then simple random sampling was used to get respondents from each sub-group /category.

Sample size is the proportion of the population to be served with the research instrument. The sample size was calculated using the method demonstrated in equation by Glenn (2013)

$$n = \frac{N}{1+N(e)^2} \text{---------- 3.1}$$

Where;
n = Sample size,
N = Population size in the sample unit (N=670)
e = Level of precision which is + 5% (0.05), at 95% confidence level.
Based on equation the sample size for this research is (n = 250)
This study used a questionnaire as Primary tool of data collection and it is divided into two (2) sections. The section A was designed to obtain relevant information to the respondents such as organisation of the respondents, qualifications, years of experience. Section B focus on strategies for achieving sustainability in supply chain management. A questionnaire was developed and administered to stakeholders in the various construction industries. Two hundred and fifty (250) questionnaires were distributed, fifty (95) for professionals, in construction and manufacturing industries, thirty-five (35) for clients, thirty-five (35) for contractor's, twenty (20) for developers, thirty (30) for subcontractors, twenty (20) for wholesaler and fifteen (15) for retailers of construction materials. Only two hundred (200) were retrieved and found suitable for the analysis.

4. Method of Data Analysis

The descriptive statistic using mean scores of each variable were determined based on the 5-point Likert scale used to collect data to establish the significant factors in each of the constructs.

5. Results

Table 1: Showing Respondents Rate Returned Questionnaires

S/N	Items	Number of Questionnaire Administer	Number of Questionnaire Returned	Percentage
1.	Architect	30	20	66.66
2.	Quantity surveyor	30	25	83.33
3.	Builder	25	20	80.00
4.	Developers	20	15	75.00
5.	Contractors	35	30	85.71
6.	Subcontractors	20	15	75.00
7.	Wholesaler	20	15	75.00
8.	Retailers	15	15	100.00
9.	Clients	35	30	85.71
10.	Engineers	20	15	75.00
	TOTAL	**250**	**200**	**100**

Table 1.0 shows the percentage of return of the administered questionnaires. Wholesalers and Retailers appears to be the participants that responded most to the questionnaires administered, it was followed by the contractors and Builders while the lowest number of respondents were the Professionals like the Architects.

Table 1.1: Educational Qualification of Respondents

S/N	Items	Frequency	Percentage
1.	OND	20	1. 10.00
2.	HND	25	2. 12.50
3.	B.Sc/BTech	75	3. 37.50
4.	MSc/MTech/PhD	35	4. 17.50
5.	Others	45	5. 22.50
	TOTAL	**200**	**100**

The Table.1.1 shows the educational qualifications of the respondents. The respondents with the highest response were BSc/BTech holders, followed by others and then MSc/MTech/PhD holders, the least response was from OND holders.

Table 1.2: Years of Experience

S/N	Items	Frequency	Percentage
1.	Less than 5 years	28	6. 14.00
2.	5-10 Years	35	7. 17.50
3.	11-15 Years	67	8. 33.50
4.	Above 15 Years	70	9. 35.00
	TOTAL	**200**	**100**

The Table1.2 shows the years of experience of the respondents. The respondents with the highest response had above 15 years working experience, followed by respondents with 11-15 years of experience, followed by 5-10 years of experience and the least was respondents with less than 5 years' experiences.

Answering of Research Questions

Table 1.3: Showing Strategies for achieving sustainability in supply chain management in construction projects.

S/No	Items	N	Mean	SD
1.	Good governance strategy	200	10. 3.32	11. 1.11
2.	Strategic supplier collaboration	200	12. 3.22	13. 1.08
3.	Circular strategy of waste reduction	200	14. 3.30	1.07
4.	Eco-friendly sourcing strategy	200	15. 3.21	16. 1.08
5.	End-to-end supply chain visibility	200	17. 3.31	18. 1.09
6.	Compliance with the strategy of sustainability	200	19. 3.38	20. 1.06
7.	Digital Strategy for Efficient Operations	200	21. 2.93	22. 1.07
8.	Transportation Optimization Strategy	200	23. 3.20	24. 1.07
			25.	

The Table 1.3 shows Strategies for achieving sustainability in supply chain management. The major Strategies was Compliance with the strategy of sustainability with a mean value of 3.38, followed by good governance strategy with a mean score of 3.32. Other strategies of sustainable supply chain include End-to-end supply chain visibility, Circular strategy of waste reduction, Strategic supplier collaboration, Eco-friendly sourcing strategy, Transportation Optimization Strategy, Digital Strategy for Efficient Operations, 3.31,3.30, 3.22, 3.21, 3.20 and 2.93 respectively.
From the perspective of the relative importance index of these strategies with regards to sustainable supply chain management, Table 1.4 ranks these strategies according to their relative importance in supply chain management. It can be observed that the most important strategies for achieving sustainable supply chain in this study is lack of Compliance with the strategy of sustainability with RII value of 0.924, followed by **good** governance strategy with RII value of 0.888 and the least strategies is, Digital Strategy for Efficient Operations with RII value of 0.600.

Table 1.4: Relative Index of Strategies for achieving Sustainability in supply chain management in Construction projects

Strategies		V. Sig.	Sig.	Av. Sig.	Lit. Sig.	Not Sig.	SUM	A*N	RII=(ΣW/A*N)	RANK
	Mark (x)	5	4	3	2	1		5		
Good governance strategy	Freq. (f)	120	50	20	10	0	200	200		
	ΣW=f(x)	600	200	60	20	0	880	1000	0.888	2nd
Strategic supplier collaboration	Freq. (f)	96	23	30	11	40	200	200		
	ΣW=f(x)	480	92	90	22	40	744	1000	0.724	5th
Circular strategy of waste reduction	Freq. (f)	105	23	32	0	40	200	200		
	ΣW=f(x)	525	92	96	0	40	753	1000	0.752	4th
Eco-friendly sourcing strategy	Freq. (f)	90	20	21	34	33	200	200		
	ΣW=f(x)	450	80	63	68	33	694	1000	0.694	6th
End-to-end supply chain visibility	Freq. (f)	78	42	63	7	10	200	200		
	ΣW=f(x)	390	168	189	14	10	771	1000	0.771	3rd
Compliance with the strategy of sustainability	Freq. (f)	150	32	10	8	0	200	200		
	ΣW=f(x)	750	128	30	16	0	924	1000	0.924	1st
Digital Strategy for Efficient Operations	Freq. (f)	60	21	38	21	60	200	200		
	ΣW=f(x)	300	84	114	42	60	600	1000	0.600	8th
Transportation Optimization Strategy	Freq. (f)	30	20	111	4	35	200	200		
	ΣW=f(x)	150	80	333	8	35	606	1000	0.606	7th

6. Conclusion

This study examined the Strategies for achieving sustainability in supply chain management in construction projects in the North Central States of Nigeria. By using a population of 200 respondents from stakeholders in construction project, data was collected with the use of questionnaire distributed amongst respondents from construction industries, manufacturing industries, professionals, clients, contractor's, developers, subcontractors, wholesaler and retailers of construction materials. By making use of descriptive statistic involving the use of mean scores of each variable through the adoption of the 5-point Likert scale and Relative Importance Index, data was analysed to establish the significant factors in each of the constructs. Study showed among Strategies for achieving sustainability in supply chain is the **Compliance with the strategy of sustainability** with a mean value of 3.38 and RII value of 0.924 was identified as the most important strategies. This was followed by the good **governance strategy** with a mean score of 3.32 and RII value of 0.888. The third most strategies of sustainable practices in supply chain management is **End-to-end supply chain visibility with mean score of 3.31 and RII value of 0.771**. Having RII values greater than 0.5 implies that the variables have significant influences on the subject under consideration.

7. Recommendations

I. Government should encourage the adoption of the strategies for achieving sustainability in supply chain management process. This will involve the use of effective government regulation and monitoring using appropriate agencies.

ii. The Construction Industries, manufacturing industries and stakeholders in the building industries should make use of the result obtain from the analysis in the decision making on how to achieve sustainability in supply chain management in construction projects.

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Impact of Entrepreneurial Activities on Housing Transformation in Public Estates: A Nigerian Perspective

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Abstract

This literature review aim to investigates the effects of enterprenuership activities on public housing transformation and urbanization in Nigeria within the last six years (2019 – 2023). The search strategy used for the identification of relevant literature was tailored to five data bases: Google Scholars, ResearchGate, Elsavier Scopus, Elicit, and Sematic Scholar. It synthesizes findings from seventeen key articles obtained from systematic literature review using PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analysis) guidelines and flow chat, 74 articles was sourced, and afterwards 17 research articles were included in the review, covering various aspects of housing dynamics in the country. Some of the criteria for screening using PRISMA includes: Relevance, Availability of Pdf, Duplication of articles, Year of publication range, and articles on Nigeria contex only. The studies shed light on the enterprenuership characteristics, methods, and mechanism leading to house design adjustments and thus housing transformation. Relevant topics used for data searching includes: "housing transformation in public residential estates", "Forms of enterprenuership activities and space negotiations", and the "Effects of available businesses on residents spaces within the Public Housing Estates". The reviewed articles indicates that, location of economic activities within a housing estate can have multifaceted effects on the estate's transformation, which can influence the quality of life for residents, property values, social dynamics, and the overall character of the community. Furthermore, the methodology obtainable from the reviewed papers are mostly quantitative, and there are limited numbers of available research on the impact of economic activities to the housing transformation within Nigeria. The findings reveled that there are arising population in the sampled public housing estates where the availability of enterprenuer activities exists, residential neighborhoods with the presence of informal economic activity has the potential to degrade the quality of the environment by causing aesthetic disorder, intrusion on land use circulation, visual blockage, and careless garbage disposal. A careful planning and management of economic activities within housing estates are essential to ensure a harmonious and thriving living environment.

Keywords: Activities, Entrepreneurship, Housing, PRISMA, Space, Transformation

1. Introduction

The housing sector in Nigeria has undergone significant transformations in recent years due to rapid urbanization and the need for improved living conditions. As cities expand and populations grow, the demand for housing has increased, leading to extensive changes in the housing landscape. Housing Transformation is a multifaceted concept that refers to the physical, functional, or social changes occurring within housing structures, layouts, or neighborhoods. This transformation can be driven by various factors such as urbanization, economic development, technological advancements, or sociocultural shifts. It involves alterations to existing housing, such as remodeling, extension, or reconfiguration, and can significantly impact the housing market, residents' living conditions, and the urban landscape (Omar *et al.,* 2016). These transformations have introduced new dynamics and challenges in housing delivery and urban development. Unah (2019) study on residential housing redevelopment in Nigeria and Girmay (2021) exploration of domestic spaces for income generation likely contribute to an understanding of how housing is not static but evolves in response to social, economic, and environmental needs. Enterprenuership activities within these housing estates are diverse, ranging from home-based enterprises to community markets (Chika *et al.,* 2019). Economic activities within a housing estate, such as home-based enterprises or local retail, may lead to physical transformations in housing to accommodate these activities (Jones, 2017). Conversely, transformations in housing design or layout can facilitate or hinder specific economic activities. These activities often lead to various housing transformations, affecting the physical layout, social interactions, and overall quality of life within the estates (Oladapo, 2021).

Public housing transformation has emerged as a crucial aspect of housing dynamics in Nigeria. The transformation of public residential estates and the integration of economic activities within these areas have impacts on multiple facets of housing, including social, economic, and environmental dimensions. Masud Ur Rashid (2018) study delve into the socio-economic benefits of rural home-based enterprises, and Carter *et al.* (2017) work explores households as sites for entrepreneurial activity. Both studies possibly contribute to understanding how homes are not merely living spaces but can also be sites of economic productivity and livelihood. Residential neighborhoods with the presence of informal economic activity has the potential to degrade the quality of the environment by causing aesthetic disorder, intrusion on land use circulation, visual blockage, and careless garbage disposal.

Understanding these effects is essential for policymakers, urban planners, and researchers to design effective strategies for sustainable housing development. Unah (2018) asserts "improving the housing condition and living standard in an area would potentially act as a catalyst for wider regeneration of similar neighborhoods that are target of redevelopment". So hence housing improvement (transformation) for economic needs can cause degeneration and open ways for more negative impact on the neighbourhood. It is therefore crucial for the authority to both understand and develop appropriate polices to best manage the pressure for redevelopment. Several Nigerian studies have focused on residential satisfaction as a measure of housing aspiration and preferences(Aduwo, 2019). This suggests a need for more research on housing redevelopment in Nigeria as part of the efforts to address the burgeoning urban housing challenge in this country.

This is a critical requirement for keeping the high standard of the journal. The primary objective of this literature review is to investigate the effects of housing transformation and urbanization on housing in Nigeria. Specifically, the focus is on the effects of public housing transformation within the country over the past six years. By examining existing research, this study aims to assess the impact of small-scale entrepreneurial activities on the physical and social transformation of public housing estates in Nigeria. This would serve as aguide for policy makers in making appropraite laws that will address the challages faced by in appropraite alterations done on public housing designs.

2. Methodology

The systematic review of literature was carried out using the preferred reporting items for systematic reviews and meta- analysis (PRISMA- 2020). The scientific process was carried out in four stages, which includes: identification of studies through wed search of various data bases, screening of studies, eligibility, and inclusion. The search strategy used for the identification of relevant literature was tailored to five data bases: Google Scholars, ResearchGate, Elsavier Scopus, Elicit, and Sematic Scholar The search guide used include phrases like: "housing transformation in public residential estates", "Forms of enterprenuership activities and space negotiations", and the "Effects of available businesses on residents spaces within the Public Housing Estates". The steps followed for the systematical literature review using PRISMA are explained below using the major stages of : Identification of resources, screening criteria, eligibility and quality assessment, inclusion and data extraction.

All together 74 articles was sourced initially and afterwards 17 research articles were included in the review. The screenvg criteris for inclusion are: Relevance, Availability of Pdf, Duplication of articles, Year of publication range, and articles on Nigeria contex only. The aim of the literature review is to search existing research in last seven years on the effects of public housing transformation in Nigeria. Therefore, the time frame for selection of articles for inclusion is between 2016- 2023, research carried out in Nigeria and in English language only.

2.1 Identification of resources

The search strategy used for the identification of relevant literature was tailored to five data bases: Google Scholars, Researchgate, Elsavier Scopus, elicit, and Sematic Scholar. The terms and word search for includes: "Public Housing", "Housing Transformation", and "Economic activities in public estates". All works published and unpublished within year 2017 – 2022 and within Nigeria. A total number of 74 studies was extracted from the databases, and uploaded onto the Zotero reference management tool library. And all duplicate studies were removed, 13 articles were removed for duplicates and additional 5 were not published in English language and have to be excluded also. A residual of 56 studies was now screened for use in the research.

2.2 Screening criteria

The search strategy used for the identification of relevant literature was tailored to five data bases: Google Scholars, Researchgate, Elsavier Scopus, elicit, and Sematic Scholar. The terms and word search for includes: "Public Housing", "Housing Transformation", and "Economic activities in public estates". All works published and unpublished within year 2017 – 2022 and within Nigeria. A total number of 74 studies was extracted from the databases, and uploaded onto the Zotero reference management tool library. And all duplicate studies were removed, 13 articles were removed for duplicates and additional 5 were not published in English language and have to be excluded also. A residual of 56 studies was now screened for use in the research.

2.3 Eligibility and Quality Assessment

The study was based on original research articles, review papers, and conference papers. To maintain the quality of the review, all duplicates were checked thoroughly. Abstract of the articles were checked deeply to ensure the quality and relevance of academic literature included in the review process. A careful evaluation of each research was carried out at the later stage. The next exclusion carried out was to limit the papers to English language, there were 4 articles that were not in English language, so they were removed. Also excluded for non-relevance to the research question were 13, while some document were inaccessible (Pdf not found), and 11 published before 2017.

2.4 Inclusion and data extraction

In the data extraction phase, 17 articles were selected and the characteristics for inclusion were:
Articles must be original paper, review paper, and conference paper. Published reports, case studies were excluded. The articles must be in English language from the field of environmental sciences. Extracted articles were published between years 2017 to 2022. The extracted papers are from Nigeria alone.

The summary of the review process is shown in PRISMA flow chat shown in figure 1 below.

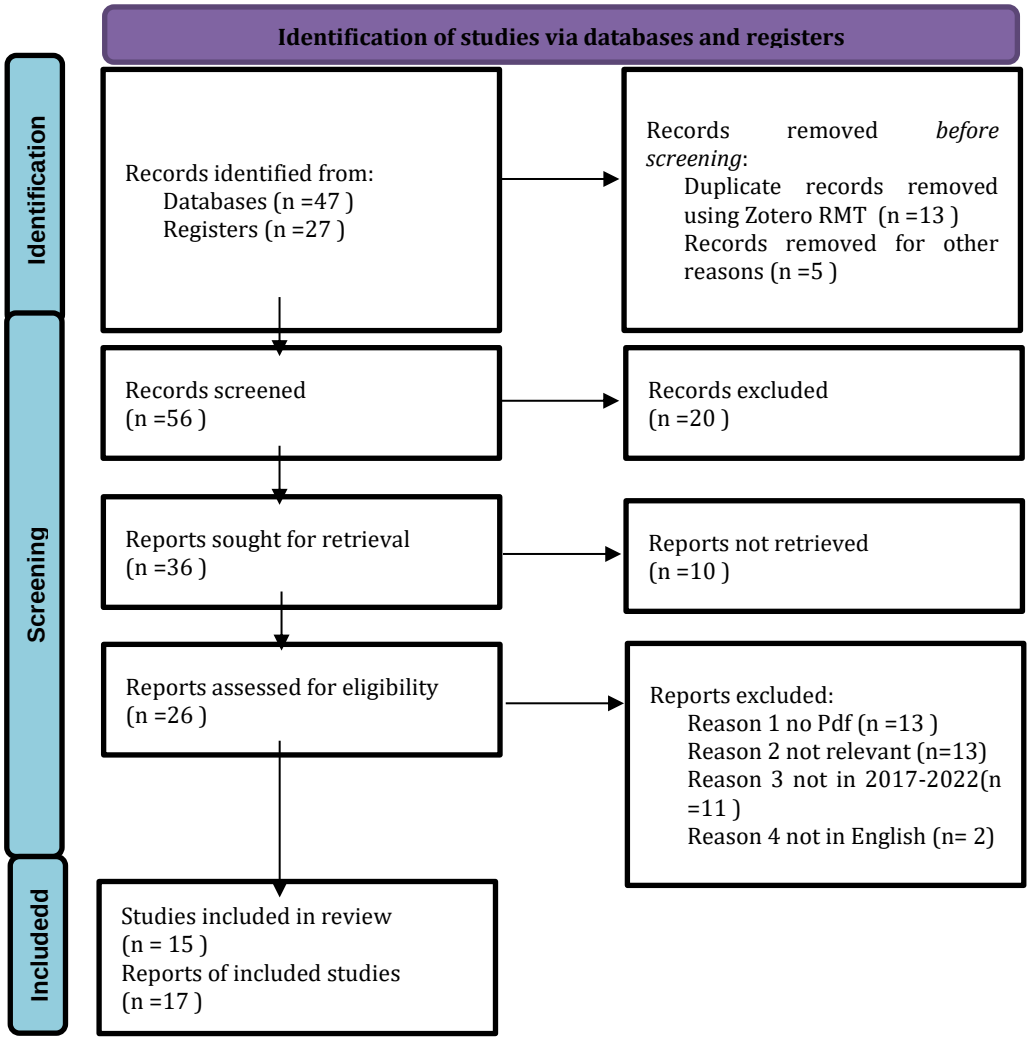

Figure 1: PRISMA Flow Chat For The Systematic Review On: Assessing the Impact Of Economic Activities On Housing Transformation In Public Housing Estates In Nigeria.

3. Results and Interpretation

The seventeen selected published articles were studied and relevant information extracted. A summary of details extracted were later inserted into Table 2.

Table 2: Summary of relevant literature on transformation of public housing estate in Nigeria

Author/Date	Year	Tittle	Method	Findings/Gap
Shiyanbola & Olaleye (2022)	2022	An investigation of housing provision strategies adopted by private developers in Lagos, Nigeria	Quantitative research	Pre-sale and turnkey housing solutions could help Nigeria's housing deficit, hence private developers should be encouraged to use them.
Atamewan (2022)	2022	Appraising Users' Satisfaction in Public Housing: A Case study of Crospil Housing Estate, Akpabuyo, Cross River State, Nigeria	Questionnaire administration, physical observation, measurement of spaces, interviews and review of the literature.	The study came to the conclusion that everyone should have access to neighborhood amenities and the fundamental functional areas needed in each dwelling unit, regardless of the users' economic level.
Sotonye & Ihenetu (2022)	2022	Informal Sector and Economic Growth in Nigeria	Survey	The results demonstrated that the growth of Nigeria's economy has been significantly aided by the informal sector.
Maina (2021)	2021	An assessment of residential satisfaction in public housing using Housing Habitability System Framework in Gombe, Northeast Nigeria	Mixed methods	Onibokun's Housing Habitability System was used in the study to measure the housing environments in Gombe, Northeast Nigeria, and it was proven to be a credible framework for gauging resident happiness. They came to the conclusion that the neighborhood's features, housing conditions, and dwellings were generally unsatisfactory to the people.
Dawaye (2021)	2021	Assessment of Residential Buildings Condition In Government Built Housing Estates of Port Harcourt Municipality, Nigeria	Quantitative research Questionnaire, physical observation and digital camera were the tools used for data collection	According to the research findings, 81.5% of the buildings in public housing estates have a solid foundation, 92.6% of the windows are in good shape, and 95.4% of the buildings have a water system. In general, 65% of respondents thought the estates' housing conditions were good (needing no repairs), while 35% said they were fair (needing just minor repairs).
Jegede *et al.* (2021)	2021	Assessment of Residential Satisfaction for Sustainability in Public-Private Partnerships (PPPs) Housing Estates in Lagos State, Nigeria	Qualitative research	The study came to the conclusion that better house maintenance procedures, efficient infrastructure, and services could improve the satisfaction experienced by inhabitants of the PPP housing estates evaluated.

Adama (2020)	2020	Abuja is not for the poor: Street vending and the politics of public space	Qualitative research	The Impact of Socio-Cultural and Economic Housing Features on Population Growth in Public Residential Estates: Towards City Resilience
Saidu & Yeom (2020)	2020	Success Criteria Evaluation for a Sustainable and Affordable Housing Model: A Case for Improving Household Welfare in Nigeria Cities	Document content analysis and a survey for household validation	According to the study, social and environmental sustainability in housing should increase household satisfaction by ensuring the safety and welfare of its occupants, adapting to its immediate environment, being acceptable, being supported by social amenities to integrate the community through participation, and, finally, managing household utility costs effectively.
Equere *et al.,* (2020)	2020	Towards City Resilience: The Influence of Socio-cultural and Economic Features of Housing on Population Growth in Public Residential Estates	A questionnaire survey	The most important factors in explaining the rising population in the sampled public housing estates were the availability of economic activities, the diversity of ethnic groupings, and the calibre of services.
Orekan & Adebimpe (2019)	2019	A Review of Public Housing Delivery System in Ogun State, Nigeria	Literature review	This study also revealed that Ogun State Housing Cooperation (OSHC) is more focused on making money than providing social welfare. Because of this, housing has become more expensive for low- and middle-income individuals.
Unah (2019)	2019	Residential housing redevelopment and its impact on Asokoro district of Abuja, Nigeria	A quantitative method was adopted in this study, using structured close-ended questionnaires as a means of collecting data	According to the findings, people started renovating and converting housing in order to add essential commercial amenities that the government did not offer. The research came to a conclusion by highlighting, among other things, the refusal to allow revised building plans on already approved building plots since it goes against the perception of the relevant authorities.
Dimuna & Olotuah, (2019a)	2019	Assessing Residents' Satisfaction with Planning and Neighbourhood Facilities of Some Public Housing Estates in Benin City, Nigeria	Questionnaire survey	The findings indicated that all of the estates' relative satisfaction index scores were within the range of "fairly satisfied" (RSI: 2.1-3.0), which suggests that locals are generally happy with the estate planning circumstances.

Dimuna & Olotuah, (2019b)	2019	Evaluation of Residents' Satisfaction with Building Features in Some Public Housing Estates in Benin City, Nigeria	Quantitative research	The research comes to the conclusion that maintaining a minimum level of functionality, structural integrity, and aesthetic appeal will increase resident satisfaction with their homes.
Farinmade *et al.* (2018)	2018	Assessing the effect of urban informal economic activity on the quality of the built environment for sustainable urban development in Lagos, Nigeria	A Case study	In residential neighborhoods, the presence of informal economic activity has the potential to degrade the quality of the environment by causing aesthetic disorder, intrusion on land use circulation, visual blockage, and careless garbage disposal.
Ibem *et al.* (2018)	2018	Residential Satisfaction Among Low-Income Earners in Government-Subsidized Housing Estates in Ogun State, Nigeria	Quantitative – questionnaire survey	The residents' satisfaction with their homes' privacy and size of the main gathering places was generally high; their level of satisfaction with the estates' economic climate was lower.
Akinde (2018)	2018	A Comparative Analysis Of Residential Quality Of Public And Private Estates In An Urban Centre Of Lagos, Nigeria: A Case Study Of Iba Estate In Ojo And Unity Estate In Alimosho	Mixed methods – questionnaires, observations and pictorial documentation.	According to research, setbacks are absent from private estates while they are present in public estates but are occupied by roadside businesses. Private estate security is of a better calibre than that of public estate. Private estates have superior roads than public estates, which have a decrepit and badly maintained road network. Both estates have a reliable source of electricity.
Mukhtar *et al.* (2017)	2017	Critical Success Factors(CFS) for public housing projects in developing countries: a case study of Nigeria	Mixed methods – Questionnaires and Interviews	The study creates seven CSFs in Nigeria for PHPs. These include: (1) the institutional framework for public housing; (2) the availability of qualified personnel; (3) efficient project management; (4) sound maintenance management procedures; (5) suitable design and location; (6) a successful housing finance system; and (7) sufficient political support.
Chiamaka & Aduwo (2019)	2019	Evaluation of sustainability concepts in public housing projects in ogun state, nigeria	Mixed methods with questionnaire and interviews	According to the study's findings, the state's housing agencies should prioritize the provision and upkeep of public amenities in order to increase resident satisfaction. They should also use adaptable spaces when designing homes in order to accommodate unforeseen

	family growth and raise residents' quality of life.

4. Discussion

The papers collectively highlight the challenges and issues related to housing transformation in Nigeria. They emphasize the prevalence of poor housing quality and homelessness in urban areas despite government policies aimed at addressing the housing shortage. The papers discuss the negative consequences of inadequate housing, such as overcrowding, inadequate infrastructure, and increased poverty and social vices. They also emphasize the need for sustainable housing development and official intervention to reduce homelessness and improve housing conditions. The papers call for strengthening institutions, overhauling systems and processes, and recognizing housing as a social responsibility. They also highlight the effects of urbanization on housing demand and the need for addressing inequalities and developing a national land use policy. The papers collectively provide insights into the effects of housing transformation and urbanization on housing in Nigeria. Aduwo (2017) focuses on housing transformation in public residential estates in Lagos, highlighting the socio-economic characteristics of those engaged in housing transformation and the methods they employ. Adeyemi (2019) discusses the impact of urbanization on housing demand in Nigeria, emphasizing the lack of access to land for housing development and the increasing demand for housing units. Nwalusi (2022) examines the impact of rural-urban migration and urbanization on public housing delivery in Enugu, highlighting issues such as housing shortage, high rent, and the emergence of squatter settlements. Gethsemane (2018) assesses the role of mortgage banks in housing development in Nigeria, emphasizing the importance of mortgage financing and the need for accessible funds for property development. In summary, these papers collectively suggest that housing transformation, urbanization, and the role of mortgage banks have significant effects on housing in Nigeria, including issues related to housing demand, access to land, housing shortages, and the need for affordable housing solutions.

Additionally, Chiamaka and Aduwo (2019) emphasized the importance of considering public amenities and adaptable spaces in the design and location of housing projects. The provision and maintenance of public amenities within a housing estate can contribute to the overall transformation and livability of the area, potentially attracting economic activities that enhance socio-economic development. Ibem *et al*. (2018) found that residents in government-subsidized housing estates in Nigeria had lower satisfaction with the economic climate of the estates. This suggests that the presence and location of economic activities within the estate may affect residents' perception of the overall transformation and development of the housing estate. Akinde (2018) compared public and private housing estates in Nigeria and observed that private estates had better road networks and superior security compared to public estates. The presence and location of economic activities within the estates also differed between the two types. Setbacks occupied by roadside businesses were prevalent in public estates, which may have influenced the transformation and quality of the housing estate. The papers collectively suggest that economic activities have a significant impact on housing transformation in Nigeria. Aduwo (2017) found that housing transformation in public residential estates in Lagos was mainly carried out by low-income household heads with large families, and it was often done without building plans and authorizations. Egidario (2016) highlighted that urbanization in Nigeria has led to the proliferation of urban slums and exacerbated housing challenges for low-income earners. Olugbenga (2017) emphasized the potential of the housing sector in Nigeria to address the housing deficit and stimulate economic growth through interventions by the government and involvement of the informal sector. In summary, economic activities in Nigeria, such as low-income earnings and urbanization, contribute to housing transformation and pose challenges for affordable housing. Methodologies used by most of the authors are both mixed methods and quantitative methods. Summary of the methodology used are shown in Table 3 below:

Table 3: Summary of methods used in reviewed article papers

Methodology	**Authors**
Mixed Methods	Chiamaka and Aduwo (2019), Mukhtar *et al*. (2017), Akinde (2018), Maina (2021), Atamewan (2022),
Quantitative	Ibem *et al*. (2018), Dimuna and Olotuah (2019b), Dimuna and Olotuah (2019a) Unah (2019), Equere *et al*. (2020), Dawaye (2021), Shiyanbola and Olaleye (2022).
Qualitative	Adama (2020) Jegede *et al*. (2021,

5. Conclusions

The collective findings of these studies shed light on the effects of housing transformation and urbanization on housing in Nigeria. Aduwo (2017) examines housing transformation in public residential estates in Lagos, highlighting the socio-economic characteristics of those involved and the methods employed. Adeyemi (2019) discusses the impact of urbanization on housing demand, emphasizing land scarcity and the growing need for housing units. Nwalusi (2022) explores the influence of rural-urban migration on public housing delivery in Enugu, addressing housing shortages and the emergence of squatter settlements. Gethsemane (2018) assesses the role of mortgage banks in housing development, stressing the importance of mortgage financing and accessible funds for property development. In summary, these articles indicate that housing transformation, urbanization, and mortgage banks significantly impact housing in Nigeria, including factors such as housing demand, land accessibility, shortages, and affordable solutions. The inclusion of public amenities and the location of economic activities within housing estates also affect their transformation and livability.

Furthermore, from the publications studied specifically addressed the economic consequences of housing change in Nigerian public housing Estates. The impact of housing's socio-cultural and economic characteristics on population increase in public housing estates is examined by Equere *et al*. (2020). The study discovered that the accessibility of economic opportunities, ethnic variety, and the standard of services were all important contributors to the population growth in the tested public housing estates. Additionally, Unah (2019) investigates the effects of residential housing reconstruction on Abuja, Nigeria's Asokoro neighborhood. According to the research, people were remodeling and converting homes to provide the essential business amenities that the government did not supply. The report also emphasized the government's resistance to approving updated building plans on previously approved properties. In summary, the location of economic activities within a housing estate can have multifaceted effects on the estate's transformation. It can influence the quality of life for residents, property values, social dynamics, and the overall character of the community. Therefore, careful planning and management of economic activities within housing estates are essential to ensure a harmonious and thriving living environment. And judging from the limited number of available research on the impact of economic activities to the housing transformation within Nigeria there is a research gap waiting to be looked into.

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Influence of Rice Husk Ash (RHA) on the Sorptivity and Water Absorption Characteristics of Sachet Water Waste Fibrous Concrete

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Abstract

Concrete, the world's most widely used construction material, significantly contributes to global carbon dioxide emissions through cement production. This study investigates an eco-friendly alternative: fibrous concrete incorporating Rice Husk Ash (RHA) and sachet water waste as partial cement replacements. The objective is to evaluate the sorptivity and water absorption properties of this innovative concrete mix. The research methodology involved preparing concrete samples with varying proportions of sachet water waste fibres (0%, 0.5%, and 1.0% by volume) and RHA as a supplementary cementitious material. Aggregates and Portland cement completed the mix design. Water absorption and sorptivity tests were conducted on the hardened concrete specimens. Results indicate that the addition of sachet water waste fibres to RHA-containing concrete led to a decrease in both sorptivity coefficient and water absorption rates. This improvement is attributed to the enhanced density of the concrete matrix, likely due to the elasticity limit of the fibres. The study concludes that incorporating sachet water waste fibres and RHA in concrete can potentially improve its durability properties while addressing environmental concerns related to waste management and cement production. Further research is recommended to optimize the mix design and explore additional performance characteristics of this sustainable concrete alternative.

Keywords: Sorptivity, Water absorption, Fibrous concrete, Rich husk ash (RHA), Sachet water waste.

1. Introduction

Concrete, the world's most widely used construction material, has undergone significant evolution since the early 20th century. From modest compressive strengths of 13.8 MPa in the 1900s to modern high-performance concretes (HPCs) reaching 140 MPa, the advancement in concrete technology has been remarkable (Naik, 2008). Research on the durability and performance of concrete accelerated due to concerns about deterioration, long-term poor performance, and inadequate resistance to harsh environments. These factors, combined with growing architectural demands, drove advancements in the microstructure of cement and concrete and the development of more detailed codes and standards (Alengaram *et al*., 2013). Recent studies have demonstrated further progress, particularly in the development of ultra-high-performance concrete (UHPC) with compressive strengths exceeding 140 MPa, enhancing durability and environmental resistance (Safiuddin *et al*., 2021).

The development of High-Performance Concrete (HPC) marks a significant milestone in this evolution. HPC is characterized by its superior strength, durability, and performance, achieved primarily through the reduction of voids in the concrete matrix (Li *et al*., 2021). This improvement in microstructure not only enhances mechanical properties but also significantly impacts the concrete's resistance to environmental factors. In recent years, the focus has shifted towards sustainable concrete production, with particular emphasis on the use of Supplementary Cementitious Materials (SCMs). These materials, often industrial by-products, serve a dual purpose: they reduce the environmental impact of concrete production while enhancing its properties. Among these SCMs, Rice Husk Ash (RHA) has gained significant attention due to its high pozzolanic activity and abundance, especially in rice-producing countries (Thomas, 2018).

RHA, derived from the controlled burning of rice husks, is rich in amorphous silica. When incorporated into concrete, it reacts with calcium hydroxide produced during cement hydration, forming additional calcium silicate hydrate (C-

S-H) gel. This reaction not only improves the strength of the concrete but also enhances its durability by refining the pore structure (Zeyad *et al*., 2022). Recent studies have shown that the optimal replacement of cement with RHA can lead to significant improvements in concrete properties, with 20% replacement often cited as the optimum dosage (Muthadhi and Kothandaraman, 2013). Concurrent with the development of SCMs, the use of fibre reinforcement in concrete has gained traction. Fibres, whether synthetic or natural, contribute to crack resistance and overall durability of concrete structures. In the context of sustainability, the use of waste materials as fibre reinforcement presents an innovative approach to waste management and concrete enhancement. Sachet water waste, a prevalent environmental issue in many developing countries, offers potential as a source of synthetic fibres for concrete reinforcement (Afroughsabet *et al*., 2019).

The durability of concrete is intrinsically linked to its ability to resist the ingress of water and harmful substances. Two key properties in this regard are sorptivity and water absorption. Sorptivity, which characterizes the material's ability to absorb and transmit water through capillary action, is particularly relevant for above-ground structures exposed to rainwater and humidity. Water absorption, on the other hand, relates to the total volume of water that can be absorbed by the concrete, indicating its open porosity (Kurda *et al*., 2019).

While previous research has extensively studied the effects of RHA on concrete strength and permeability, there is a gap in understanding its impact on sorptivity and water absorption, particularly in fibre-reinforced concretes using waste materials. This study aims to bridge this gap by investigating the influence of RHA on the sorptivity and water absorption characteristics of sachet water waste fibrous concrete. By combining RHA as a partial cement replacement with sachet water waste as fibre reinforcement, this research not only addresses the need for sustainable concrete solutions but also explores the synergistic effects of these materials on concrete durability. The findings of this study have the potential to contribute to the development of more resilient and environmentally friendly concrete formulations, particularly suited for regions where both rice husk and sachet water waste are abundant.

As concrete technology continues to evolve, understanding the complex interactions between supplementary cementitious materials, fibre reinforcement, and the resulting concrete properties becomes increasingly crucial. This research aims to contribute to this body of knowledge, offering insights that could inform future developments in sustainable and high-performance concrete technology.

2. Material and Method

2.1 Materials

The materials used in this study include fine aggregate, coarse aggregate, water, superplasticizer, rice husk ash (RHA), and Portland cement.

The Portland Cement (PC) for this study was Dangote brand (3X) whose properties conform with ASTM Type 1. It was purchased from a cement store in Gidan-Kwano, Minna, Niger State. River sand with the maximum nominal size of 5mm was used as fine aggregate (FA) for this study. It was tested for 4.5mm sieve percentage passing, specific gravity on the saturated surface dry basis, oven dry basis bulk density, and sieve analysis, ASTM C136 recommendation was strictly adhered to for the fine aggregate sieve analysis. Therefore, the fine aggregate was well-graded. Fine aggregate are those materials that pass through the 4.75 BS sieve size and they include sharp sand. Sharp sand used in this study was gotten from a building material dealer in Minna, Niger state and transported to Building Department. All through the study, a normal tap water supply was used for the concrete mixing, specimen curing and for other purposes that relate to the experiments. (ASTM C1602/ C1602M – 12).

A crushed granite of 10mm nominal maximum size, obtained from the quarry was used as coarse aggregate (CA) in this study. The coarse aggregate was also tested for specific gravity on the saturated surface dry basis, oven dry basis bulk density, absorption, sieve analysis. ASTM C136 recommendation was strictly adhered to for the coarse aggregate sieve analysis. ASTM C127 was followed in determining the coarse aggregate specific gravity. The coarse aggregates used in this study were assumed to be saturated surface dry when the mix design was done. They are those retained on the 4.75 sieve size. The rice husk was gotten from Kure market in Minna, Niger State. The husk was dried and burnt in open air to get the ash which act as the pozzolana in the concreting material. To achieve the desired and targeted slump with low water-cement ratio and also a good workability, a chloride-free superplasticiser containing a synthetic polymer under the commercial name of Hydroplast - 300 from Armorsil Chemicals Company was added to the concrete mix. It complies with the specification of ASTM C 494 Type A and F.

2.2 Methods

2.2.1 properties of constituent materials.

The chemical compositions of SCM (RHA) were conducted at the *labour*atory of Lafarge Plc Lagos State using the XRF spectrometry machine. About 100g of RHA was packaged in sealed polythene bags and sent after the calcination, grinding and sieving for oxide compositions determination in accordance with BS EN 196-6: 2016. The

particle size distribution of the aggregate's samples (i.e. the sieved sand and granite stone) was determined by wet sieving while the specific gravity of the aggregate and binders were also determined in the Building *Labour*atory of FUT, Minna.

2.2.2 Production of Fibrous concrete

The concrete mix proportions were designed based on Department of the Environmental (DOE) methods of concrete as presented in table 1 below. A verification of the mix design was done using the outcome of the trial mixes test. RHA suitable mix design and appropriation mixing procedure were developed after several trial mix has been conducted. Sequel to batching, the total batch volume was first calculated based on the required mix proportion. During the batching process, about 15% of the estimated concrete quantity was added to cater for waste that may cause ensue during mixing and casting. Although the mix design was based on the absolute volume of the concrete, the equivalent weight of the respective constituent materials was used for batching. For a uniform RHA distribution in the concrete mixture, the water required for the mixing was weighed.

Table 1: Mix proportion for trial mixes

Mix	CEMENT [kg/m^3]	RHA (%)	RHA [kg/m^3]	Water [kg/m^3]	FA [kg/m^3]	CA [kg/m^3]	V_f (%)	V_f [kg/m^3]
PC	521	-	-	250	784.5	784.5	-	-
RHA	442.85	15	78.15	250	784.5	784.5	-	-
PC2	521	-	-	250	784.5	784.5	0.5	43
RHA2	442.85	15	78.15	250	784.5	784.5	0.5	43
PC3	521	-	-	250	784.5	784.5	1.0	126
RHA3	442.85	15	78.15	250	784.5	784.5	1.0	126

Where PC represent Portland cement, RHA1 represent trial mix with 0% fibre, PC2 represent plain concrete with 0.5% fibre, RHA2 represent concrete with RHA and 0.5% fibre, PC3 represent plain concrete with1.0% fibre, RHA3 represent concrete with RHA and 1.0%fibre.

2.2.3 Fresh and Strength Properties

This type of test is carried out to investigate and determine the physical properties, fresh properties, Sorptivity and water absorption behaviour of a fibrous concrete containing RHA, which is the main focus of this research work. The objective of the test is to determine the Sorptivity and water absorption behaviour of synthetic fibrous concrete containing high RHA.

3. Results and Discussion

Table 2 below is the result of the chemical analysis of RHA which was burnt in open air and analyzed in Lafarge cement company, for its pozzolanic constituents. The RHA sample has silica (SiO_2**)** content of 83.79%. The Table reveal the agro waste ash has Class N Pozzolan with total SiO_2+Al_2O_3+Fe_2O_3 above 70%, SO_3 below 4% and loss on ignition (LOI) of less than 10% maximum, an indication that no heat treatment will be required for more effective performance of the material.

Table 2: Oxide Composition of Binders (PC and RHA)

Oxide	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	K_2O	P_2O_5	TiO_2	M_2O_5	Loss on Ignition	SiO_2 + Al_2O_3 + Fe_2O_3
RHA (%)	1.26	83.76	0.54	1.38	1.55	1.56	6.29	0.20	0.29	2.93	85.71

Figure 1 and Table 3 and 4 show the physical properties of the aggregate used for the study. From the result reveals that the fine aggregate is in conformity to the medium sand classification of Shetty (2004) having a uniformity coefficient (C_u) of 2.96, coefficient of curvature (C_c) of 0.91 and finenessmodulus (FM) of 2.58. The coarse aggregates used for the study have a coefficient of uniformity (Cu) of 1.32 and coefficient of curvature (Cc) of 0.92 and belong to the class of uniformly graded stone.

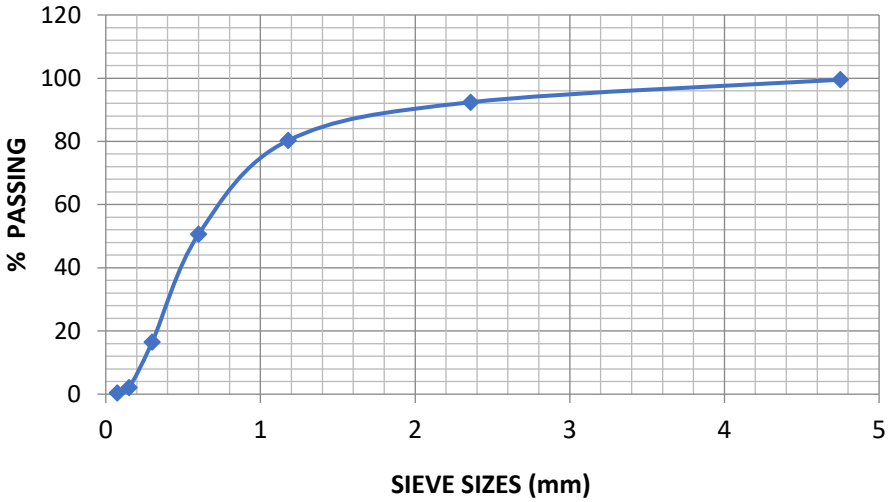

Figure 1: Particle size distribution of aggregates

Table 3: Physical properties of fine aggregate

Properties	Test value	Max. Allowable value	Relevant standards
Material finer than 75um	0.4%	3%	ASTM C33, C177
Oven dry Bulk density (unit weight)	1648 kg/m^3	1600-1700	Kosmatka *et al*., 2002
Specific gravity on sat surface dry basis	2.64%	2.4-3.0%	Neville, 2011
Evaporated Moisture content	0.12%	0.05-0.80%	Neville, 2011
Water Absorption	1.59%	0.2-3.15%	Neville, 2011

Table 4: Physical properties of Coarse aggregate

Properties	Test value	Max. Allowable value	Relevant standards
Bulk density (unit weight)	1635 kg/m^3	1200-1750	Kosmatka etal., 2002
Specific gravity on sat surface dry basis	2.90%	2.4-2.90%	Neville, 2011
Evaporated Moisture Content	0.65%	1.0-1.13%	Neville, 2011
Water Absorption	1.59%	0.2-4.5%	Neville, 2011

3. 1 Properties of Fresh concrete

3.1.1 Workability Test

Various workability tests were carried out on the concrete which includes: Slump test, Vebe test as well as Compacting factor test. Slump test, Vebe test were carried out on all the concrete mixes including mixes with and without fibre. The slump tests and vebe test were carried out according to ASTM C143 and ASTM C1170 respectively. Table 4 below shows the result of slump and vebe test for all the concrete mixes.

Table 5: Workability Test Properties of Concrete

Specimen ID	Varyof fibre	RHA %	Plasticizer %	Slump	Vebe (S)	Compacting factor	Fresh density(kg)
Aa	0			173	3.60	0.98	
Ab	0.5	0	0	168	4.12	1.0	1.90
Ac	1.0			160	4.48	1.0	
Ba	0			110	6.30	0.96	
Bb	0.5	15	0.2	95	6.04	0.99	1.90
Bc	1.0						

Where Aa =plain concrete with 0% fibre, Ab=plain concrete with 0.5% fibre, Ac= plain concrete with 1.0% fibre, Ba=RHA concrete with 0% fibre, Bb=RHA concrete with 0.5%, Bc=RHA concrete with 1.0% fibre. The results presented in Table 5 reveal a clear trend in the workability of fibrous concrete mixtures. As the fibre content in the concrete increases, there is a corresponding decrease in the slump value. This relationship suggests that the addition

of fibres has a significant impact on the concrete's workability. Also, the plain concrete mixture, containing 0% fibre, has the highest slump value among all samples tested. This serves as a useful baseline, highlighting the effect that even small amounts of fibre can have on concrete workability.

3.1.2 Fresh Density of Concrete

The fresh density of concrete was obtained after full compaction of the concrete in a cylinder of 6.03 volume was weighed. The weight of the cylinder was subtracted from the overall weight of concrete + cylinder and the results were divided by the volume of cylinder accordingly. Figure 2 below shows the fresh density values for all the mixes.

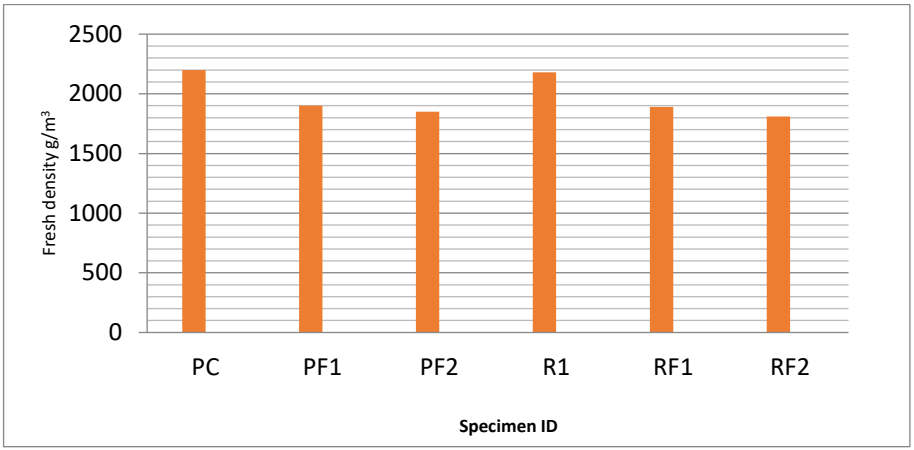

Figure 2: Fresh Density of Concrete

PC=plain concrete, PF1and PF2= Cement + agg + fibre (0.5and 1.0) respectively, R1= RHA based concrete, RF! And RF2= RHA based concrete + fibre (0.5 and 1.0) respectively. From the results thus far, it can be noticed that the fresh density of concrete containing fibre is lesser than that without fibre.

3.2 Hardened Properties Test of Fibrous Concrete containing RHA

3.2.1 Compressive Test

Table 6 below shows the result of the comparison of the compressive test of a concrete containing RHA and a fibrous Concrete Containing RHA. From the result it was deduced that the compressive strength values for concrete mixes without fibre is more than mixes containing fibre at 7 and 28days of curing. However, it can also be noticed that the compressive strength of mixes containing RHA is more than mixes without RHA at 7 and 28days of curing age.

Table 6: Compressive test result

Compressive Strength (N/Mm²)						
RHA Content	0%			15%		
Specimen ID	PC	PF1	PF2	R1	RF2	RF3
Curing Ages/ VF	0%	0.5%	1%	0%	0.5%	1%
7days	20	16.5	6.97	22	18	
28days	33			35		

3.2.2 Sorptivity and Water Absorption Test of Fibrous Concrete

The sorptivity test of the specimen casted for 7,28 and 56 days was tested at 3,5,9,12,16,20 and 25 minutes respectively. The absorption rate of specimen containing RHA with fibre is higher compare to plain concrete with fibre. The figures insinuate that along with the curing time, the use of RHA in concrete had a good result on the sorptivity rate of concrete. The water absorption behaviour of a fibrous RHA concrete and PC was taken for specimen at 7,14,28 and 56days respectively. From the water absorption behaviour of both concrete, it was deduced that a plain fibrous concrete containing sachet water waste at 0.5% and 1.0% respectively has a higher absorption rate compare to an RHA fibrous concrete. The figure and table below show the result obtained from the test carried out on fibrous concrete.

Table 7: Water Absorption table

Specimen	Dry wt in (kg)		Wet wt in(kg)		%Water absorption	
Days	14days	28days	14days	28days	14days	28days
PC0.5%	2.08	2.11	2.13	2.25	2.40	2.11
RHA0.5%	2.19	2.11	2.26	2.23	3.19	2.11
PC1.0%	2.23	2.17	2.3	2.3	3.14	2.17
RHA1.0%	1.97	2.08	2.11	2.21	7.11	2.08

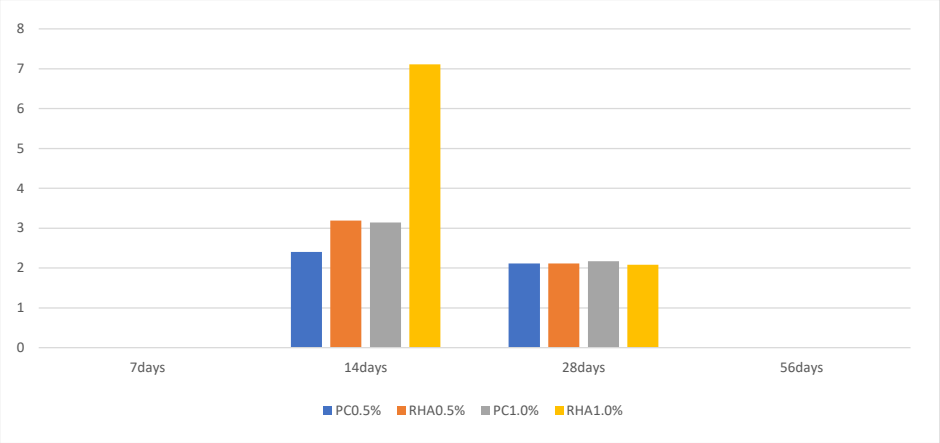

Figure 3: Water Absorption of Fibrous Concrete

3.3 Summary of Finding

Based on the results of the experiment carried out to determine the sorptivity and water absorption of a synthetic fibrous concrete containing RHA the following findings were obtained;

1. The specimen during oven drying was flaking.ie efflorescent occurring in which white particles are on the surface of the specimen
2. During water absorption test, there are bubbles forming due to the substance used for the extraction of moisture from the specimen after ovendrying.
3. The absorption rate of a plain fibrous concrete is higher than the RHA fibrous concrete.
4. The compressive residual strength of a plain concrete is higher than the strength of an RHA fibrous concrete.

4. Conclusion

This research investigated the influence of Rice Husk Ash (RHA) on the sorptivity and water absorption characteristics of fibrous concrete incorporating sachet water waste. The study aimed to explore sustainable alternatives in concrete production by utilizing agricultural and plastic waste materials. The following conclusions can be drawn from the experimental results and subsequent analysis:

1. The chemical and physical properties of RHA were thoroughly examined and presented. The results indicate that RHA possesses pozzolanic properties suitable for partial cement replacement in concrete mixtures.
2. RHA demonstrated potential as a partial replacement for cement in concrete production. This finding has significant implications for reducing the carbon footprint associated with cement manufacturing while maintaining concrete performance.
3. Sachet water waste, when processed into synthetic fibres, showed promise as a binding agent in plain concrete. This discovery presents an innovative approach to plastic waste management and concrete reinforcement.
4. This research demonstrates the potential for transforming abundant agricultural waste (rice husks) and plastic waste (sachet water packaging) from potential environmental hazards into valuable, natural building materials. This approach aligns with circular economy principles and sustainable construction practices.

In conclusion, this research contributes to the growing body of knowledge on sustainable concrete technology. By demonstrating the feasibility of incorporating Rice Husk Ash and sachet water waste fibres in concrete, it offers a promising approach to addressing both waste management challenges and the need for eco-friendly construction materials. The findings support the potential for developing high-performance, environmentally responsible concrete solutions that can contribute to more sustainable construction practices globally.

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Assessment of Fire Safety Measures in The Design of Shopping Malls, Abuja

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Abstract

A shopping mall is a large retail complex managed as a single property, which includes stores and restaurants in nearby buildings or one large building in which growth tends to be most rapid. The rapid growth in the population of Nigeria has led to the incidence of many disasters and emergencies that involve fires caused by combustible materials. Fire safety remains a critical concern in shopping malls, particularly in densely populated urban areas like Abuja, Nigeria. The study examines the potential hazards and vulnerabilities that contribute to fire incidents in shopping malls and how mitigation measures can be taken to prevent such occurrences It also seeks to discover the appropriate measures currently implemented to address these issues and to develop effective fire safety and evacuation plans. A closed-end structured questionnaire was employed to gather data from the research is a case study that adopted quantitative research approach. Data was gathered from 237 participants with the use of a closed-end structured questionnaire that was analysed. The findings indicate that significant fire hazards in shopping malls include electrical failures, improper storage of combustible materials, and overcrowding. The study also identifies existing fire safety measures and gaps in emergency preparedness. To improve safety outcomes, the research recommends comprehensive strategies, such as advanced fire suppression technologies and clearly defined evacuation routes.

Keywords: fire safety, shopping mall, measures, risk assessment, Nigeria.

1. Introduction

In recent years, the business sector especially retail, has experienced significant growth. Nigeria is no exception, with an increasing number of shopping malls being constructed nationwide (Dankani *et al*., 2022). According to (Makhitha, 2023), shopping malls are evolving into innovative structures that cater to contemporary customers, departing from traditional retail centres and becoming increasingly active. Within the literature on consumption, malls, and modern, two theoretical concepts that view malls as extensions of global modernity and collective consumption have been identified as central to this study's findings and form the basis for our analysis (Eduful & Eduful, 2022). These concepts perceive malls as an extension of global modernity and as a manifestation of collective consumption. Furthermore, these concepts serve as the foundation upon which our analytical framework is built. Despite this growth, ire safety is critically important in shopping malls, especially in densely populated urban areas such as Abuja, Nigeria. Many Nigerian shopping malls overlook fire safety measures during both the planning and construction phases (Bayo & Kayii, 2020). From the beginning of the design process, an architect may guarantee that a building, its occupants, and its contents are sufficiently protected from beginning to end by incorporating security and safety considerations (Hanif, Sowemimo Damilare; Ugwoke Ifunanya Jasmie, 2021). The aim is to achieve a comprehensive understanding of fire safety measures incorporated in shopping malls within Abuja. Because of the transient population, smoking, and improper storage of combustible goods, malls are more likely to experience fires. The potential risks and hazards of fires in such densely populated areas cannot be ignored. Therefore, it becomes crucial to assess and evaluate the fire safety measures implemented in these shopping malls to identify any gaps or areas that require improvement.

2. Literature review

Shopping malls is group of retail businesses built on a site that is planned, developed, owned, and managed as a unit (Krowicki & Maciejewski, 2023). These large retail establishments, usually located in the suburbs outside the city centre and the traffic congestion are a group of diverse retail shops combined in a single, specific plan (Van Nes, 2021). Shopping malls according to the International Council of Shopping Centres is defined as a group of retail and other commercial establishment that has been planned, developed, owned and managed as a single property with the provision of its own on-site parking (Kimpton *et al*., 2021). There have been conflicts in its definition with that

of a shopping centre. They are however used interchangeably but shopping malls can be distinguished in that it houses many shops inside, could be on two or three floors with several large stores on the end while a shopping centre could be a shopping mall but actually a shopping destination (Iroham *et al*., 2019). These establishments are critical for urban development as they provide goods, services, and employment, yet their complex structures and large crowds necessitate strict safety measures.

2.1 Overview on Fire Safety

Fire is a rapid oxidation process that usually involves oxygen and fuel and produces heat and radiation. Class C fires are electrical, Class D fires are metal, Class K fires are frying oils and fats, Class A fires are solid materials like wood and paper, Class B fires are flammable liquids and gasses (Farrell *et al*., 2023). Electrical problems, such as malfunctioning appliances, and mechanical problems, such as friction, are frequent sources of fire in shopping centers.

Fire extinguishers, smoke and fire alarms, fire signs, fire prevention systems, medical equipment, and fire blankets are examples of instruments and equipment used in fire safety (Rabajczyk *et al*., 2021). Sprinklers, smoke control, and routine equipment maintenance are all effective safety measures in malls. Clear escape routes, training, frequent drills, preventative techniques, and coordination with fire authorities are all included in an extensive fire safety plan. To achieve safe building designs, architects must take fire safety standards, materials, and layout into account. Using fewer combustible materials, creating accessible escape routes, and making sure fire escape routes are law-abiding, functional, and safe are all important considerations. Architectural features work with engineers to employ fire-resistant materials and construction methods, as well as to limit hazards, safeguard lighting, and specify materials.

Shopping malls are essential for providing fire safety features like smoke and sprinkler control, alarms, and signs. On the other hand, the majority of retail centers' fire and escape equipment is not properly maintained. Standardized processes for creating and putting into practice fire safety programs include preventing fires through routine preventative measures, training management and employees on fire safety issues, running emergency procedures and fire evacuation drills, giving out fire safety instructions to the general public and visitors, maintaining fire protection equipment, maintaining buildings, and maintaining fire safety records (Hossain, 2021).

Building layout, fire escape routes, and the materials used in construction are the three main design factors that architects need to take into account when designing residential and commercial buildings in order to ensure fire safety. The way buildings are laid out can have a big impact on how quickly emergency personnel can rescue victims of situations like fires. All buildings, especially those with a significant number of residents, require architects to design safe and feasible fire escape routes. They also need to be knowledgeable about fire safety rules. The literature review emphasizes how modern shopping malls are becoming more sophisticated, which presents both increased risks and economic potential. Although the need for fire safety precautions like sprinklers and evacuation routes is widely acknowledged, research shows that their application is severely lacking, especially in emerging areas like Abuja. This disparity between the intended design and actual results raises serious concerns regarding how safety regulations are enforced. Kimpton *et al*. (2021) show that many malls, especially in Nigeria, either do not install or fail to maintain automatic fire suppression equipment, such as sprinklers, despite their proven value. This implies that although best practices and international standards are widely recognized, local implementation varies. This draws attention to a regulatory gap that compromises the general efficacy of fire protection protocols in commercial centers in Abuja.

The literature also highlights how incorrect storage of flammable goods and overcrowding are major causes of fire occurrences. Although these dangers are recognized by Rahim *et al*. (2014) and Van Nes (2021), their suggested remedies such as routine maintenance and staff training are not frequently implemented because of financial limitations or a lack of enforcement. This implies further that administrative and financial constraints could jeopardize the security of Abuja's shopping centers. Furthermore, the literature continuously emphasizes the importance of planners and architects in creating safer shopping centers. Strategic construction design and the usage of fire-resistant.

3. Research methodology

The study employs in the research is to assess the fire safety measures in the design of shopping malls in Abuja, Nigeria, thus, the study is a case study. It includes the sampling strategy, data collection methods, and data analysis techniques used to achieve the study's objectives. A purposive sampling strategy was employed for this study. This approach was chosen to ensure that the selected participants had relevant experience and knowledge regarding fire safety measures in shopping malls. The sample included key stakeholders such as mall managers, fire safety officers, and architectural designers involved in the planning and operation of shopping malls in Abuja. Due to the significant number of shopping mall in Abuja using Tao Yamane method, from figures received from the 5 shopping malls, the study population of 300 participating in the survey research. A closed-end structured questionnaire was employed

to gather data from the research is a case study that adopted quantitative research approach. Data was gathered from 237 participants with the use of a closed-end structured questionnaire that was analysed with SPSS software. The findings were presented descriptively, with the aid of tables.

4. Result and Discussion

The fire safety precautions evaluated in the architecture of Abuja's commercial centers are thoroughly examined in this chapter. Surveys of important stakeholders, such as mall management, fire safety officers, and patrons, yielded the results, which were then organized to support the goals of the research. In order to answer the study objectives, each outcome is provided, offering a thorough grasp of the fire safety procedures now in place in Abuja commercial malls. This section also assesses how well these efforts have worked to improve emergency readiness in the malls, lower fire hazards, and guarantee occupant safety.

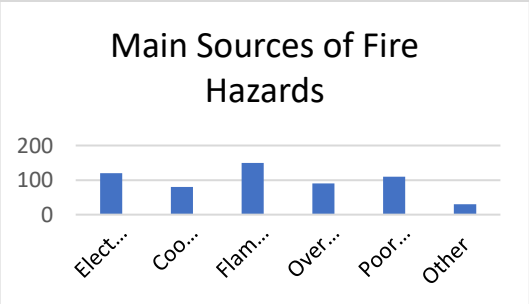
Main Sources of Fire Hazards

The survey results reveal that 45.28% of fire accidents in Abuja commercial malls are caused by electrical failures. This emphasizes how crucial it is to regularly examine and maintain electrical systems in order to lower the danger of fire. A significant danger that affected 56.60% of responders was the inappropriate storage of combustible products. 41.51% of respondents mentioned poor maintenance, highlighting the significance of immediate repairs. Furthermore, hazards included cooking equipment (30.19%) and overcrowding (33.96%), particularly in food courts where crowded areas make escape difficult in an emergency.

These results correspond with those of (Bayo & Kayii, 2020), who also noted that poor maintenance and electrical malfunctions were the leading causes of fires in Nigerian shopping malls In contrast to previous findings, this study places more attention on overcrowding, which may indicate that expanding urban populations are making crowded shopping malls are more vulnerable to fire.

Table 2: Main Sources of Fire Hazards

Fire Hazard	Frequency	Percentage (%)
Electrical faults	120	45.28
Cooking equipment	80	30.19
Flammable materials	150	56.60
Overcrowding	90	33.96
Poor maintenance	110	41.51
Other	30	11.32

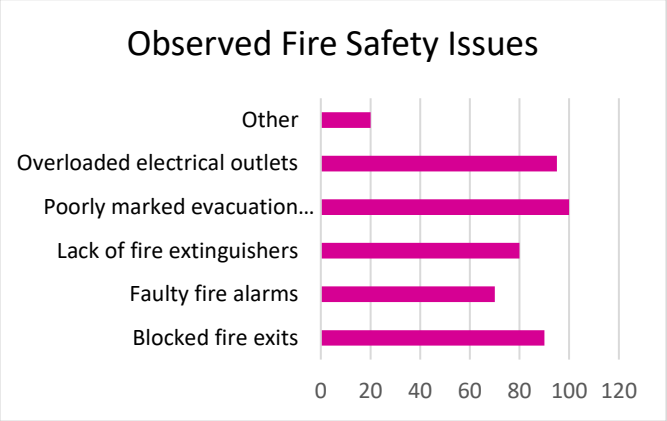


Observed Fire Safety Issues

The data reveals that blocked fire exits, faulty fire alarms, and overloaded electrical outlets are frequent issues, with improperly marked evacuation routes being particularly prevalent. The lack of functional fire safety equipment and clear escape routes indicates gaps in compliance with fire safety regulations, aligning with (Shittu *et al*., 2022) who found similar shortcomings in Nigerian shopping centers. These findings emphasize the need for better maintenance and training programs to ensure malls are adequately prepared for fire emergencies.

Table 3: Observed Fire Safety Issues

Fire Safety Issue	Frequency	Percentage (%)
Blocked fire exits	90	33.96
Faulty fire alarms	70	26.42
Lack of fire extinguishers	80	30.19
Poorly marked evacuation routes	100	37.74
Overloaded electrical outlets	95	35.85
Other	20	7.55

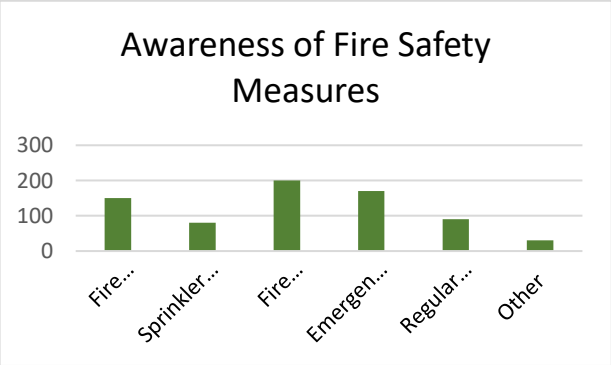


Awareness of Fire Safety Measures

Only 30.19% of respondents were familiar with sprinkler systems, despite 75.47% of them being aware of fire extinguishers, according to the survey, indicating a lack of awareness on important fire suppression equipment. The results of this study indicate that sprinklers are still either unused or poorly understood in Abuja malls,

Table 4: Awareness of Fire Safety Measures

Fire Safety Measures	Frequency	Percentage (%)
Fire alarms	150	56.60
Sprinkler systems	80	30.19
Fire extinguishers	200	75.47
Emergency exits	170	64.15
Regular fire drills	90	33.96
Other	30	11.32



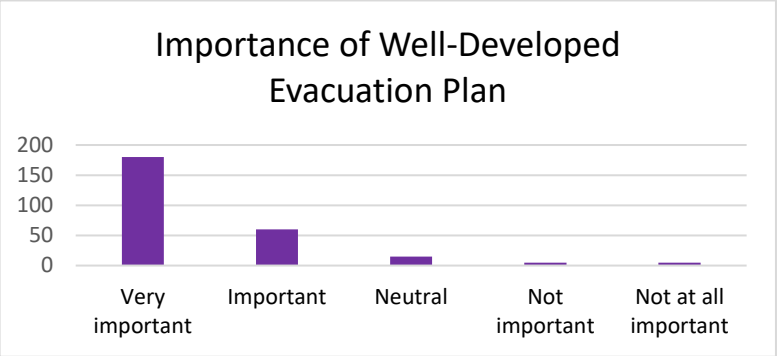
Importance of Well-Developed Evacuation Plan

There is broad agreement in the findings regarding the significance of having a well-thought-out evacuation strategy; 67.92% of participants said it was essential. Nonetheless, a tiny proportion are neutral, maybe as a result of ignorance or insufficient exposure to real-world situations. This disconnect may indicate insufficient exposure to fire drills or awareness campaigns. (Liu *et al*., 2023) also stressed the importance of practical fire safety education,

and these results suggest a need for increased training and real-world drills to ensure all occupants can respond effectively in emergencies.

Table 5: Importance of Well-Developed Evacuation Plan

Importance	Frequency	Percentage (%)
Very important	180	67.92
Important	60	22.64
Neutral	15	5.66
Not important	5	1.89
Not at all important	5	1.89



5. Conclusions

This study successfully investigated the potential hazards and vulnerabilities contributing to fire incidents in shopping malls in Abuja, identifying key factors such as electrical failures, improper storage of combustible materials, and overcrowding. The findings reveal that these issues significantly increase the risk of fire, necessitating immediate attention and action. With 67.92% of participants emphasizing the necessity of a well-developed evacuation plan, it is evident that practical fire safety education and training are essential for enhancing emergency preparedness. Architects and builders bear a legal and ethical responsibility to prioritize fire safety in their designs, ensuring the protection of lives and property in these increasingly popular commercial spaces. Enhanced awareness and implementation of fire safety measures are vital to mitigate risks and safeguard occupants in Abuja's shopping malls. Furthermore, the research highlighted the measures currently implemented to address these fire safety concerns, including the need for regular maintenance and adherence to safety regulations. However, gaps remain in the effectiveness of these measures, particularly regarding emergency preparedness and evacuation protocols.

Based on the objectives of this study, it is clear that developing comprehensive fire safety and evacuation plans is essential. Recommendations include the incorporation of advanced fire suppression technologies, well-defined evacuation routes, and regular fire safety training for both mall management and occupants. By adopting these features, shopping malls can enhance their fire safety standards, ultimately protecting lives and property while fostering a culture of safety within these bustling commercial environments.

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The Impact of Confined Construction Sites Condition on Project Team Health and Safety in Port Harcourt, Rivers State

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Abstract

This study investigates the impact of confined construction sites on project team health and safety in Port Harcourt, Rivers State, Nigeria. The research addresses the growing safety challenges faced by construction teams working in confined sites. Through a quantitative research approach, the study examined multiple confined construction sites to assess how spatial constraints affect workplace safety and identify the most significant risk factors. The methodology employed purposive sampling to select fifteen confined construction sites in Port Harcourt. Data collection was conducted through structured questionnaires distributed to construction professionals, including project managers, structural engineers, safety officers, and site supervisors. Statistical analysis, including descriptive statistics and regression analysis, was used to examine the relationships between confined site conditions and safety outcomes. The findings revealed that limited access routes, restricted movement space, and poor ventilation are the most significant challenges that influence safety outcomes in confined construction sites. Space limitation emerged as the strongest predictor of safety incidents, followed by ventilation issues and restricted access routes. The study also found that material storage constraints and lighting conditions, while important, had a relatively lesser impact on safety outcomes. The research demonstrated a strong relationship between confined site conditions and the frequency of safety incidents, with site conditions explaining a substantial portion of the variation in accident occurrence. The findings highlight the need for specialized safety protocols and management strategies for confined construction sites, particularly in rapidly urbanizing areas. The study's results can inform the development of more effective safety policies and practices that suits confined construction environments. This will ultimately contribute to improved workplace safety in urban construction projects.

Keywords: Confined Construction Sites, Health and Safety, Construction

1. Introduction

The construction industry plays an important role in Nigeria's economic development, especially in rapidly growing urban centers like Port Harcourt, the capital of Rivers State. As the city experiences urban expansion, the demand for infrastructure and buildings has increased which has led to increased construction activity in densely populated areas (Nna, 2012). This urban density has resulted in a rise of confined construction sites which are characterized by limited space, restricted access, and close proximity to existing structures. Confined construction sites present unique and substantial health and safety risks, worsening an already concerning safety record in Nigeria's construction industry (Isah, 2019). The sector, while contributing significantly to the nation's GDP, has been plagued by poor safety practices and high accident rates (Ogbu, 2011; Umeokafor *et al*., 2014). In confined sites, hazards such as limited maneuverability, elevated risks of falls and collisions, inadequate ventilation, and challenges in emergency evacuation are intensified (Manu *et al*., 2018; Abdelhamid and Everett, 2000). These conditions not only affect workers' physical health but also increase stress levels, which may further contribute to accidents. Additionally, the proximity of these sites to public areas raises concerns about the safety of both the construction teams and the surrounding community. Despite an increasing awareness of occupational health and safety in Nigeria, the specific risks associated with confined construction sites, particularly in Port Harcourt, remain underexplored. While previous studies have addressed general construction safety (Idoro, 2011; Diugwu *et al*., 2012), the unique challenges of space-constrained environments in urban areas like Port Harcourt have not been thoroughly examined. This gap in knowledge hinders the development of effective safety management strategies that suits the unique challenges of confined construction sites. Therefore, this study seeks to address this gap by investigating how confined construction site conditions in Port Harcourt impact the health and safety of project teams. The findings aim to inform more effective safety practices and policies that can mitigate risks and enhance worker well-being in Nigeria's fast-growing urban construction sector.

2. Literature Review

2.1 Construction Health and Safety in Nigeria

Health and safety in construction have been the focus of numerous studies globally which reflects the inherent risks of construction activities. This literature review examines general health and safety issues within the construction industry in Nigeria, focusing specifically on confined construction sites in Port Harcourt. It also highlights key gaps in the existing research that this study seeks to address.

2.2 Health and Safety in the Nigerian Construction Industry

It is important to provide secure working environments for construction workers due to the inherent dangers and risks in every construction task (Olutuase, 2014). According to Oresegun (2009), the effectiveness of construction personnel is closely tied to the safety of their working environment. Kheni *et al*. (2008) expanded on this, emphasizing that both the physical and mental well-being of workers, along with those whose health could be negatively impacted by construction activities, must be prioritized. Idoro (2011) highlighted that the construction sector in Nigeria has a poor safety record and one of the highest accident rates among all industries. Umeokafor *et al*. (2014) further noted that the absence of comprehensive national policies on occupational safety and health, specifically suited to the construction sector worsens this issue. Despite the existence of regulations, such as the Factories Act of 1987 and the Labour, Safety, Health, and Welfare Bill of 2012, enforcement remains a major concern (Diugwu *et al*., 2012). Many construction firms in Nigeria, especially small and medium-sized enterprises (SMEs), prioritize profit and project completion over worker safety, as noted by Umeokafor *et al*. (2014). This practice further undermines health and safety efforts. In Port Harcourt, Wokekoro and Owei (2014) observed that rapid urban development and the booming oil-driven economy have led to a rise in construction activities, often in unsafe environments. However, a notable gap exists in the collection of localized data on construction-related accidents in Port Harcourt which indicates a need for more research into the specific health and safety challenges within the city.

2.3 Confined Construction Sites

Confined construction sites are typically characterized by limited space, restricted access, and proximity to existing structures or public spaces (Manu *et al*., 2018). These sites are increasingly common in urban areas like Port Harcourt due to land scarcity and the need for urban regeneration. The spatial constraints inherent in these sites present unique challenges, particularly in terms of health and safety. Ommelein and Zouein (1993) argued that space on construction sites should be managed as critically as other physical resources, as poor spatial management can increase the likelihood of accidents and reduce overall productivity. According to Pradhananga and Teizer (2014), space constraints on urban construction sites lead to additional safety hazards, especially when multiple crews and heavy machinery operate simultaneously within the same confined area. Similarly, Mossman (2008) emphasized that smaller workspaces are often more dangerous due to the increased proximity of workers to machinery, materials, and other potential hazards. Spillane and Oyedele (2013) defined confined construction sites as those where permanent works occupy most of the available footprint, leaving little room for essential operations like material storage, equipment movement, and worker coordination. It is important to differentiate confined construction sites from confined spaces, as defined by the Occupational Safety and Health Administration (OSHA) (2017). Confined spaces refer to spaces that are large enough for worker entry but are not intended for continuous occupancy, such as storage tanks, boilers, or tunnels. These spaces pose additional hazards, including the risk of toxic substances, oxygen deficiency, and flammable gases (Michigan Institute of Safety and Health Administration, 2015). In the Nigerian context, Okoye *et al*. (2016) found that many construction projects lack proper site planning and organization which leads to cluttered and hazardous work environments. These issues are particularly pronounced in confined construction sites, where spatial constraints make the coordination of resources, personnel, and equipment even more difficult.

2.4 Health and Safety Practices in Confined Construction Sites

Managing health and safety in confined construction sites requires unique practices to address the specific hazards posed by limited space, restricted access, and the presence of heavy machinery. Zhao *et al*. (2021) emphasized the importance of comprehensive risk assessments, noting that confined construction sites often introduce additional risks not found in conventional construction environments. These risks necessitate a multidisciplinary approach to risk assessment, involving input from various stakeholders, including project managers, safety professionals, and workers. Li and Peng (2023) highlighted the importance of adequate worker insurance coverage in high-risk environments like confined construction sites. Their study found that sites with comprehensive insurance coverage not only protected workers financially but also incentivized companies to adhere to higher safety standards. A positive correlation was noted between the extent of insurance coverage and overall safety performance on confined projects.

Thompson *et al*. (2022) advocated for the use of digital tools in the documentation and monitoring of health and safety practices on confined sites. Their research showed that the use of digital platforms for real-time safety reporting resulted in a 30% reduction in workplace incidents compared to traditional paper-based systems. This highlights the potential benefits of leveraging technology to improve safety management in confined spaces.

Research by Chen and Wang (2024) demonstrated that construction companies with well-defined, site-specific health and safety policies experienced fewer accidents and injuries on confined sites. Their study emphasized the need for policies that address the unique challenges of confined sites, such as limited access points and restricted movement of personnel and equipment. Other studies underscore the importance of emergency preparedness and proper equipment on confined sites. Rodriguez *et al*. (2023) found that sites with emergency medical kits and properly fitted personal protective equipment (PPE) reported 40% fewer severe injuries compared to sites with inadequate provisions. Kim and Lee (2022) demonstrated that confined sites with full-time safety officers and adequate fire safety equipment experienced 50% fewer fire-related incidents.

Given the limited space in confined construction sites, lifting apparatus and fall protection systems are crucial. Zhang *et al*. (2023) revealed that the use of compact lifting equipment and comprehensive fall protection systems led to a significant reduction in manual handling injuries and fall-related incidents. While the literature on health and safety practices in construction is robust, there is a clear gap when it comes to confined construction sites in Nigeria, particularly in Port Harcourt. The limited research on spatial constraints and site-specific safety challenges indicates a need for more localized studies. Furthermore, despite the presence of safety regulations, enforcement remains weak in Nigeria, and there is little information on how confined site conditions exacerbate these challenges.

This study aims to fill this gap by examining how the confined conditions of construction sites in Port Harcourt affect the health and safety of project teams. By focusing on localized data, this research will provide insights into the specific hazards faced in urban construction environments and offer practical recommendations for improving health and safety standards in these confined spaces.

3. Research Methodology

This study employs a quantitative research design to investigate the effect of confined construction sites on project team health and safety in Port Harcourt, Rivers State, Nigeria. A purposive sampling technique was used to ensure that the selected sites represent confined construction environments. This sampling method was justified by the need to focus specifically on sites that presented the distinct challenges typically associated with confined construction sites. The identification of 15 confined construction sites was achieved through physical site visits, ensuring that the sample was representative of environments facing the issues under investigation. The primary data collection instrument was a structured questionnaire. Reliability testing was conducted using Cronbach's alpha coefficient to ensure internal consistency of the questionnaire. A Cronbach's alpha value of 0.83 was achieved which indicates that the questionnaire is reliable. The data collection involved distributing five questionnaires at each of the 15 identified confined construction sites, resulting in a total of 75 questionnaires. The target respondents included site managers, safety officers, supervisors, and experienced workers who were directly involved in implementing health and safety practices. A total of 70 questionnaires were returned which represents a 93% response rate. Incomplete or improperly filled questionnaires were excluded from the analysis to maintain the integrity of the data. The collected data were analyzed using descriptive and inferential statistical methods. Descriptive statistics were used to summarize the demographic characteristics of respondents and provide an overview of the sample. For the inferential analysis, regression analysis was selected as the primary method to assess the relationship between confined construction site conditions (independent variables) and safety outcomes (dependent variables). Regression analysis was chosen because it allows the study to quantify the impact of multiple site conditions on safety outcomes. This method aligns with the study's objective of identifying how confined site conditions influence health and safety outcome.

4. Findings and Discussion of Results

The study engaged a diverse range of construction professionals, including Safety Officers, Site Supervisors, and project managers, builders, and engineers. Table 1 provides a summary of the background information of the 70 respondents.

Table 6: Summary of Respondents Background Information

Category	Classification	Frequency	Percentage (%)
Professional Role	Project Manager	18	25.7
	Structural Engineer	14	20.0
	Construction Manager	12	17.1
	Health and Safety Officer	11	15.7
	Site Supervisor	9	12.9
	Architect	6	8.6
	Total	70	100
Educational Background	Bachelor's Degree	38	54.3
	Master's Degree	22	31.4
	Higher National Diploma	10	14.3
	Total	70	100
Years of Experience	Less than 5 years	12	17.1
	5 - 10 years	28	40.0
	11 - 15 years	16	22.9
	16 - 20 years	10	14.3
	Over 20 years	4	5.7
	Total	70	100

Source: Field Survey

The data indicates a diverse representation of professionals. Project Managers constitute the largest group, followed by Structural Engineers and Health and Safety Officers which aligns with the study's focus on safety. In terms of educational background, the majority hold a Bachelor's degree, with a notable portion holding Master's degrees, indicating that respondents are well-qualified to contribute insights on construction safety. Regarding industry experience, 40.0% of respondents have 5-10 years of experience, while 22.9% have 11-15 years which reflects a balance between early-career and experienced professionals. The presence of those with over 20 years of experience adds valuable long-term perspectives. Table 2 shows the safety issues on confined construction sites.

Table 7: Safety issues on confined construction sites

Injury Type	Frequency	Percentage (%)
Trips and falls	45	64.3
Strain injuries from repetitive movements	40	57.1
Impacts from falling objects	38	54.3
Compression between materials or equipment	33	47.1
Equipment-related accidents	26	37.1
Excavation cave-ins	22	31.4
Falls from elevations	9	12.9
Electric shocks	4	5.7
Combustion or blast incidents	1	1.4

Source: Field Survey

The analysis of injury patterns in confined construction sites reveals several significant safety concerns that merit careful consideration. The predominant hazard identified was trips and falls, affecting 64.3% of respondents, which represents a substantial occupational risk in confined construction environments. This finding aligns with and extends the work of Orji *et al*. (2016), who identified falls as a primary safety concern in urban construction sites across South-Eastern Nigeria. The higher prevalence in confined sites suggests that spatial constraints may exacerbate traditional construction risks. Strain injuries emerged as the second most significant concern, with 57.1% of respondents reporting strain injuries from repetitive movements. This finding builds upon Ajayi *et al*.'s (2017) research by demonstrating the specific impact of spatial constraints on worker ergonomics. The confined nature of these sites often necessitates awkward working positions and repetitive movements, potentially increasing the risk of strain and musculoskeletal disorders among construction workers. The study revealed that impacts from falling objects affected 54.3% of workers, a finding that corresponds with Olutuase's (2014) research on material handling risks. In confined construction environments, this risk appears to be amplified due to limited storage space and restricted movement paths. The data suggests that compression injuries (47.1%) and equipment-

related accidents (37.1%) represent significant secondary risks, likely worsened by the spatial limitations of confined sites.

A notable finding was the relatively lower incidence of falls from elevations (12.9%) compared to other hazards. This contrasts with some previous studies but may reflect the implementation of more stringent safety measures for elevated work in confined spaces. Less frequent but still concerning were incidents of electric shocks (5.7%) and combustion events (1.4%), suggesting that while these risks are present, they may be better controlled in confined construction environments. The findings extend our understanding of construction safety by highlighting how spatial constraints create distinct risk profiles. As Atubi (2015) observed in the Niger Delta region, construction sites face various environmental and operational challenges. Our research suggests that confined spaces introduce additional complexities to these challenges, particularly in terms of movement patterns and material handling. This analysis contributes to the growing body of literature on construction safety in urban environments, where confined construction sites are becoming increasingly common due to spatial limitations in developing cities. Table 3 shows the ratings of how confined construction sites conditions affect health and safety outcomes.

Table 3: Confined Construction Site Conditions

Confined Construction Site Conditions	Mean	SD
Limited access routes and exit routes on the site increase safety concerns	4.23	0.67
Space limitation on our construction site increases safety risks.	4.12	0.73
Lack material storage space increases safety concerns.	4.10	0.71
Poor lighting due to confined space makes it difficult to work safely.	3.95	0.88
Ventilation issues associated with confined site negatively increases safety concerns.	3.85	0.82

Source: Researcher's Analysis, 2024

The analysis of confined construction sites revealed several significant safety challenges through descriptive statistics. Limited access and exit routes emerged as the primary concern, achieving the highest mean score. This strong agreement among respondents aligns with Thompson's (2022) findings on construction logistics, where restricted access points were found to significantly impair both routine operations and emergency response capabilities. The low standard deviation indicates consistent recognition of this challenge across different construction sites. Space limitations represented another critical concern which reflects the substantial challenges workers face in maneuvering within confined environments. This finding corresponds with Wang *et al.*'s (2023) research, which documented a 40% increase in near-miss incidents in spatially constrained construction projects. The lack of material storage space closely followed as a significant concern, indicating how spatial constraints affect not only movement but also material management practices. Poor lighting conditions and ventilation issues were also identified as substantial safety concerns. The relatively higher standard deviations for these factors suggest more varied experiences across different sites, possibly due to differences in site configurations and management approaches. These findings support Kim and Martinez's (2023) research on the relationship between environmental conditions and worker safety in confined spaces. A regression analysis was conducted to further assess the relationship between confined site conditions and health and safety outcomes. The results are presented in table 4 below.

Table 4: R-squared value

Statistic	Value
R-Squared	0.722
Adjusted R-Squared	0.701
F-Statistic	37.45
Significance	0.000

Source: Researcher's Analysis, 2024

The model demonstrated strong explanatory power with an R-squared value of 0.722, indicating that the identified confined site conditions explain 72.2% of the variation in accident frequency. Table 5 below shows the regression coefficients for each predictor which further provides insight into their influence on health and safety.

Table 5: Regression Co-efficients

Predictor Variable	Coefficient (B)	Standard Error	t-Value	p-Value
Constant	0.665	0.304	2.19	0.032
Space Limitation	0.452	0.105	4.30	0.000
Ventilation	0.398	0.121	3.29	0.002

Access Routes	0.373	0.109	3.42	0.001
Lighting	0.230	0.115	2.00	0.048
Material Storage	0.192	0.117	1.64	0.107

Source: Researcher's Analysis, 2024

The regression coefficients revealed space limitation as the strongest predictor of safety incidents, suggesting that restricted space significantly increases the likelihood of accidents. This finding provides statistical validation for the descriptive results and supports Chen *et al.*'s (2023) research on spatial constraints in construction safety. Ventilation emerged as the second most influential factor, followed by access routes. These statistical relationships demonstrate how environmental conditions in confined sites significantly affect safety outcomes. The analysis showed a moderate impact of lighting conditions, while material storage had the weakest influence among the factors studied. The regression results particularly reinforce Rodriguez and Smith's (2023) findings about the compounding effects of multiple spatial constraints on safety outcomes. The strong statistical significance of space limitation, ventilation, and access routes suggests these factors should be prioritized in safety management strategies for confined construction sites. The hierarchical importance of these factors, as revealed by the regression analysis, provides empirical evidence for focusing safety interventions on the most critical aspects of confined construction environments.

4. Conclusions

This research on the impact of confined construction sites on project team health and safety in Port Harcourt has revealed significant insights into the challenges and risks faced by construction professionals in confined construction sites. The study's findings, drawn from a diverse group of construction professionals including project managers, structural engineers, and safety officers, demonstrates the complex relationship between confined site conditions and safety outcomes. The research demonstrates that spatial constraints significantly influence safety conditions in confined construction sites. The study found that limited access and exit routes represent the most pressing safety concern, indicating strong agreement among respondents about this risk factor. This was closely followed by restricted movement space, and limited material storage capacity, forming a trio of critical spatial challenges that directly impact worker safety. Statistical analysis through regression analysis revealed that site conditions explain 72.2% of the variation in accident frequency, with space limitation emerging as the strongest predictor, The significance of ventilation, and access routes in predicting safety outcomes emphasizes the complex nature of safety challenges in confined construction environments. These findings align with contemporary research in urban construction safety, particularly regarding the relationship between spatial constraints and accident rates. Based on these findings, several practical recommendations emerge for improving safety in confined construction sites. Construction managers should prioritize the development of detailed site layout plans that maximize the use of limited space while maintaining clear access routes. This should include the implementation of advanced logistics systems for material delivery and storage, reducing on-site congestion. The strong correlation between ventilation issues and safety risks suggests the need for enhanced ventilation systems, particularly in deeply confined areas where natural airflow is limited. For policy development, the findings support the need for specialized regulations addressing confined construction sites. These should include minimum space requirements for different construction activities, mandatory ventilation standards, and specific emergency response protocols adapted to restricted environments. The high educational qualification of the study participants, with 85.7% holding bachelor's degrees or higher, suggests that the industry has the technical capacity to implement more sophisticated safety protocols. The construction industry in Port Harcourt would benefit from the establishment of a comprehensive training program focusing specifically on confined site safety management. This should incorporate both technical skills for working in restricted spaces and emergency response procedures tailored to confined environments. The experience profile of the respondents, with 40% having 5-10 years of experience, indicates a workforce that could readily adapt to enhanced safety protocols.

Looking forward, several areas warrant further research attention. There is a need to investigate the long-term health impacts of working in confined construction environments, particularly regarding respiratory health given the ventilation concerns identified. Future studies should also explore the application of emerging technologies in monitoring and managing safety in confined sites. The economic implications of implementing enhanced safety measures in confined sites deserve investigation, particularly in the context of developing economies like Nigeria. Additionally, research is needed to understand how cultural and organizational factors specific to Port Harcourt influence safety practices in confined construction environments. This could include examining the relationship between traditional construction practices and modern safety requirements, as well as investigating how local organizational structures affect safety implementation.

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Assessment of Passive Design for Fire Safety in University Buildings: The case for University Students' Centres in Minna, Nigeria

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Abstract

Infrastructural facilities are a crucial element of university campuses. Thus, they are important for the overall organisational performance of universities as they provide healthy learning environments for students as well as create safe and conducive working environments for university workers. In order to achieve optimal safety and mitigate risks in such facilities, fire safety measures become a critical consideration in architectural design and building management. These safety measures cover a range of finely blended practices that work in tandem to prevent the outbreak of fire incidents. In recent times, the frequency of fire outbreaks in various student facilities throughout Nigeria has made university infrastructure a matter of immediate concern. As such, this study seeks to assess passive design measures for fire safety in university student centres in Nigeria, using the Federal University of Technology Minna as a case study. The objective is to enhance users' safety and protection in the event of fire outbreaks. The research employed qualitative method with data collected through semi structured interviews. Five professionals in the building industry were interviewed and thematic analysis was used to explore the integration of passive fire safety measures in building design. Findings indicated the most appropriate passive fire safety measures needed to be inculcated in the design of university student centres for adequate fire protection. Recommendations for professionals and stakeholders in the built environment for effective integration of passive design for fire safety were presented.

Keywords: Fire safety, Passive design strategies, Student centres buildings, University, Nigeria

1. Introduction

Human and social development realized by identifying, training and providing the skill and innovation students require based on continuously changing demand environments is one of the foremost aims of higher education (Umar *et al*., 2019). As such, a conducive learning environment that supports the cognitive, emotional, and physical development of students is essential for their holistic growth (Ayeni and Adelabu, 2012). Consequently, it is crucial to create a welcoming, secure, and comfortable educational setting. This, in turn, fosters an unrestricted learning environment that encourages the free exchange of ideas, ultimately enabling students to reach their full academic potential (Ekeh and Venketsamy, 2020; Banditvilai, 2016).

Mbazor *et al*. (2018) emphasized that facilities on universities play a crucial role in the overall organizational performance of institutions, further mentioning the fact that these facilities contribute significantly to creating healthy learning environments for students as well as fostering a conducive working atmosphere for university workers consequently leading us to the fact that academic facilities and users' comfort are intertwined and cannot be ignored. In addition to the significance of facilities, attention must be given to safety considerations in architectural design. Effective fire safety strategies are essential in mitigating risks associated with fire incidents within educational environments. This involves a comprehensive approach that includes the use of fire-resistent materials, the implementation of early detection systems and evacuation plans, strategic planning for natural ventilation and general incorporation of passive design strategies. Fire safety is a multifaceted discipline that requires careful consideration throughout the design and construction process, as well as ongoing maintenance and training to ensure the protection of occupants and property (Na'inna and Bature, 2023).

According to Findik (2022), fire is a chemical occurrence triggered by the interaction of heat, oxygen, and matter, posing a significant hazard when not managed effectively. Meanwhile, hazards of any kind require global safety standards to ensure the safety of human activities (Olarenwaju and Adebiyi, 2017). In addition, fire safety measures in architecture encompass a comprehensive approach that considers the entire lifecycle of a building, from its initial design and construction to its ongoing maintenance and occupancy. These measures are meticulously planned and implemented to ensure the safety and well-being of the building's inhabitants, safeguarding them against potential

fire hazards throughout the structure's existence. By integrating fire safety considerations into every stage of a building's development, architects and construction professionals work collaboratively to create safe and secure environments that prioritize the protection of human lives.

2. Statement of the Research problem

According to Agyekum *et al*. (2016), there are drawbacks to growing populations, one of which being a higher danger of fire outbreak. There exist records of numerous fire incidents in university buildings, resulting in the loss of life and valuables of students (Nwabueze, 2012). These frequency of fire outbreaks in various student facilities throughout Nigeria poses this subject as a matter of immediate concern. Passive design strategies play a crucial role in enhancing fire safety within buikldings. However, there remains a significant research gap in the effectiveness of these strategies under varying conditions, particularly in the context of modern materials and construction techniques. Most existing studies focus on theoretical models or isolated case studies, lacking comprehensive empirical data that evaluates the performance of passive design during real fire incidents. FUTMINNA is not an exception as there have been occurrences of fire outbreak in some crucial facilities in year 2013, 2017 and 2018 affecting the Campus Radio Station, Bosso Campus School Clinic and the School's Ultramodern market respectively. These past fire incidents have revealed shortcomings in current design practices. For example, the fire outbreak at Federal University of Technology Minna Ultramodern market which was reportedly caused by an electric spark claimed millions of Naira worth of properties. These and many other incidents highlights the need for improved fire-resistant materials and better compartmentalization strategies. These events presents the importance of integrating lessons learned into contemporary design standards and in order to ensure the safety and wellbeing of students, employees, and visitors, it is imperative that fire safety precautions be incorporated into the design of a student centre at FUT Minna, Niger State.

3. Aim

The aim of this study is to assess existing passive fire safety measures in student centres and recommend effective design improvements based on findings.

4. Student Centres

Western Colorado University (2024), describes a university's student centre as a central facility that serves as a hub for student life and activities on campus. It typically includes a variety of spaces and amenities to support the needs and interests of students serving as an indicator for an active lifestyle. While these flexible spaces foster collaboration, exploration and discovery (Kariippanon, 2018), they also present unique challenges related to fire safety. As the Federal University of Technology Minna (FUTMINNA) evolves to stand as a beacon of academic excellence renowned for its commitment to innovation and student-centred learning, there arises a crucial need to re-envision its physical infrastructure to meet the dynamic needs of its diverse student body (Cort *et al*., 2017). Central to this endeavor is the design of a modern and adaptable student centre, serving as a vibrant hub for collaboration, social interaction and academic engagement. The design of this centre must address the shortcomings hihghlighted by past fire incidents in similar facilities. Recent trends in educational architecture has presented a paradigm shift emphasizing flexible spaces that accommodate diverse learning styles one of which is student centres within campus facilities (McLaughlin and Faulkner, 2012). This shift is driven by the recognition that traditional, static environments are ill-suited to accommodate the diverse learning styles and evolving pedagogical approaches of the 21st century. However, this flexibility should not compromise safety. Research indicates that an atmosphere that is conducive for learning consists of suitable amenities that facilitate and increase quality learning outcomes while also preventing dropouts (Ogedi and Obiano, 2017). Ultimately, as Muhamad-shah *et al*. (2016) notes, a university as a place to provide services to fulfil the needs of student's is measured not only by the quality of teaching but also the state of facilities. By addressing fire safety within the design framework of student centres, FUTMinna can create an inclusive, secure environment that supports both academic success and community engagement.

5. The Fire Concept

Fire, a fundamental element of human civilization, has played a crucial role in our advancement as a society (Starr, 2019). However, this double-edged sword also poses a significant threat to human life and property. Agyekum *et al*. (2016) emphasizes the universal nature of this threat, noting that fire can strike any type of building, from bungalows and terraces to duplexes, tenement houses, and high-rise structures. Fire, as defined by Osunsanmi *et al*. (2017), is a combustion process involving the oxidation of fuel in the presence of oxygen, emitting heat and light. This study defines fire as the result of the combination of oxygen, fuel, and heat, noting that fire can be extinguished

by removing any of these elements (See Figure 1). This knowledge should aid in preventing and combating fire incidents.

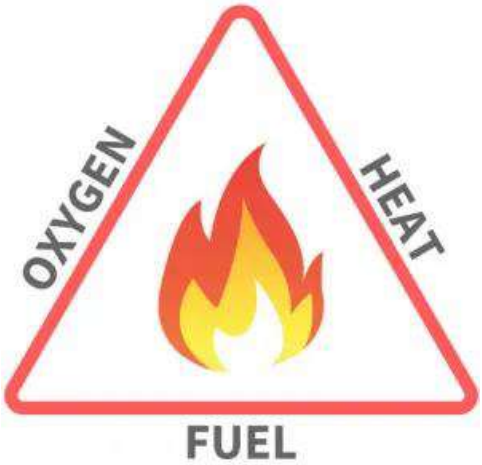

Figure 1: The fire triangle
Source: Fire action (2017)

Numerous studies have identified various causes of fire outbreaks in buildings. Fire outbreaks in buildings often result from occupant negligence (Nimlyat *et al*., 2017). However, even buildings equipped with advanced fire prevention technologies remain at high risk of fire if the occupants do not adhere to proper fire safety measures (Kim *et al*., 2017). Occupants in buildings experiencing fires suffer greater injuries due to inadequate knowledge of fire safety protocols (Abdullahi *et al*. 2017. Popoola *et al*. (2016) found that human activities such as bush and refuse burning, improper electrical installations, high voltage electricity, and fireworks are prominent causes. According to Asigri *et al*. (2017), major fire causes in student hostels, include cooking, arson, open flames, electrical appliances, mechanical faults, and carelessness. Lawal *et al*. (2018) categorized fire causes in public buildings into natural (such as lightning, earthquakes), accidental (such as arcing, overheating), and incendiary (malicious intent or negligence). Domestic fire are causesd by electrical faults, heat, sparks, gas cylinders, arson, carelessness, naked flames, and power surges (Adekunle *et al*. 2016). Other contributing factors include the use of substandard electrical materials, faulty electrical designs, improper installation of electrical systems, and inadequate safety measures during construction. Despite occasional natural causes, human behaviour, often due to carelessness, deliberate actions, or accidental circumstances, is the most significant contributor to fire hazards (Oloke *et al*., 2021).

6. Fire Safety Measures

Fire safety is the reduction of the potential for harm to life because of fire in buildings (Hopkin, 2017). While it is acknowledged that the risk of fire-related fatalities cannot be entirely eliminated (Chow, 2004), proactive measures can be put in place to significantly reduce the risk. According to Buchanan and Abu (2017), the magnitude of fire outbreak can be reduced only when the structure is designed, constructed, equipped, maintained and operated with a view to save the life and property of its occupants. Kodur *et al*. (2020) highlighted an integrated framework for mitigating fire hazards in buildings. This framework covers fire protection features, regulation and enforcement, consumer awareness and technology and resources advancement (see Figure 2). It also emphasizes the enhancement of fire protection features in buildings to manage the impact of fire hazards. This includes implementing reliable fire protection systems, such as fire detection and alarms, fire suppression and technology systems. The use of fire-resistant materials and proper compartmentalization can help contain the spread of fire and smoke. Furthermore, effective regulation and enforcement of building codes and fire safety standards are crucial for improving fire safety thereby suggesting the strengthening of the building code, ensuring proper enforcement, and conducting regular inspections to identify and address fire hazards. Achieving fire safety is not solely the responsibility of builders and regulators. Increasing user-awareness is crucial for fostering a culture of safety. In short, a multifaceted approach that combines thoughtful design, robust regulations, advanced technology and user engagement is pivotal.

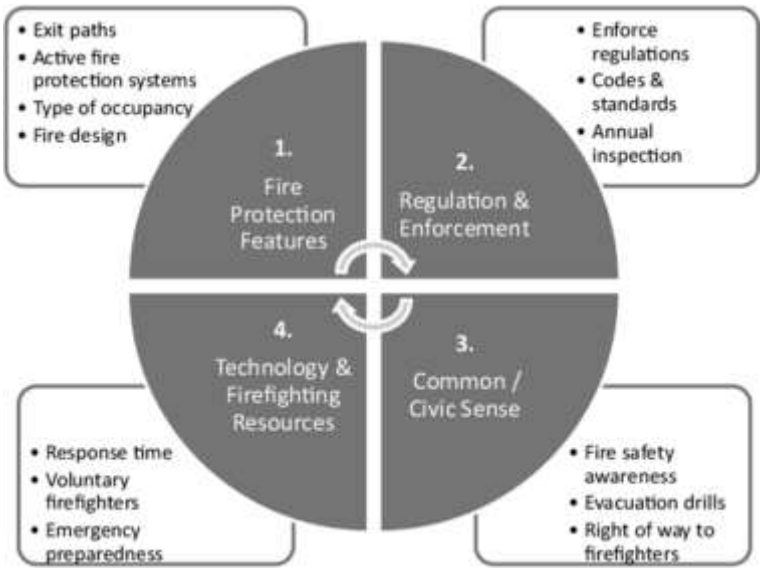

Figure 2: Integrated framework for mitigating fire hazards in buildings
Source: Kodur *et al*. (2020)

7. Passive Strategies for Fire Safety

Passive fire safety strategies are integral to building design, focusing on preventing the spread of fire and ensuring the structural integrity of a building without the need for human intervention or mechanical systems (Buchanan & Abu, 2017; Cadena *et al*., 2022). These strategies often involve the use of fire-resistant materials and construction techniques. Cadena *et al*. (2022) proposed a Maximum Allowable Damage (MAD) approach to quantify fire safety performance in their paper "*Maximum allowable damage approach to fire safety performance quantification".* This approach aligns with the principles of passive fire safety, which aims to limit fire damage and protect occupants without relying on active systems. The MAD approach involves defining acceptable levels of damage for different fire scenarios, such as the maximum allowable temperature rise in structural elements or the maximum allowed area of fire spread. By establishing these thresholds, designers can evaluate the performance of passive fire protection measures, such as fire-resistant materials and compartmentalization, in preventing or delaying the onset of unacceptable damage. This helps designers optimize the use of passive fire protection measures and ensure the resilience of buildings in the face of fire hazards. Some passive strategies for fire safety are highlighted and discussed below:

a. Fire-resistant materials and construction techniques are designed to withstand high temperatures, ensure structural integrity and prevent the spread of fire. Common materials include fire-rated gypsum board, intumescent coatings, and fire-resistant glass. Gypsum Boards are widely used in walls and ceilings, gypsum board has inherent fire-resistant properties due to the presence of water in its structure (Kolaitis *et al*., 2014; Manzello *et al*., 2007). When exposed to fire, the water is released as steam, slowing the spread of flames. This material can significantly enhance safety in Nigerian universities where budget constraints often limits options. Additionally, intumescent coatings are thermally reactive materials composed of organic and inorganic components bound in a polymer matrix, which expand and char when exposed to heat, forming an insulating layer that protects the underlying steel thus, slowing the spread of fire (Cirpici *et al*., 2016; De Silva *et al*., 2019). However, theur effectiveness may be compromised in environments with high humidity or inconsistent maintenance, common in many Nigerian institutions.
b. Effective egress strategies, particularly the design of staircases is essential for ensuring safe evacuations during emergencies. Wei *et al*. (2023) investigates the group movement characteristics of evacuees in stairwells of high-rise buildings during emergency situations. The study found out that, staircase width and landing size significantly influence evacuation time and crowd density. Wider staircases and larger landings resulted in faster evacuation times and lower crowd densities compared to narrower staircases and smaller landings. Additionally, the presence of obstacles, such as fire extinguishers or hoses, in the stairwell can impede the flow of evacuees and increase evacuation time. Therefore, it is important to consider staircase design in the context of building safety and emergency preparedness. According to Asigiri *et al.* (2021), escape routes like corridors, lobbies, landings, and stairways should have non-slip, even surfaces especially in Nigeria's often wet conditions. The minimum clear headroom for escape routes should be 2 meters and doors along the escape route should generally open in the direction of travel for people escaping. Architects and building designers should

prioritize the incorporation of wide staircases and ample landings to facilitate efficient evacuation during emergencies and the need for careful placement of equipment and obstacles within stairwells to minimize interference with the evacuation process. Shittu *et al*. (2016) emphasizes the importance of incorporating means of escape as an integral part of building design, allowing occupants to safely reach designated assembly points without assistance as properly planned egress routes are critical for preventing bottlenecks and ensuring swift evacuation. They further highlight the need to consider means of escape in conjunction with the evacuation process, outlining the phases of evacuation as described by Herbert (1999):

i. **Phase 1:** evacuation from the room or area to a common corridor, a protected stairway or to a final exit;
ii. **Phase 2:** evacuation via a common corridor to a protected stairway or a final exit; and
iii. **Phase 3:** vertical evacuation via a protected stairway to a final exit and a designated assembly point

c. Fire safety building codes and regulations are a set of standards and requirements designed to protect people and property from the dangers of fire in buildings. These codes cover various aspects of building design, construction, and maintenance to ensure that structures are built with adequate fire protection measures. The Nigerian Building Code, also known as NIS 89: Part 5: 1991, sets out the minimum requirements for the design, construction and maintenance of buildings in Nigeria, including fire safety regulations. The Nigerian Building Code was made available by the federal government of Nigeria to set minimum standards on buildings at the pre-design, design, construction, and post construction stages. Additionally, the Standards Organization of Nigeria (SON) is responsible for ensuring that products and services in Nigeria conform to national and international standards, which includes providing for the testing, certification, and marking of building materials.
d. Compartmentalization involves dividing a building into sections using fire-resistant walls and floors to contain the spread of fire and smoke within a limited area (Smith, 2021). The aim of fire compartmentalization is to prevent the spread of fire and smoke between compartments, allowing for easier evacuation and access for fire-fighters and also to reduce the overall damage caused by fires (Croner-i, 2023). These elements help to maintain compartmentalization and prevent the spread of fire and smoke. The study by Arowolo *et al*. (2021) suggested segregating (zoning) areas susceptible to fire from less susceptible places. The researchers underscored the importance of addressing fire safety effectively in buildings from the design stage, as they found that the Abubakar Rimi Market was not properly designed with regards to fire outbreak, and fire could easily spread due to lack of adequate space and flexibility in case of an emergency. Meanwhile, Effective compartmentalization is supported by fire doors and windows, which are designed to withstand fire for specific durations, usually ranging from 30 minutes to several hours thus maintaining the integrity of fire compartments.
e. Fire safety management is vital in ensuring the long-term sustainability of buildings as a result, there is the need for regular maintenance, training of building occupants, and implementation of effective emergency response plans thereby enhancing the safety and well-being of building users. Sanni-Anibire and Hassanain (2015) study on fire safety assessment of a student housing facility emphasize the need for comprehensive assessments that go beyond mere compliance with fire codes and regulations. Their work highlights the significance of considering various factors, such as building design, occupancy characteristics, and fire safety management practices, to ensure the overall safety of building users. The authors developed a checklist for fire safety assessment which serves as a practical tool for evaluating the fire safety performance of student housing facilities. By systematically assessing factors such as fire detection and alarm systems, fire suppression equipment, means of egress, and fire safety management procedures, the checklist enables a thorough evaluation of a building's fire safety preparedness.

8. Research Methodology

This study aims to assess the design and evaluation of passive fire safety measures in building design and identify common themes and best practices in the field through expert insights. The research employed qualitative method with data collected through semi structured interviews in-person. Considering the wealth of experience of the respondents as well as geographical distribution cover, the purposive sampling method was employed by engaging five professionals in the building industry were interviewed in order to get rich resource of knowledge for the research. All respondents had no concerns on information confidentiality. Thematic analysis using the Nvivo software was employed to explore the integration of passive fire safety measures in building design. The aim is to understand how these experts approach the design and evaluation of passive fire safety systems and to identify common themes and best practices in the field. The responses provided by the interviewees offer a comprehensive view of current practices and highlight key factors that influence the integration of these measures into building design. Table 1 reveals the demographics of the professionals interviewed.

Table 1: Background information of the respondents

Code	Names	Role	Educational Qualification	Years of Experience
R1	Architect Janet Aishatu Maikenti	Consultant architect	Msc	22
R2	Architect Nwando Mogbo	Teacher and Researcher	MSc	15
R3	Architect Oloye Michael	Registered architect	MSc	8
R4	Engineer Akeju Babatunde Solomon	Registered civil structural engineer	MSc	15
R5	Architect Dr. John Agmada Bawa	Practicing architect, lecturer, member of Nigeria Institute of Architects and Green building council of Nigeria.	PhD	15

9. Discussion of Results

This section presents a thematic synthesis of the respondents' insights, critically analyzing their perspectives and situating them within the context of current literature on passive fire safety measures. The responses collectively emphasize the importance of passive fire safety measures, particularly in material selection, spatial planning, and the design of egress routes. For instance, R1 and R3 highlighted the critical role of fire-resistant materials (doors, ceilings, and coatings), which is a consistent theme echoed by R2, R4, and R5. The use of fire-resistant materials is fundamental in limiting the spread of fire, which aligns with existing studies that underscore the significance of compartmentalization and fire-rated materials in fire prevention (Lee & Kim, 2020). Incorporating fire-resistant materials into building design is complemented by spatial planning, as discussed by R1 and R3, who stressed the importance of escape staircases, exits, and fire safety signage. These measures facilitate safe evacuation and reflect best practices in architectural design for fire safety, as noted in various fire protection guidelines.

9.1 Assessment of Current Fire Safety Measures

The current fire safety measures were generally assessed as satisfactory, though areas for improvement were identified. R1 emphasized the implementation of smoke and heat detectors, fire extinguishers, hydrants, and sprinklers across campus buildings, which reflect compliance with basic safety standards. However, R1 and R5 identified gaps, such as outdated systems and the absence of advanced technologies like water mist systems, which could improve fire suppression efficiency. This suggests that while baseline measures are in place, they may not fully meet the evolving demands of fire safety, particularly in educational settings, as other studies have suggested (Smith *et al*., 2019). R2 and R4 highlighted the importance of regular inspections and adherence to fire safety codes. R2's emphasis on maintenance and inspections resonates with the literature, which points to the crucial role of routine evaluations in maintaining building safety standards (Johnson, 2021). R4's structured approach to documentation review and compliance with fire codes ensures that buildings remain compliant with the latest fire safety regulations.

9.2 Key Considerations for Integrating Fire Safety Measures

The respondents identified several critical factors to consider when integrating fire safety measures into design. Prevention, detection, escape, and containment emerged as core principles, as articulated by R1, R3, and R4. These align with the principles outlined in fire safety design literature, which emphasizes a holistic approach to fire prevention and management (Lee & Kim, 2020). For example, R1's focus on fire-resistant materials for prevention and R3's consideration of building use and occupancy are consistent with the passive fire protection guidelines that advocate for tailored solutions based on building function and user needs. The respondents also discussed the importance of regulatory compliance (R2, R4), smoke control systems (R2, R3), and the role of material choices in ensuring structural integrity. These factors are critical in designing buildings that meet both functional and safety requirements, with fire compartmentalization and egress design being particularly vital in large public spaces like student centers.

9.3 Enhancing Fire Safety in Student Center Design

The recommendations for enhancing fire safety in student centers focus on integrating both passive and active measures. All respondents emphasized the importance of clear exit routes, fire-resistant materials, and adequate signage, which are supported by existing studies on the design of safe public spaces (Chen *et al*., 2021). R1 and R5 suggested incorporating real-time monitoring systems, such as alarms and sprinklers integrated into building management systems, which would allow for swift responses during emergencies. Furthermore, R4 and R5 advocated for the design of multiple exits and wide corridors, ensuring accessibility and ease of evacuation, which are standard recommendations for high-occupancy buildings

(Johnson, 2021). These suggestions reflect best practices in fire safety design, which prioritize the protection of life through well-planned evacuation routes and the strategic placement of fire safety equipment.

9.4 Comparison with Literature

The findings from this study are consistent with existing literature on passive fire safety measures in educational buildings. For example, the emphasis on material selection, egress design, and regulatory compliance aligns with the recommendations of Lee & Kim (2020), who argue that these factors are essential in mitigating fire risks. However, the respondents also highlighted gaps, such as the need for modern systems and better maintenance, which suggests that while passive measures are being implemented, there is still room for improvement, particularly in adopting newer technologies.

10. Findings

The examination of interview responses reveals several significant insights regarding fire safety measures in building design, which are further explored below:

i. **Importance of Passive Fire Safety Measures:** The interviews underscore the essential role of passive fire safety elements, such as fire-resistant materials and compartmentalization. These strategies are fundamental in controlling fire spread and protecting building occupants, particularly in high-occupancy structures like educational institutions. According to Smith *et al.* (2020), integrating passive fire safety measures can reduce fire risk by up to 40%. The professionals interviewed consistently emphasized the necessity of incorporating these measures into building design to enhance overall safety, echoing research that passive strategies act as the first line of defense in fire scenarios.

ii. **Evaluation Practices for Existing Fire Safety Measures:** Assessing current fire safety protocols requires a detailed process involving the review of building documentation, on-site evaluations, and hazard identification. This comprehensive approach ensures that existing safety measures remain effective and compliant with regulatory standards, such as those outlined in the National Fire Protection Association (NFPA) codes. As noted by Johnson (2021), regular assessments are critical for identifying gaps and implementing timely improvements. The professionals stressed the importance of ongoing assessments to adapt to changing safety regulations and emerging risks.

iii. **Factors in Integrating Fire Safety Measures:** When integrating fire safety features, several key factors must be considered, including the building's intended use, occupancy levels, and material selection. Different building types necessitate tailored fire safety solutions, and the interviews highlight the need for these customizations. For instance, university buildings, especially in regions like Minna, Nigeria, often face unique challenges such as overcrowding and limited access to modern fire-resistant materials. Research shows that buildings designed with specific risks in mind are more resilient to fire hazards (Lee & Kim, 2020).

iv. **Enhancing Safety in Student Centers:** Student centers present unique challenges due to their high occupancy and diverse use cases. The interviews revealed that ensuring safety during emergencies involves designing clear escape routes, providing multiple exits, and installing effective fire control systems, such as sprinklers and alarms. This aligns with global best practices, where evacuation efficiency is maximized through strategic placement of exits and fire safety signage (Chen *et al*., 2021). These design elements are crucial for facilitating safe and efficient evacuations, particularly in buildings frequently used by large numbers of students.

v. **Common Themes and Differences:** While the interviews highlighted diverse perspectives on fire safety, a few common themes emerged. Passive fire safety measures were universally regarded as crucial, yet the integration of active systems—such as smoke detectors and sprinklers—was identified as equally important for a comprehensive fire protection strategy. As highlighted in the literature, combining passive and active safety measures results in a more robust system for managing fire risks (Smith *et al*., 2020). This balanced approach ensures both prevention and rapid response, contributing to optimal fire safety outcomes.

11. Conclusion and Recommendations

The varied perspectives on fire safety measures reveal the complexity of designing for fire protection. While passive measures are crucial, integrating both passive and active fire safety systems is highly recommended as effective. This indicates the need for a comprehensive approach combining different measures for effective fire safety. The interviews with architectural and engineering experts highlight the vital role of passive fire safety measures in building design. These measures are essential in preventing the spread of fire and ensuring safety in both new and existing structures. A comprehensive assessment of fire safety practices, involving documentation reviews, on-site inspections, and hazard assessments, is necessary to ensure that fire safety standards are consistently met. Factors such as a building's purpose, occupancy, and material choice play a crucial role in tailoring fire safety strategies. For student centres, enhancing evacuation paths, providing multiple exits, and strengthening fire control systems are key safety improvements. Furthermore, implementing regular inspections, eliminating dangerous equipment, and

using only standardized, safe heating systems are essential steps to reduce fire risk. Another crucial element is educating students, teachers, and staff on fire safety. Enlightening all building users is key to promoting safety as this help familiarize building occupants with emergency procedures and test the effectiveness of safety systems.

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Conceptual Framework for Sustainable Materials Waste Management in Construction Projects in Nigeria.

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Abstract

The construction industry is faced with the challenge of construction waste management, which is already causing environmental concerns around the globe. Aside from the fact that waste contributes to cost overruns, it also has environmental implications in the form of pollution. The few sustainability-related materials waste management models barely capture the full cycle of sustainability, which includes social, economic, and environmental responsibilities. This research aimed to develop a conceptual framework for sustainable materials waste management for building construction projects in Nigeria. The existing theoretical models developed for Sustainable Materials Waste Management did not holistically consider the Critical Success Factors (CSFs) for enhancing the sustainability of material waste management in construction projects, nor developed a sustainable materials waste management model for enhancing the sustainability of construction projects in Nigeria. Therefore, this research adopted a desktop methodology by conducting a thorough literature search on existing models related to sustainable materials waste management for construction projects. This, led to the development of conceptual framework for sustainable materials waste management in construction projects in Nigeria. The study found that to achieve sustainable materials waste management, the barriers hindering the practices of sustainable waste management must be identified which must be interlinked with the critical success factors for enhancing sustainability in construction projects. All these must be interrelated to all the circular economy concept of waste management and other waste management techniques with the sustainability components. This will lead to the achievement of sustainable materials waste management in construction projects. The study recommended the development of a full path model for enhancing the sustainability of construction projects in Nigeria.

Keywords: Construction Projects, Conceptual framework, Sustainability, Materials Waste Management, Model.

1. Introduction

The construction industry is a vital part of the economic backbone in many countries and its activities affects general development of any nation by playing a key role in improving the quality of the built environment (Fei *et al.,* 2021). A common characteristic is the rapid growth in the standard of living, demands for infrastructure projects, changes in consumption habits, as well as natural increase in population (Yuan, 2022). Basically, contractors are responsible for maintaining a sanitary work environment and to dispose of waste from working area (Lunagcharoenrat *et al.,* 2019).

Therefore, a surge of criticism has been overtly targeted at construction, which is perceived as the culprit of environmental degradation, consumption of non-renewable natural resources, gas and dust emission, solid waste generation, noise pollution, as well as land depletion and deterioration (Khajuria, 2021; Yang *et al.,* 2022; Wu *et al.,* 2023). Material waste generation is a prominent issue in construction projects, and the adverse effect of waste has influenced the management of construction waste in many countries, where construction waste is the major contributor to nearly 15–30% of the volume of waste disposed in several landfill sites in most countries (Duan and Poon, 2019; Erich, 2020). Construction waste is classified into physical waste and the non - physical waste (Saini and Dhania, 2020). The physical waste is generated in the form of material waste that contributes to a significant part of landfill while the non-physical waste is generated from construction activities identified in time and cost overrun (Saini and Dhania, 2020). Consequently, Oyedele *et al.* (2020) noted that more than 50% of the physical waste materials generated by construction projects are deposited in landfill and almost 26% of the landfill is occupied with construction waste and this is not economically profitable to construction projects. The physical construction waste has greater impact on environment, economy and social responsibility of construction project which contribute to a reduction in construction productivity and thus reduce the performance of the overall construction project (Saini and Dhania, 2020).

To address this problem, sustainable material waste management has emerged as a critical solution to the challenges of increased material waste generation, promoting recycling, recovery of energy, dwindling natural resources, and environmental degradation. Sustainability in construction waste can be seen as stepwise strategy to achieve desirable and most suited process depending on the conditions and type of waste generated (Khajuria, 2021).

Sustainable waste management is an essential component of a circular economy which involves a systemic approach to economic development that opposes the take-make-waste model and seeks to decouple growth from the consumption of finite resources (Duan *et al.,* 2019). According to Udomsap and Halliger (2020), sustainable waste management provides more direct solutions to the numerous problems caused by waste, where the construction organizations should have the capacity to effectively manage waste, from generation to disposal. All stages of the management process are important, scholars and governments have provided the final step, being disposal, unabated attention in order to ensure effective management (Kabirifar *et al.,* 2020).

A sustainable waste management model can mitigate these negative environmental impacts (World Bank, 2020). By developing a sustainable waste management model, construction projects in Nigeria can potentially reduce material waste, leading to cost savings and improved economic profitability (Oluwoye *et al.,* 2018). Thus, the research work seeks to develop a conceptual framework for sustainable material waste management model for construction projects with a view to enhancing sustainable materials waste practices of construction projects in Abuja, Nigeria.

2. Review of Relevant Theories in Construction Waste

2.1 Sustainability theory

Construction waste may be classified into two categories: physical waste and non-physical waste. This waste has significant consequences for the environment, as well as the social and economic performance of every country (Nagapan *et al.,* 2012; Marzouk and Azab, 2014; Saidu, 2016). According to reports, a significant amount of construction waste is produced globally each year, leading to many economic, environmental, and social issues. However, the severity of these problems differs across countries (Yuan *et al.*, 2022). In order for waste management to be successful in construction projects, it is essential to establish a strong connection and focus on three key performance indicators: social, economic, and environmental performance (Yuan, 2013). In their study, Yuan *et al.* (2022) established a connection between these characteristics and the concepts of sustainable building. Yuan *et al.* (2022) described sustainable construction as a comprehensive process that seeks to restore and maintain a balance between the natural and built ecosystems, while also promoting a settlement that upholds human dignity and fosters economic fairness. Ding *et al.* (2022) stated that sustainable construction encompasses a wide array of issues, including the resolution of conflicts between different objectives, and the simultaneous pursuit of economic prosperity, environmental quality, and social equity, as depicted in Figure 1.

Figure 1: The triple bottom line of sustainability
Source: Ding *et al.* (2022)

In order to achieve this objective, it is anticipated that the building industry would enhance its methods of safeguarding the built environment, since this is a crucial aspect of the sustainability discourse. According to Ding *et al.* (2022) it is strategically positioned to serve as a means of enhancing quality of life and as a determinant of environmental sustainability. Hence, in order to achieve sustainability in construction, it is crucial to focus on both

efficient control and effective management of construction material waste. Effective management should not solely prioritise economic performance, but should also consider the associated aspects of society and the environment. According to Yuan (2013), the absence of these indicators hinders the proper evaluation and subsequent enhancement of waste management's overall efficiency.
Incorporating sustainability theory into the conceptual framework for a Sustainable Materials Waste Management Model for construction projects in Abuja, Nigeria, can significantly impact various aspects of waste management practices.

2.2. Environmental Implications

The sustainability theory emphasizes minimizing resource use and promoting recycling and reuse. In Abuja, integrating sustainability can lead to reduced consumption of natural resources by encouraging the use of recycled or locally available sustainable materials in construction. The framework would prioritize reducing waste generation at the source by adopting strategies such as prefabrication, on-site waste sorting, and optimized material use, thus reducing the need for landfill disposal and mitigating environmental degradation.

2.3 Economic Implications

Implementing sustainable waste management practices can reduce construction costs in the long run. Efficient material usage, recycling, and reuse strategies lower the cost of waste disposal and potentially generate revenue from recycled materials. Developing sustainable waste management systems can foster economic growth by creating new jobs in recycling facilities, waste collection, and sustainable material production.

2.4 Social Implications

By managing construction waste effectively, risks related to improper waste disposal, such as pollution, hazardous material exposure, and related health issues, can be minimized. This is particularly relevant for Abuja, where rapid urbanization has resulted in increased construction activity. The model would include public education and community involvement in sustainable waste practices. This can promote a culture of sustainability and environmental responsibility among the residents.

2.5 Policy and Regulatory Implications

The framework would help Abuja align with global and national environmental policies, such as the Sustainable Development Goals (SDGs). It can drive the adoption of stricter regulations regarding construction waste management. Implementing a sustainability-driven model can standardize waste management practices across the construction industry, ensuring consistency and reducing the negative impacts of ad hoc waste management.

2.6. Technological Implications

Incorporating sustainability in the framework can drive the adoption of new technologies for waste management, such as advanced recycling techniques, waste-to-energy conversion, and digital tools for waste tracking.There would be a focus on using eco-friendly construction materials, such as recycled aggregates, sustainable timber, or materials with a lower carbon footprint, which align with sustainable construction practices.

2.7 Lifecycle Approach

Sustainability theory emphasizes the lifecycle approach, where the environmental impact of materials is considered from production to disposal. The framework would encourage selecting materials based on their entire lifecycle impact, thus promoting long-term sustainability in construction projects.The model would incorporate strategies for deconstruction rather than demolition, allowing materials to be reused or recycled at the end of a building's life.

2.8 Climate Change Mitigation

By using sustainable materials and reducing waste, the construction industry in Abuja can decrease greenhouse gas emissions associated with material production, transportation, and waste disposal. The integration of sustainability theory into this conceptual framework will encourage a holistic approach to construction waste management, fostering environmental, economic, social, and technological benefits while aligning with Abuja's developmental needs.

2.9 Theoretical findings

Existing models were reviewed under the studies of Yuan (2022); Gaffar *et al*. (2020); Wambua (2020); Rishabah *et al.*(2008); Stefanovic *et al.*(2014); Oluwoye *et al.* (2020) and Ogunmakinde (2019). The model of Yuan (2022) developed a system dynamic model for evaluation of social performance of construction of waste management. The

model concentrated only on social performance of sustainability. Gaffar *et al* (2020) and Wambua (2010) developed a generalised linear model for construction waste estimation in construction projects. The model only concentrated on quantification of waste. Oluwoye *et al.* (2020) developed a model for waste minimization using waste management techniques and circular economy concepts. The main limitation of these models is their failure to account for the three pillars of sustainability's influence on building construction projects.

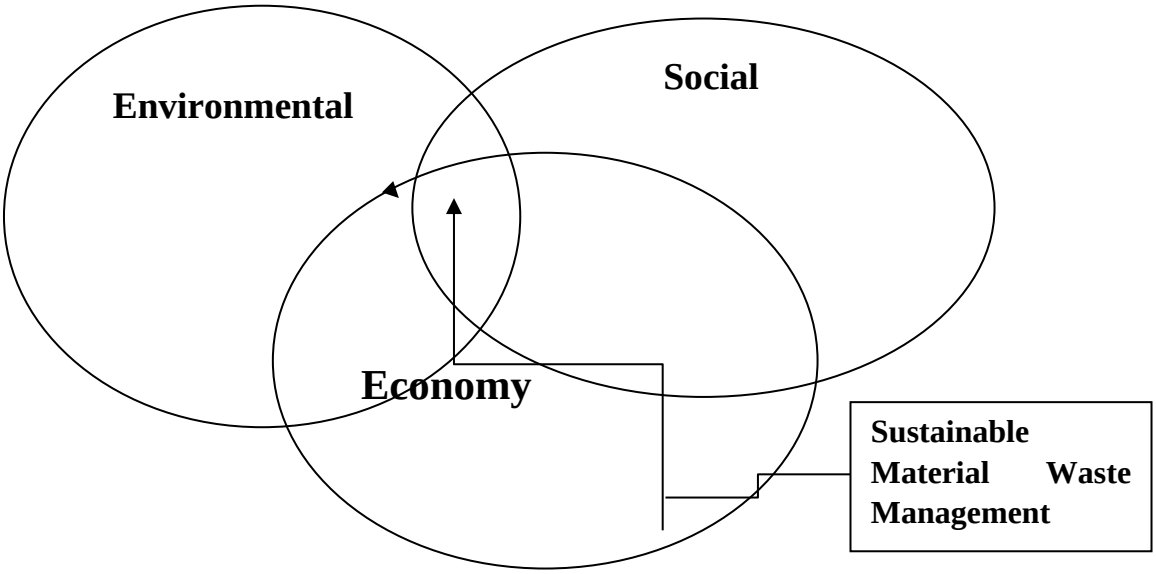

Figure 2: theoretical framework of Sustainable Material Waste Management for construction projects
Source: researchers construct (2024).

3.0 Research Methodology

This study employed the desktop research methodology, conducting a comprehensive literature search on existing frameworks related to sustainable material waste management. These frameworks served as the foundation for the development of the sustainable material waste management model, which in turn informed the development of the conceptual framework for the research.

4.0 Results and Discussion

4.1 Research Conceptual Framework

This section presents the researcher concepts on the constructs that emanate from the research in attempts to fill the theoretical gaps identified in this study.

4.2 Conceptual Framework for Sustainable Material Waste Management

This section is concerned with the circulation of the conceptual framework of the study. This refers to how the researcher views the problem of the study and the tools that can be applied to solve such problem. Therefore, the researcher's conceptual framework is based on the theories reviewed on the theoretical framework. The conceptual framework in Figure 3 shows that to achieve a sustainable materials waste management in any construction project, the barriers hindering the practices of sustainable waste management must be identified and critically evaluated for the projects. This will be interlinked with the critical success factors for enhancing sustainability in construction projects. All these must be interrelated to all the circular economy concept of waste management and other waste management techniques with the sustainability components of social responsibility, economic profitability and environmental responsibilities. This will lead to the achievement of sustainable materials waste management in construction projects as shown in Figure 3.

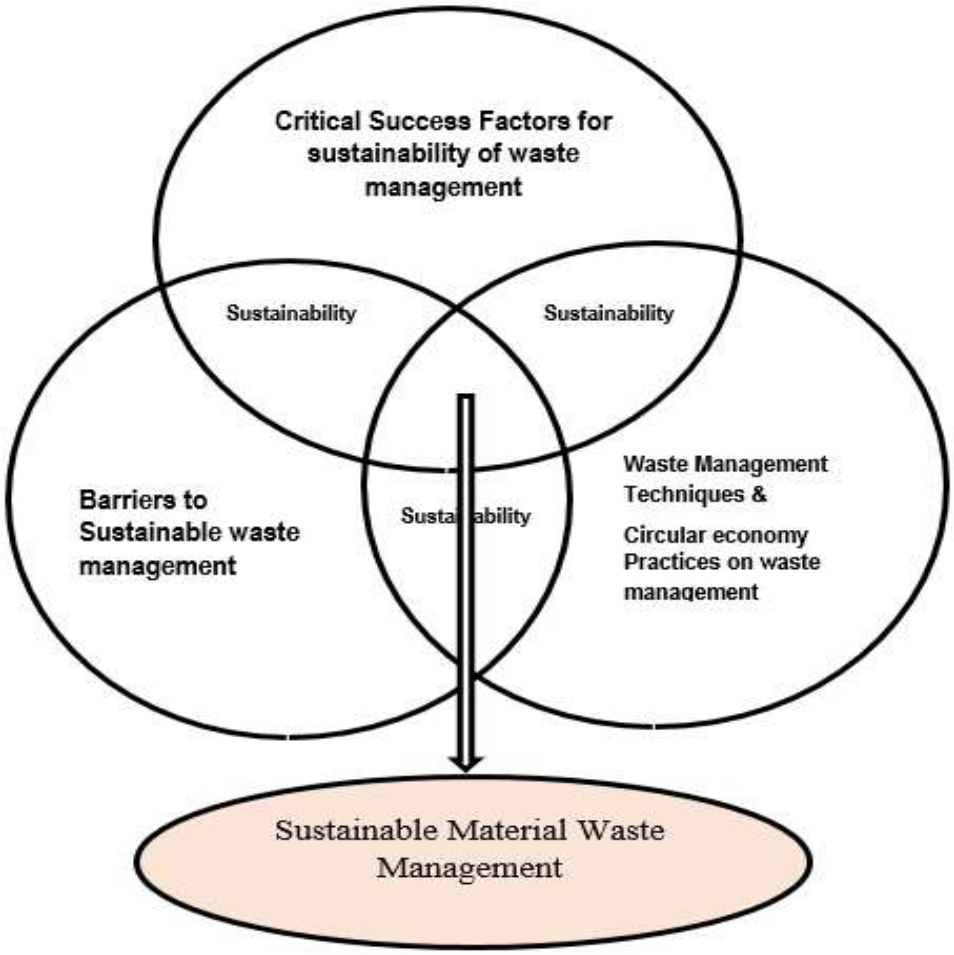

Figure 3: Conceptual Framework for Sustainable Material Waste Management
Source: Researcher's construct (2024)

5. Conclusion And Recommendations

The current sustainability-related materials waste management models barely capture the full cycle of sustainability, which includes social, economic, and environmental responsibilities. This study developed a conceptual framework for the management of sustainable materials waste using a desktop technique. The conceptual framework indicated that to attain sustainable materials waste management in building projects, it is essential to identify and critically assess the hurdles obstructing sustainable waste management methods. This will be connected to the essential success elements for improving sustainability in building projects. All these variables must be linked with the circular economy principles of waste management and other waste management strategies, alongside the sustainability elements of social responsibility, economic viability, and environmental obligations. This will result in the attainment of sustainable waste management for materials in construction. It is recommended that the development of the full path model for sustainable construction waste management would lead to a sustainable management of materials waste in construction projects.

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Assessment of Environmental Management Practice in Secondary Schools in Lokoja

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Abstract

The aim of this research is to assess the environmental management practice in selected secondary school premises in Lokoja area of Kogi state, Nigeria and recommend the appropriate measure to ensure a safe and healthy environment for the students, staffs and visitors. To achieve the aim of this study the following four specific objectives were used, identify adjoining land use activities surrounding the school premises, evaluate ventilation factors in Lokoja secondary schools, assess solid waste management practices in Lokoja secondary schools and identify current environmental management practices in Lokoja secondary schools. However, in the pursuit of excellence of this work; both qualitative and quantitative research methods with descriptive cross-sectional survey design used to collect and analyze data, data were sourced primarily through questionnaire instrument distributed randomly to the selected secondary schools. The analysis however made the following findings; the study revealed that many school were surrounded by residential areas (60%). While this can be beneficial for students accessibility and it also raises concerns about traffic congestion during the school hours and potential noise pollution affecting nearby residents. The study also revealed that 90% of the surveyed classrooms rely primarily on natural ventilation, with windows and doors serving as the main sources of air circulation. Currently used waste disposal methods within the school environment, were open burning, and, compositing were currently being used, incinerator and recycling are not being practiced as claimed by the students as waste disposal methods within the school environment. Practices of waste management in their respective schools, responses showed that 18.75%> of students are not sure of practice of burying wastes in landfill sites. 83.13% of respondents agreed that burning and incinerating of waste were the major practice of waste management, in conclusion, the school authorities need to understand great implications for environmental management practices in schools and the need for creating buffer zone, improving ventilation, integrating architectural, operational, and policy-level interventions to create healthier and more conducive learning environments.

Keywords: assessment, environment, environmental management and environmental management practice

1. Introduction

1.1 Background to the Study

Environmental Management Practices (EMPs) refer to the systematic approaches and activities organizations undertake to minimize their negative environmental impacts while maximizing their efficient use of resources. These practices encompass a wide range of actions and strategies aimed at improving environmental performance and achieving sustainability goals. In the context of educational institutions, Gough (2005) defines environmental management practices as "the actions taken by schools to reduce their environmental impact, integrate sustainability into the curriculum, and foster environmental awareness and responsibility among students and staff". These practices typically include waste management, energy conservation, water management, and green space maintenance (Ackley, 2009). In the context of Nigerian secondary schools, studies have shown that while there is growing awareness of environmental issues, the implementation of comprehensive EMPs remains a challenge (Adebayo & Ogunleye, 2017).

Environmental management has emerged as a critical concern in the 21st century, particularly in rapidly developing urban areas of Nigeria. As centres of learning and community influence, secondary schools play a pivotal role in shaping environmental awareness and practices (Ogunyemi & Ifegbesan, 2011).

Lokoja, situated at the confluence of the Niger and Benue rivers, faces unique environmental challenges due to its geographical location, rapid urbanization, and climatic conditions. The city's population has grown significantly, from approximately 45,000 in 1991 to over 200,000 in recent estimates (World Population Review, 2021). This rapid growth has intensified pressure on environmental resources, making it imperative to instil sustainable practices in its educational institutions.

This study focuses on assessing the environmental management practices in secondary schools in Lokoja, the capital city of Kogi State, Nigeria in order to create healthier learning environments that foster academic excellence,

promote overall well-being, and contribute to the sustainable development of the local community. The findings and recommendations from this assessment will serve as a foundation for implementing targeted interventions, policy reforms, and educational initiatives to safeguard the health and well-being of students and staff in Lokoja's secondary schools.

2. Conceptual Literature Review

2.1 Environmental awareness

The global environmental awareness is getting concerned because there has been a lot of excessive damage in various areas such as waters and settlements caused by human activity. Even in forest area, there has been a lot of damage. As a result of the accidents, the natural balance disrupted. There are many disasters such as droughts, floods, landslides, storms, and so forth. The disruption of the natural balance cannot separate from human behaviors that exploit the natural resources and the environment indefinitely. Related to human behavior towards the natural resources and environmental conditions that tend to be less concerned. The change of human behavior has duly become a priority in addressing the ecological crisis. The fact about today's environmental crisis can only resolve by a shift in perspective and practice on nature fundamentally and radically. One of the efforts to change the human behavior and standpoint towards life 'and the environment is through education (Pertiwi and Dirawan, 2015)

2.2 Need for environmental education in school

Today, school is the only institution that has the ability to have a larger impact on us and our families. The organization of schools is an important aspect of the educational process in the nation. A well-organized school is the cradle of all educational opportunities. Because they are referred to be small societies, their primary goal is to promote education across the community. We spend a significant amount of time at school, not only studying and collecting knowledge, but also helping us to shape our character and learn the fundamental concepts of life and society. During our school years, the fundamental characteristics of our personalities are developed.

2.3 Environmental Activities Practiced by Secondary Students

The physical environment of a school adds a lot of value to the school. Egim (2003) observed in her study on School Environment and Administrator's Role Performance in Cross River State

Secondary Schools believes that the physical environment contributes either negatively or positively to the administrator's role performance in the school. The school physical environment includes the buildings, classrooms, furniture, equipment, instructional materials, *labour*atories, libraries, play grounds and so on. Others are walls, machinery, decorative objects, play fields, skating rinks, swimming pools, audio-visual equipment (Egim. 2003). The design and structure of school environment forms the physical appearance of the school which may attract parents and friends of educational institutions in their initial judgments about the quality of what goes on in the school. They have effect on the perception and choice for learning experience desired by parents and students (Mitchell. 2008).

Learning environment has since been emphasized as an essential requirement for smooth teaching and learning process to take place (National Teachers' Institute (NTI). (2008). This is because students' study habits are to a large extent tied to it. According to Sharon Mitchell, director of Mental Health, Wellness and Safety Promotion (2008), "the environment in which you study can have a big effect on how efficient your study time is". He identified noise, interruptions, lighting, temperature, neatness, comfort and equipment to have potential effect on study habits. This is supported by Sanitation Connection (2005) which points out that as schools provide an important learning environment, the promotion of personal hygiene and environmental sanitation within schools is essential. In addition schools provide ideal environment in which to help children to adopt good habits that will serve for the rest of their lives.

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The number of pages, including references and figures, must be exactly 6 pages with each page being utilised fully, i.e. no unnecessary spacing. The 6th page must be at least 60 % occupied. Please Do NOT insert page numbers. Please Do NOT use the Headers or the Footers. They are reserved for the technical editing of the volume by the SETIC editors. Horizontal page is not allowed.

2.4 The extent to which the student are committed to environmental activities and practices

The extent of commitment to environmental activities by secondary students encompasses Environmental Educators recognizing teachers who employ innovative approaches to environmental education and use the environment as a context for learning for their students. According to the White I louse Council on Environmental Quality (CEQ). In partnership with the U.S. Environmental Protection Agency (EPA) the support and courage

educators who incorporate environmental education instil in their classrooms & teaching methods have greater influence on the students' commitment to environmental activities and practices. At the Growing up Green Charter School students in committed to covering predictable topics like recycling and tree planting, they are alerted on problems like sooty air and negative media representations of their neighbourhood s.

3. Methodology

3.1 Research Design

The research was based on both qualitative and quantitative research methods with descriptive cross-sectional survey design used to collect and analyze data. Qualitative techniques were used to collect and analyze verbal data while quantitative methods were used in collecting and analyzing numerical data. The design preferred for the study generates quick self-reports from the participants under study (Creswell, 2003).

3.2 Sampling Selection Procedure.

To arrive at appropriate sample size as a representative of the total number of schools from sample frame, a multi stage sampling techniques was adopted, in which stratified sampling technique were used to group the schools into strata based on public and private. Three of schools were selected from each stratum and it was been determined by random sampling techniques.

Purposive sampling techniques was used to select the student and teacher within the selected schools for survey and also the key informant such as principal, health teachers and facility managers were aslo interviewed.

4. Results and Discussions

4.1 Identify adjoining land use activities surrounding the school

Table 4.1 showing adjoining land use surrounding secondary school

S/N	Land use activities	Percentage
1	Residential	60
2	Commercial	20
3	Mixed use	15
4	Open space	5

The study revealed a diverse range of land uses adjacent to secondary school in Lokoja. These include residential area commercial zone and in some cases light industry. The study reveal that many school were surrounded by residential areas (60%). While this can be beneficial for students accessibility and it also raises concerns about traffic congestion during the school hours and potential noise pollution affecting nearby residents follow by commercial land use (20%), school located along the road where many commercial activities taken place increase exposure to vehicular emission and noise pollution and it also provide easy access to resources for both students and staffs.

4.2 Evaluate ventilation factors in Lokoja

The study found that 90% of the surveyed classrooms rely primarily on natural ventilation, with windows and doors serving as the main sources of air circulation. This high dependence on natural ventilation aligns with Oyedepo's (2014) observations in other Nigerian schools, where energy constraints often limit the use of mechanical ventilation systems. Analysis of the window-to-floor area ratio (WFR) revealed that 50% of classrooms fall below the recommended 15-20% WFR suggested by Jamaludin *et al*. (2014) for naturally ventilated buildings in tropical climates. The average WFR in Lokoja schools was found to be 11.5%, indicating insufficient window area for optimal natural ventilation.

4.3 Solid waste management practices in Lokoja secondary school

Table 4.1 showing adjoining land use surrounding secondary school

s/n	Waste generation	kilogram	percentage
1	Paper and cardboard	366.6	47%
2	Organic waste (food scraps, leaves)	179.4	23%
3	Plastics:	124.8	16%
4	Metal:	78	10
5	Glass:	19.5	2.5%
6	Others: 2%	11.7	1.5
	Total	**780**	**100**

The study revealed that paper and card (47%) are the most waste generate by secondary school Lokoja which is in line with Babayemi and Dauda (2009) observations on the prevalence of improper waste disposal methods in Nigerian institutions. 88% of schools had no waste segregation system 10% attempted some level of segregation (usually paper from other waste) Only 2% had a comprehensive waste segregation system. 65% of schools had no recycling initiatives, 25% had informal paper reuse practices (e.g., using one side of paper before disposal) while 10% participated in occasional recycling drives, usually led by external organizations.

4.3.1 Waste disposal

Table 4.3 Showing waste disposal method within the school.

Waste disposal methods within the school environment	**Currently used**	**Most often used**	**Sometimes used**	**Never used**	**Mean**	**std**
Open burning of waste	33(20.63%)	12(7.5%)	39(24.38%)	76(47.5%)	2.8	2.8
Landfill site	4(2.5%)	10(6.25%)	15(9.38%)	131(81.88%)	1.3	0.90
Composting waste	80(50.0%)	55(36.38%)	15(9.38%)	10(6.25%)	3.3	0.82
Incinerator	0	0	0	160(100%)	1.0	0.15
Recycling	0	0	0	160(100%)	1.0	0.09
Don't know	111(69.38%)	9(5.63%)	21(13.13%)	19(11.88%)	3.3	0.23
Grand mean					**3.3**	

The data on the Table 4.3 showed that open burning 20.63% said were currently used waste disposal methods within the school environment, 7.5% said most often used, 24.38% said sometimes used, while 47.5% said open burning of waste were never, used. Majority 81.88% of the students claimed that landfill sites were never used waste disposal methods within the school environment, while few 2.5%, 6.25% and 9.38% claimed that landfill site was currently, most often and sometimes used waste disposal methods within the school environment respectively. 50.0% of the students said compositing were currently used waste disposal methods within the school environment, some 36.38% said compositing were most often used, while 9.38% and 6.25% were sometimes and never used waste disposal methods within the school environment respectively. Majority 69.38% don't know-waste disposal methods used within the school environment, while 5.63%, 13.13% and 11.88% most often, sometimes and never knew waste disposal methods used within the school environment. On the other hand, incinerator and recycling are not being practiced as claimed by the students as waste disposal methods within the school environment. The mean score of the currently used waste disposal methods within the school environment revealed 1.3, 1.0 and 1.0, were below the expected mean of 2.5, while 2.8, 3.3 and 3.3 were above the expected mean score 2.5. On the grand mean 3.2 above the expected mean score revealed that the students were aware of the current used waste disposal methods within their school environment.

5. Conclusion.

The adjoining land use patterns around secondary schools in Lokoja reflect the city's rapid urbanization and present significant challenges for environmental management. The proximity of commercial and industrial activities, coupled with limited green spaces, creates a complex environmental context for schools. These findings underscore the need for integrated urban planning that considers the unique requirements of educational institutions and their surrounding environments.

The evaluation of ventilation factors in Lokoja secondary schools reveals significant challenges in maintaining adequate indoor environmental quality. The predominance of natural ventilation, while energy-efficient, is compromised by inadequate window areas, overcrowding, and suboptimal building design. These factors contribute to poor air quality, thermal discomfort, and potential health risks for students and staff.

The assessment of solid waste management practices in Lokoja secondary schools reveals significant room for improvement. The prevalence of open dumping, lack of waste segregation, minimal recycling efforts, and limited waste reduction strategies indicate a need for a more comprehensive and sustainable approach to waste management in secondary in Lokoja.

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Reviewing the Need for the Adoption of Computer-Aided Visual Management for Safety Risk Detection on Construction Sites in Abuja, Nigeria

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Abstract

The construction industry is one of the most hazardous sectors globally, with numerous risks to the safety and well-being of workers. In developing countries like Nigeria, where infrastructure development is rapidly expanding, safety management has become a pressing issue. Despite existing safety regulations and policies, the implementation of effective safety risk detection and management practices remains suboptimal in many Nigerian construction projects. This study therefore reviewed the need for the adoption of computer-aided visual management for safety risk detection on construction sites in Abuja with a view to reducing the rate of accidents on site. Using information obtained from relevant literature reviews which are acquired from textbooks, journals, conferences and online publication. Primary and secondary data were obtained from various constructions. The findings revealed that the adoption of computer-aided visual management for safety risk detection on construction sites in Abuja, Nigeria, offers a promising solution to the persistent safety challenges faced by the industry. In the light of the findings, this study concludes that by adopting computer-aided visual management for safety risk detection on construction sites, construction firms can improve their safety management practices, reduce accidents, and promote a culture of safety awareness.

Keywords: computer-aided visual management, construction sites, nigeria, safety risks

1. Introduction

The construction industry is one of the most hazardous sectors globally, with numerous risks to the safety and well-being of workers. In developing countries like Nigeria, where infrastructure development is rapidly expanding, safety management has become a pressing issue. Construction sites are characterized by dynamic and complex environments, which make it challenging to identify, assess, and manage safety risks efficiently. Traditional safety management practices, which often rely on manual processes and human observation, are increasingly proving inadequate due to the limitations of human perception and delayed response times in identifying potential hazards (Amoah *et al.,* 2019). This has led to an exploration of more advanced technological solutions to enhance safety management on construction sites.

Accident and injury rates in developing countries such as Nigeria are generally considered to be higher than in the developed countries (Amusan *et al.,* 2018). This has been attributed to lack of appropriate consideration of health and safety (H&S) management practices in construction project delivery process (Oloke *et al*,.2017). Amusan *et al.,* (2018) noted that safety should be a major concern for employers, but in Nigeria, it is believed that only the large sized construction industry has employees' safety as a major concern.

In recent years, the adoption of technology in construction safety management has garnered significant attention. One such technology is computer-aided visual management (CAVM), which combines visual data, such as images and videos, with automated systems to detect and assess safety risks in real-time. CAVM leverages artificial intelligence (AI), machine learning (ML), and computer vision to monitor activities on construction sites, identifying hazards that might otherwise go unnoticed. By using cameras, sensors, and advanced software, CAVM can track worker behaviour, monitor the use of personal protective equipment (PPE), and detect unsafe conditions, providing real-time alerts to site managers for immediate intervention (Wang *et al.,* 2020).

In order to achieve this aim, this paper reviewed literature on the current safety monitoring in construction; technology advancement in construction safety; computer vision-based safety and health monitoring; benefits for adopting computer-aided visual management safety risk detection; barriers to adoption of computer-aided visual management for safety risk detection on construction sites; and drivers enhancing the adoption of computer-aided visual management for safety risk detection on construction sites.

2. Literature review

2.1 Current safety monitoring in construction

Construction safety is becoming increasingly important as more emphasis is placed on developing extra infrastructure, such as complex buildings and large projects (Li *et al.,* 2024). Consequently, its unique nature poses difficulties in terms of safety monitoring and occupational health. Because of its inefficiency in dealings with these risky environments, the construction sector does not have an outstanding global reputation. Driven by this over the last decade

The current conventional method for addressing safety concerns is the traditional top-to-bottom control strategy, which is commonly employed for safety monitoring during the construction execution stage at job sites. In this study, the top-to-bottom approach is defined as a safety monitoring process sin which safety methods are enforced exclusively from top-level managers downward. Conversely, the bottom-up approach is defined as safety management in which the bottom managers also participate and report the information from the bottom to the top. The traditional top-to-bottom job site observation during construction relies on the physical presence of a safety manager to identify hazards or violations of safety rules (Khan *et al.,* 2019). Observation of the construction job site is generally performed on a weekly or biweekly basis, depending on the size and complexity, with random visits lasting for 1 to 3 hours (Seo *et al*., 2015). The staff visually investigates the equipment, tools, and work area (Reese and Eidson, 2006) to report the hazards to be eliminated. The success of these observations for safety rule compliance is determined by the expertise and competence of the concerned person (Cayet *et al,*2009). Existing safety observation methods are manual, costly, and time-consuming (Liu *et al*,.2016). Researchers have recently sought to develop advanced approaches such as Computer Vision (CV) and Internet of Things (IoT)-based automated security management as a solution to these challenges, reducing the challenges associated with manual safety inspection (Fang *et al*., 2019).

2.2 Technology advancement in construction safety

Technology has been playing an increasingly pivotal role in enhancing job site safety with construction task automation (Suddin 2015; Ju and Rowlinson, 2014). Development and technological advancements have inspired each area of the construction sector, including safety management. Information and communication technologies (ICT) have been widely used in construction safety management (CSM) over the past decade (Ozumba and Shakantu, 2020). Skibniewski (2014) reviewed the use of ICT for CS Mover the past decade. One particular area where technology has shown promise is in the application of visualization technology for construction safety training. By harnessing the power of visualization tools, construction professionals can gain a better understanding of potential risks and take proactive measures to mitigate them (Jeelani *et al*., 2020). These tools facilitate the education of workers regarding safety protocols, assist in safety monitoring (Guo *et al*., 2016; Guo *et al*., 2017), and aid in job hazard analysis (Zhang, 2015).

Similarly, CV technologies have witnessed rapid advancement and have found in- creasing application sin CSM. The abundance of digital image data from real construction sites has paved the way for more accurate and efficient CV-based object detection methods. These technologies can analyze image sand video foot age to identify potential safety hazards, monitor worker behavior, and ensure compliance with safety protocols (Arshad *et al*., 2023). Additionally, CV technology can automate the process of job hazard analysis by automatically detecting and categorizing potential hazards based on visual data (Khan *et al.,* 2019).

2.2.1 Computer vision-based safety and health monitoring

In computer vision-based technology, imagery data collected using either 2D or 3D camera systems are processed by a variety of algorithms to realize object detection, on the basis of which the object tracking and action recognition are accomplished if needed (Seo *et al*., 2015). In the example scenario, the worker and the excavator must first be detected from a piece of video footage as objects at the construction site. According to Regona *et al*. (2022), successful detection is not enough to conclude that the worker is in a dangerous situation. If the distance between worker and excavator is sufficient and the worker is stationary, or if the worker is moving but the worker is protected by a fencing system and the excavator is operating at a safe distance, or if the worker is moving in an area with no fencing system but the excavator is not being operated, then the worker is safe (Shanti *et al*., 2022). However, the worker and the excavator operator need to be warned if the worker moves towards a working excavator and the area around the excavator is not fenced. In this scenario, the CV needs to track the movement of the worker and predict his or her trajectory in following few seconds, understand the surrounding context, and recognize the action of the excavator. RTLS: The RTLS module in this framework locates and tracks the movement of workers, materials, and equipment with an acceptable accuracy (Shanti *et al*., 2022).

Although CV is capable of tracking objects, the actual performance is insufficient to support industry practices. As such, a RTLS is used to assist the CV approach, for example, to calculate the distance between a worker and an

excavator, track the movement of the worker, and predict the worker's trajectory. Through outdoor RTLS (e.g., GPS), indoor RTLS (e.g., RFID-based system), or mixed RTLS (e.g., UWB system), local coordinates of an object being tracked are calculated by the Received Signal Strength (RSS) method (Park *et al.*, 2011).

Computer vision is an interdisciplinary field closely related to deep learning, with the primary objective of analyzing and extracting information from images or videos obtained through industrial cameras, like how human eyes analyze visual information (Fang *et al*., 2018), This is accomplished using a series of algorithms, including convolutional neural networks, Faster R-CNN, and the widely used YOLO, which extract features from images and identify objects within them. Common tasks in computer vision include object detection, object tracking, and semantic segmentation (Zhao *et al*., 2022). Object detection involves the process of a computer algorithm detecting whether an input image contains a specific object and marking its location within the image, which is often a prerequisite for subsequent analysis. In the construction field, object detection can be utilized to conduct preliminary safety equipment inspections on construction workers (Park *et al*., 2020). For example, detecting safety helmets can determine whether workers are wearing them and provide timely warnings to those who are not, thus significantly reducing the likelihood of accidents resulting from the failure to wear safety helmets.

The adoption rate of new technologies is still relatively low in the construction industry, particularly for mitigating occupational safety and health (OSH) risks, which is traditionally a largely labour-intensive activity in developing countries, occupying ill-afforded non-productive management resources (Yap *et al*., 2022). However, understanding why this is the case is a relatively unresearched area in developing countries such as Nigeria. It has been established that construction workers' behaviours directly affect labour productivity and their own safety, thereby influencing project quality. Recognizing and monitoring the construction-related behaviours is therefore crucial for high-quality management and orderly construction site operation. Recent strides in computer vision technology suggest its potential to replace traditional manual supervision approaches (Li *et al*., 2024).

Traditionally, professionals conduct on-site inspections and supervise and record work, which often leads to problems such as insufficient coverage, unreasonable personnel scheduling, time-consuming tasks, and subjective supervision results (Dawood *et al*., 2018). In recent years, many countries have embraced the concept of intelligent construction, driven by the development of information technology and the Internet of Things (Xu *et al*., 2018). Thanks to technology and policy, several intelligent technologies, such as sensor technology, audio technology, and computer vision technology, are being employed in engineering construction supervision.

2.2.2 Benefits for adopting computer-aided visual management safety risk detection on construction sites

This section summarizes previous studies on the detection and real-world localization of construction entities in digital images extracted from construction sites. The pros and cons of the various approaches are also explored. CV is a field of science that deals with how computers understand high-level information from frames of images (Park *et al*., 2020). Advancements in machine learning have enabled computers to better interpret visual data, leading to significant progress in CV (Fang *et al,.*2020).However, traditional machine learning algorithms still face limitations in analyzing raw data, necessitating the development of feature descriptions using expert knowledge and engineering experience (Lecun *et al.,* 2015).Convolutional neural network (CNN)-based models have proven successful and effective in extracting object information, as demonstrated by their application to Microsoft Common Objects in Context and PASCAL Visual Object Classes (VOC) 2007 data sets (Fang *et al,.*2020).By integrating deep learning methods with collected images and employing CV, it becomes possible to automatically acquire and utilize data for training that may include features not originally designed by human engineers. In contrast to artificial neural networks, deep learning models consist of multiple processing layers based on neural networks that learn from data at various levels of abstraction (Lecun *et al*., 2015). CNN is the most widely used deep learning approach, comprising three types of neural layers: (a) convolutional, (b) pooling, and (c) fully connected. CNN-based deep learning algorithms have found extensive applications in various CV tasks, such as classification, object recognition, object segmentation, and posture analysis among others.

The extant review of literature carried out in this section has revealed several benefits for adopting computer vision-based safety risk computing and visualization for safety management on construction sites. These benefits are highlighted in Table 1.

2.2.3 Barriers to adoption of computer-aided visual management for safety risk detection on construction sites

The construction industry is inherently reluctant to innovate, especially in developing countries like Nigeria (Yap *et al*., 2019). For example, in investigating contruction industry (CI) in the current Egyptian situation, Alateeq *et al*. (2023) concluded that "the implementation of CAVM within the construction industry is still lacking tremendously despite having the accessibility of these technologies." As Wang *et al*. (2013) highlighted, "the implementation of

building information modeling (BIM) in many projects has failed to achieve expected benefits due to user resistance." Likewise, in Malaysia, there is a limited utilization of automation and robotics for such on-site construction as structural steelwork and the assembly of prefabricated components (Ryoo, 2011). Previous studies found the construction industry in Nigeria having a similar pattern of problems despite different geographical, social, political and economic backgrounds (Kolar *et al*., 2018; Yap *et al*., 2019).

Recently, Mostafa and Hegazy (2021) systematic review collected and analyzed 68 articles from 2010 to 2020 to conclude that CI enabling technologies can benefit safety management. These enable the digital technologies (e.g., cyber-physical system (CPS), radio-frequency identification (RFID), internet of things (IoT), automation, modularization, robotics), simulation and modelling (e.g., building information modelling (BIM), augmented reality (AV), virtual reality (VR), mixed reality (MR)), and digitization and virtualization (e.g., cloud computing, big data, mobile computing) across the entire construction value chain (Ozumba and Shakantu, 2016). However, despite the technological advancements and academic attention in this area, the rate of integrating new technologies into construction safety science and management in Nigeria is still limited (Khan *et al.,* 2019). Furthermore, the applications of new technologies for construction safety are mainly a matter for academic research, with a limited transition into practice (Zhou *et al.,* 2015).

The rigorous literature review carried out in this section has revealed several barriers to the adoption of computer vision-based safety risk computing and visualization technology for safety management on construction sites.

2.2.4 Drivers for adoption of computer vision-based safety risk computing and visualization for safety management on construction sites

According to Fang *et al*. (2020), to address the barriers to the adoption of vision-based safety risk computing and visualization technology and ensure computer vision can be effectively and efficiently applied to monitor safety, areas of potential drivers should be determined. In view of this, Fang *et al*. (2020) identified several drivers for enhancing the adoption of vision-based safety risk computing and visualization technology. These drivers are: Combining deep learning and computer vision with digital technologies; integrating Ontology and computer vision; developing a deep learning visual analytics system for project performance based on an as-built three dimensional (3D) semantic reconstruction model and as-planned' model using computer vision; integrating As-built visual data, AR/VR, and building information models; utilizing video streams and multi-model fusion; combination of text reports and image data; and alignment between computer vision and non-visual sensor data. It was thus concluded that computer vision combined with deep learning provides the capability to automatically identify unsafe behavior and conditions on construction sites and therefore can be used to improve safety performance. Nonetheless, there remain several challenges that need to be addressed before construction can directly benefit from technological developments being made within the field of computer vision.

According to Amoah *et al.* (2019), a construction industry integrates advanced technologies, such as robots, artificial intelligence (AI), Internet of Things (IoT), and the Computer Vision (CV) to improve efficiency and productivity. The implementation of CAVM has the potential to provide many benefits, however, human safety must be prioritised. In the light of these Bhana *et al*. (2024) identified several drivers for enhancing the adoption of these technologies. These include the following: provision of personal protective equipment (PPE); having clear workspace; putting in place emergency response plan; carrying out regular maintenance; putting in place predictive maintenance plan; and carrying out regular employee training by construction industry in Abuja (Amusan *et al.,* 2018). Delgado *et al*. (2020) reported further that workers may require PPE such as safety glasses, gloves, respirators, or hard hats according to the nature of the construction industry. It is also emphasized that it is essential to maintain a clear and organized working environment to prevent accidents and injuries. When equipment and tools are not in use, they should be properly stored, and all work areas should be free of debris and clutter. An emergency response plan should be in place for construction facilities in the event of an accident, fire, or other emergencies (Eiri *et al*., 2018). A safety plan should include instructions regarding evacuation procedures, emergency contact information, and how to use safety equipment like fire extinguishers. Regular maintenance and inspections are essential for ensuring the safety of employees and equipment. Performing routine maintenance tasks, such as cleaning and oil changes, involves checking equipment for wear and tear. Intelligent construction facility relies heavily on predictive maintenance, which is a process that identifies and resolves potential equipment failures prior to their occurrence Albahbah *et al*. (2021). Machine learning algorithms and data analytics can be used to optimize maintenance schedules, reduce downtime, and improve the overall efficiency of operations. A comprehensive training programme should be provided to all employees on safe equipment operation, handling of hazardous materials, and emergency response procedures. Whenever there are any changes in safety protocols or changes in training, it is imperative that this training is regularly updated and reinforced.

The thorough review of literature carried out in this section has revealed several drivers for the adoption of computer vision-based safety risk computing and visualization technology for safety management on construction sites.

3. Methodology

Data used in this study basically consists of secondary sources as it is primarily desk research. Thus, various journals, articles, conference proceedings, textbooks and thesis were reviewed. Upon extracting data from the review inferences will be on the safety risk detection on construction sites in Abuja Nigeria and the need for adoption of computer-aided visual management on them.

All literature collected involved safety risk detection on construction sites. This is to ensure that studies are searched as extensive as possible in order to reduce risk of publication bias and to identify relevant evidence as much as possible. Both published and unpublished literature were searched. Databases such as Science Direct, Taylor, Emerald Insight, Google and Google Scholar were consulted. The search expression includes a combination of the following keywords: "Safety risk detection", "Computer aided vision management", "Construction Industry" and "Abuja, Nigeria'.

4. Conclusions

This study concludes that use of computer-aided visual management (CAVM), which combines visual data, such as images and videos, with automated systems to detect and assess safety risks in real-time. CAVM leverages artificial intelligence (AI), machine learning (ML), and computer vision to monitor activities on construction sites, identifying hazards that might otherwise go unnoticed. By using cameras, sensors, and advanced software, CAVM can track worker behaviour, monitor the use of personal protective equipment (PPE), and detect unsafe conditions, providing real-time alerts to site managers for immediate intervention can be used for safety risk detection if properly adopted. This study also concludes that combining deep learning and computer vision with digital technologies; combination of text reports and image data; and understanding the interactions between different activities, scenarios, or work packages of the objects (including humans) are one of the significant drivers enhancing the adoption of computer-aided visual management for safety risk detection on construction sites.

In view of the findings and conclusions, the study recommends the following:

i. The need to adopt advanced technologies like CAVM in Abuja's construction industry stems from the recognition of the limitations of current safety management systems and the increasing complexity of construction projects. By integrating CAVM, construction companies in Abuja could improve their ability to detect and mitigate safety risks, ensuring a safer working environment for their employees

ii. Additionally, the use of CAVM could foster compliance with international safety standards, enhance productivity by reducing the occurrence of accidents, and lower the overall costs associated with workplace injuries and fatalities.

iii. On the challenges of the adoption of CAVM in Abuja, one major issue is the cost of implementing such advanced technologies, which may be prohibitive for smaller construction firms. Therefore, there is a need for technical expertise to operate and maintain CAVM systems, which may require additional training and capacity-building efforts.

iv. Finally, organisations and construction stakeholders should encourage, ensure, and promote the proper adoption of the CAVM into construction safety management in order to enhance firm's competitive advantage and boost performance.

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Parameters and Drivers of Safety Management Cost of Multi-Storey Building Projects in Bayelsa State

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Abstract

Most of the construction industry's Safety Management Costs (SMCs) are set lower than the actual budget required especially for multi-storey buildings. Therefore, the budget estimated for safety measures in the construction of multi-storey buildings are not accurate, resulting to higher rate of risks of accident and fatalities on site. In view of this, the study aimed at assessing the parameters and divers for the accuracy of estimation of safety management cost of multi-storey building projects in Yenagoa, Bayelsa State. The research adopted a quantitative approach. Systematic random sampling technique was used to collect data from 72 construction professionals of Bayelsa state ministry of works and infrastructure, Federal ministry of works and housing and the building contractors in the state. Mean Item Score (MIS) was used to analyse the data collected. Findings from the analysis indicates that cost of communication devices, management's cost and cost of ergonomic training for design staffs are the most important parameters for measuring SMC. Clear and reasonable safety goals, design firm engagement and management support/top management involvement are the most effective drivers for enhancing the accuracy of estimation of SMC for multi-storey building projects. The study suggests that in order to enhance the accuracy of the estimation of SMC for multi-storey building projects in Bayelsa State, construction firms and all other relevant stakeholders should develop a mechanism that will include and incorporate all the drivers and basic parameters identified in this study.

Keywords: Building Projects, Drivers, Multi-storey, Parameters, Safety Management Cost

1. Introduction

Construction is one of the world's biggest industries that include jobs as diverse as building, civil engineering, demolition, renovation, repair and maintenance which exposed workers to a wide variety of hazards (Shittu *et al*., 2022). According to Mahmoud *et al*. (2020), Nations all over the world consider the construction industry as a major stimulant to their economic growth and development. The construction industry experiences high injury and fatality rates and is far from achieving a zero-injury goal. Thus, effective safety management systems are critical to ongoing efforts to improve safety especially in multi-storey building projects (Jazayeri and Dadi, 2017). The estimated economic loss caused by work-related injuries and disease was equivalent to 4% of the world's gross national product (Fekele *et al*., 2016). Laws on occupational safety and health are not strictly enforced, safety rules in most construction sites do not exist and if they exist, the regulatory authority is weak in implementing each rule effectively, however, when accidents occur, they result in both direct and indirect costs. Direct cost includes, medical bills, premium for compensation benefits, liability and property loss. Indirect cost includes, time lost while attending burial ceremonies, time lost in investigation, down time on damaged equipment and losses arising from site closure (Kibe, 2016). Kim *et al*., (2019) further disclosed that worldwide, at least 108,000 workers are killed every year in the construction industry, which represents about 30% of all fatal occupational accidents.

The safety management costs of building projects in Nigeria are significantly influenced by the implementation of health and safety practices, which are often perceived as burdensome by stakeholders. This perception leads to neglect in safety measures, ultimately increasing overall project costs due to accidents and injuries (Zubair and Udo, 2023). Gurcanli *et al*. (2015) added that despite the critical role of safety management in preventing these incidents, the costs associated with implementing effective safety protocols are still often viewed as an unnecessary financial burden. Han *et al*. (2022), also revealed that safety accidents can be decreased if design for safety (DFS) is conducted on structures of varied shapes, and efforts are concentrated on reducing safety accidents at the construction stage. However, the safety management cost (SMC) suitable for the characteristics of the construction site must be invested in for efficient construction site safety management. Previous studies focused more on health and safety practices and management (Phoya, 2012; Gitau, 2015; Li *et al*., 2018; Trinh and Feng 2020; Parsamehr *et al*., 2022). However, no or little research was found on success factors to the accuracy of estimation of safety management cost especially

for multi-storey building projects. In view of this, this study evaluates the basic parameters for measuring and drivers for the accuracy of estimation of safety management cost of multi-storey building projects in Yenagoa, Bayelsa State.

2. Literature review

2.1 Concept of safety management cost

Safety is an important issue to ensure uninterrupted work and save lives of workers in any type of industry. Safety and health in construction is a condition in which an employee needs a safe and healthy environment for herself and other people that be affected by its activities (Brahmachary *et al*., 2018). Alaloul *et al*. (2020), stated that the application of Occupational Health and Safety (OHS) practices have been a common matter within construction industry when it comes to safety management in developed countries and Nigeria as well. Moreover, every construction firms needed to implement the safety management in the organization. As indicated by Alaloul *et al*. (2020), limited resources of safety management have been facing by most of the company and contractors are needed to handle the matter itself. Health and safety equipment such PPE is beneficial against potential risks that arises on-site. Consequently, adaptation of safety performance in the construction industry is crucial as it protects the lives of the workers and enhances the flow of the construction projects.

Moda *et al*. (2022) revealed that safety of workers have long been a global concern. The International Labour Organization Convention has placed emphasis on the need to protect employees from occupational injuries and fatalities, which often manifest into negative impact on productivity, economic and social development of a nation. Additionally, prioritizing management practices like hazard analysis, safe work methods, and safety meetings can enhance *labour* productivity and subsequently affect safety management cost in multi-storey building project (Mangave *et al*., 2023). Safe and healthy working conditions do not happen by chance, employers need to have a written safety policy for their enterprise, setting out the safety and health standards which it is their objective to achieve (Fekele *et al*., 2016). Proper planning, scheduling, and the presence of a warning system throughout the project are vital to control delays and manage resources effectively, ultimately impacting safety management cost. Understanding and addressing security risks in construction projects are crucial for cost-effective risk management and project success. Thus, effective safety management cost are critical to ongoing efforts to improve safety (Jazayeri and Dadi, 2017).

2.2 Parameters for measuring safety management cost of multi-storey building projects

The demand for multi-storey building projects grows over time, which leads to an increase in the number of accidents and fatalities during construction (Manzoor *et al*., 2022). Therefore, the safety costs play an important role in enhancing the safety level of the construction site; however, the allocations of the safety budget are still not optimal in terms of the prevention of accidents in the construction industry (Yang *et al*., 2021). Yang *et al*. (2021) added that a safety cost expenditure guideline is beneficial to effectively allocate the safety budget for accident prevention and prevent occupational injuries. Some basic suitable measurement parameters or elements of successful health and safety management cost systems is summarised in Table 1.

Table 1: Parameters for measuring safety management cost of multi-storey building projects

S/N	Basic Parameters	Sources
1	Management's Cost	Jazayeri and Dadi (2017)
2	Cost of training employees	Jazayeri and Dadi (2017)
3	Cost of communication devices	Chandi *et al*., 2018
4	Cost of accident investigation procedures	Manzoor *et al*., (2022)
5	Cost of ergonomic training for Design staffs	Setiawan *et al*., (2017)
6	Safety Personnel Salaries and Benefits	Zhu *et al*, (2024)
7	Safety Equipment and Gear	Park *et al*., (2020).
8	Safety Meetings and Programs	Yang *et al*., (2021).
9	Safety Inspections and Audits	Gurmu (2020)
10	Safety Software and Technology	Zhu *et al*, (2024)
11	Safety Consultancy Services	Mangave *et al*., (2023)
12	Emergency Preparedness and Response	Murali and Rafikullah, (2021).

2.3 Drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects

Every effort must be taken to bring up the level of consciousness among the employees as well as management about the importance of health and safety and its cost implications at work sites; It is highly desirable to decrease the rate of accidents for employee working in the construction industry all over the world (Kanchana *et al*., 2015). Mahmoud *et al*. (2020) added that construction safety is significantly impacted when safety on site is considered at the conceptualization stage. Murali and Rafikullah (2021), established that the details of the element of critical management factors that can enhance safety and health management practices on a multi-storey building project are summarized in Table 2.

Table 2: Drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects

S/N	Drivers	Sources
1	Design Firm Engagement	Bieder *et al*. (2017); Ni *et al*. (2020)
2	Contractor Selection	Reese, (2018); Okechukwu, *et al*. (2021)
3	Contractual Arrangement	Roumboutsos and Saussier (2014)s
4	Safety education and training for workers	Ayodele and Olubayo-Fatiregun, (2013); Murali and Rafikullah (2021)
5	Health and safety communication and feedback	Okechukwu, *et al*. (2021); Murali and Rafikullah (2021)
6	Safety incentive or reward system	Kanchana *et al*. (2015) Murali and Rafikullah (2021)
7	Management support	Bieder *et al*. (2017)
8	Occupational health and safety policies and programs	Reese (2018)
9	Occupational health and safety committee	Reese (2018)
10	Control of sub-contractor	Biketi *et al*. (2019)
11	Resources and insurance policies	Heunis *et al*. (2019) Murali and Rafikullah (2021)
12	Emergency Response Plan (ERP)	Ni *et al*. 2020; Murali and Rafikullah (2021)
13	Suitable supervision	Murali and Rafikullah (2021)
14	Clear and reasonable safety goals	Ayodele and Olubayo-Fatiregun (2013)
15	Safety environment	Murali and Rafikullah (2021)
16	Health and safety meetings	Murali and Rafikullah (2021)
17	Job hazard analysis	Shittu *et al*. (2019)
18	Post-accident investigation	Shittu *et al*. (2019)
19	Compliance with customer or regular certification schemes	Shittu *et al*. (2019)

2. Research methodology

This study utilised a quantitative approach, with a questionnaire survey, to assess parameters and divers for the accuracy of estimation of safety management cost of multi-storey building projects in Yenagoa, Bayelsa State. The population of this study consist of 138 construction professionals (34 Safety officers, 48 Quantity surveyors and 56 building contractors in the state) who are actively involved in site activities of multi-storey building projects executed by Bayelsa State Ministry of Works and Infrastructure, Federal Ministry of Works and Housing and are engaged in site safety management. The sample size of the study was 102 using a simplified formula proportion as illustrated by Glenn (2013). Therefore, 72 out of 102 questionnaires distributed were retrieved at the end showing an effective response rate of 70.58%. Descriptive statistics, using the Mean Item Score (MIS) was employed to analyse the collected data using the Statistical Package for Social Science (SPSS) version 26 and Microsoft Excel.

3. Research findings and discussion of results

3.1 Respondents' information

Table 3 presents the demographic and professional characteristics of survey respondents, along with the percentages for each category. In terms of respondents' designation, it revealed that the highest was Quantity

Surveyors (38.89%). With respect to respondents' professions, Quantity Surveyors were highest, representing 30.56% of the population. It was also shown that most of the respondents are holders of BSc/BTech degree, representing 50% of the population. This is followed by holders of HND who represent 25%. The respondents were also revealed to be registered members of their professional bodies. The profile of respondents also shows that most of the respondents have 6 – 10 years' experience, representing 47.22% of the total population. This however, shows that the respondents are educated, qualified and experienced enough to provide reliable information needed for the study.

Table 3: Respondents' Profile

Profile	Statistics	
Respondents' Designation	**Frequency**	**Proportion (%)**
Safety Officer	21	29.17
Quantity surveyor	28	38.89
Contractors	23	31.94
Respondents' Profession	**Frequency**	**Proportion (%)**
Architect	12	16.67
Builder	9	12.50
Engineer	18	25
Quantity Surveyor	22	30.56
Others	11	15.27
Respondents' Highest Academic Qualification	**Frequency**	**Proportion (%)**
Higher National Diploma (HND)	18	25
Bachelor's Degree (BSc/B.Tech)	36	50
Master's Degree (MSc/MTech)	11	15.28
Doctoral Degree (PhD)	2	2.78
Others	5	6.94
Respondents' Years of Experience	**Frequency**	**Proportion (%)**
0-5 Years	17	23.61
6-10 Years	34	47.22
11-15 Years	10	13.89
16-20 Years	7	9.72
Above 20 Years	4	5.56
TOTAL	***72***	***100***

3.2 Mean item score of the parameters for measuring safety management cost of multi-storey building projects

Table 4 revealed twelve (12) parameters for measuring safety management cost of multi-storey building projects with mean score ranging between 4.83 and 3.54. "Cost of communication devices", "Management's cost" and "Cost of ergonomic training for design staffs were ranked the most important parameters for measuring safety management cost of multi-storey building projects with a mean score of 4.83, 4.68 and 4.50 respectively. On the average, all the identified parameters for measuring safety management cost of multi-storey building projects are important (average MIS = 4.01). Past studies also support the findings of this study by revealing that there are variety of safety management systems being used in industries and their foundations are similar (Jazayeri and Dadi, 2017). Also, in line with the findings of this study, Jazayeri and Dadi (2017) revealed that cost of communication devices and management cost are crucial safety management system parameters and performance measurements which will increase awareness for researchers and practitioners.

Table 4: Parameters for measuring safety management cost for multi-storey building projects

Code No.	Basic parameters	MIS	Rank	Decision
B3	Cost of communication devices	4.83	1st	Very Important
B1	Management's Cost	4.68	2nd	Very Important
B5	Cost of ergonomic training for Design staffs	4.50	3rd	Very Important
B4	Cost of accident investigation procedures	4.21	4th	Important
B7	Safety Equipment and Gear	3.98	5th	Important
B9	Safety Inspections and Audits	3.94	6th	Important
B11	Safety Consultancy Services	3.90	7th	Important

B2	Cost of training employees	3.79	8th	Important
B6	Safety Personnel Salaries and Benefits	3.65	9th	Important
B10	Safety Software and Technology	3.60	10th	Important
B12	Emergency Preparedness and Response	3.58	11th	Important
B8	Safety Meetings and Programs	3.54	12th	Important
	Average	4.01		Important

3.5 Mean item score of the drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects

Table 5 revealed nineteen (19) drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects with mean score ranging between 4.81 and 3.54. Drivers such as "Clear and reasonable safety goals", "Design Firm Engagement" and "Management support/Top Management Involvement" were ranked first (1st), second (2nd) and third (3rd) as the most effective drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects with a mean score of 4.81, 4.70 and 4.51 respectively. On the average, all the identified drivers for enhancing the accuracy of estimation of safety management cost of multi-storey building projects are effective (average MIS = 3.99). The findings from this study are in tandem with submissions from Murali and Rafikullah (2021) who stated that safety and health management in multi-storey building construction projects were highly significance. Thus, these drivers may underlie the main reasons for accidents, injuries, and fatalities in multi-storey building construction projects. The findings of this study are further supported by Mahmoud *et al*. (2020) which stated that safety related issues should be considered in the feasibility study during the design conceptualization phase and the responsiveness of design firms towards safety to forms the bases for their selection.

Table 5: Drivers for enhancing the accuracy of estimation of safety management cost for multi-storey building projects

Code No.	Drivers	MIS	Rank	Decision
D14	Clear and reasonable safety goals	4.81	1st	Very Effective
D1	Design Firm Engagement	4.70	2nd	Very Effective
D7	Management support/Top Management Involvement	4.51	3rd	Very Effective
D5	Health and safety communication and feedback	4.47	4th	Effective
D2	Contractor Selection	4.10	5th	Effective
D3	Contractual Arrangement	4.06	6th	Effective
D4	Safety education and training for workers	4.04	7th	Effective
D8	Occupational health and safety policies and programs	3.98	8th	Effective
D9	Occupational health and safety committee	3.88	9th	Effective
D10	Control of sub-contractor	3.87	10th	Effective
D11	Resources and insurance policies	3.83	11th	Effective
D6	Safety incentive or reward system	3.75	12th	Effective
D16	Health and safety meetings	3.75	12th	Effective
D12	Emergency Response Plan (ERP)	3.73	14th	Effective
D15	Safety Environment	3.73	14th	Effective
D13	Suitable supervision	3.69	16th	Effective
D19	Compliance with customer or regular certification schemes	3.67	17th	Effective
D18	Post-accident investigation	3.65	18th	Effective
D17	Job hazard analysis	3.54	19th	Effective
	Average	*3.99*		*Effective*

4. Conclusion and recommendation

Health and Safety practices have been a common matter within construction industry when it comes to safety management in developed countries and Nigeria as well. Moreover, every construction firms needed to implement the safety management in the organization and limited resources of safety management have been facing by most of the company and contractors are needed to handle the matter itself. The study therefore concludes that top management should support and be involved in the health and safety plan before commencement of design/construction project. The study further recommends that there should be a proper and adequate communications and coordination among contractors, clients, and workforce during design in relation to safety cost

and management and also provision of Safety education and training for workers and proper understanding of occupational health and safety policies and programs to the government and society.

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Review on Framework for the Assessment of Value For Money In PPP Projects

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Abstract

This study develops a comprehensive framework for assessing Value for Money (VfM) in Public-Private Partnership (PPP) projects in North Central Nigeria, addressing a critical gap in both literature and practice. The research employs a mixed-methods approach, combining qualitative and quantitative techniques to create a robust, context-specific framework. The study begins with a thorough literature review, exploring recent advancements in VfM concepts and assessment methodologies. In-depth interviews with key stakeholders from public and private sectors, as well as end-users and financiers, provide rich insights into local VfM perceptions and practices. A Delphi study with experts refines and validates initial framework components. Quantitative data from a large-scale survey of PPP practitioners in the region tests and validates the developed framework. The resulting framework integrates multiple value dimensions, including economic, social, and environmental factors, adopting a lifecycle approach to VfM assessment. It addresses critical factors such as stakeholder col*labour*ation, innovation, and sustainability, while considering the unique challenges of the local context, including limited institutional capacity and inadequate risk allocation. Key findings include the identification and prioritization of critical VfM factors and key performance indicators specific to North Central Nigeria, the development of practical assessment tools, and recommendations for improving VfM throughout the PPP project lifecycle. The research contributes to bridging the gap between theoretical advancements in VfM assessment and practical implementation in developing economies. This study offers valuable insights for policymakers, practitioners, and researchers involved in PPP projects in Nigeria and potentially other developing economies. The framework provides a practical tool for enhancing VfM in PPP projects, potentially leading to improved infrastructure delivery and public service provision in the region.

Keywords: Infrastructure Development, innovative value creation, Lifecycle Assessment, Mixed-Methods Research, Public-Private Partnerships, stakeholders perspective, sustainability and Value for Money

1. Introduction

Public-Private Partnerships (PPPs) have become increasingly vital for infrastructure and service delivery in developing economies like Nigeria, with a growing emphasis on ensuring Value for Money (VfM). The concept of VfM in PPPs has evolved from a narrow financial focus to a more comprehensive approach that considers broader societal and environmental impacts, aligning with global sustainability goals (Osei-Kyei and Chan, 2023; Grimsey and Lewis, 2023; Li *et al*., 2023). Recent research underscores the importance of effective stakeholder collaboration, innovation, and sustainability in achieving VfM. Studies highlight the need for aligned objectives between partners, integration of technological advancements, and adoption of a triple bottom line approach (Liu *et al*., 2024; Kwak *et al*., 2024; Elkington, 2022). Additionally, there is growing recognition of the need for a lifecycle approach to VfM assessment, encompassing continuous evaluation throughout all project phases (Henjewele *et al*., 2022).

In the context of Nigeria's North Central states, challenges persist in effectively assessing and ensuring VfM in PPP projects, including inadequate risk allocation, lack of transparency, and limited capacity for project evaluation (Babatunde *et al*., 2023). The theoretical foundations of VfM assessment have also evolved, incorporating various theories to provide a more comprehensive understanding of value generation in PPPs (Cui *et al*., 2023). Given these developments and challenges, there is a clear need for a context-specific, comprehensive framework for assessing VfM in PPP projects in North Central Nigeria, which this study aims to address.

Despite increasing PPP adoption, there is a notable lack of comprehensive, context-specific frameworks for assessing VfM throughout the project lifecycle (Osei-Kyei and Chan, 2023; Babatunde *et al*., 2023). Traditional VfM methodologies, focusing primarily on financial metrics and risk transfer, fail to capture the full spectrum of value created through PPPs, including broader societal and environmental impacts (Grimsey and Lewis, 2023; Li *et al*.,

2023). The complex dynamics of stakeholder relationships, the importance of innovation and sustainability, and the need for a lifecycle approach further complicate VfM assessment (Liu *et al*., 2024; Kwak *et al*., 2024; Elkington, 2022; Henjewele *et al*., 2022). In the North Central Nigerian context, additional challenges such as inadequate risk allocation, lack of transparency, and limited evaluation capacity impede effective VfM assessment (Babatunde *et al*., 2023). While theoretical advancements in VfM assessment have occurred (Cui *et al*., 2023), there remains a critical gap in integrating these perspectives into a practical, context-specific framework that addresses the unique challenges of the local environment, incorporates multiple stakeholder viewpoints, and accounts for sustainability and innovation factors throughout the project lifecycle. The point of convergence is the development of both quantitative and qualitative assessment mechanisms for VfM, incorporating a continuous improvement and feedback loop.

2. Literature Review

The concept of Value for Money (VfM) in Public-Private Partnership (PPP) projects has evolved significantly over the past decade, particularly in developing economies like Nigeria. Traditional approaches to VfM assessment have primarily focused on financial metrics and risk transfer, but recent literature suggests a need for a more comprehensive framework that considers the entire project lifecycle (Osei-Kyei and Chan, 2023). In the context of North Central Nigeria, where institutional capacity for managing complex PPP arrangements is often limited, there is a pressing need for a tailored approach to VfM assessment that addresses local realities while incorporating global best practices (Babatunde *et al*., 2023).

The evolution of VfM across different project lifecycle stages has been a subject of growing interest in recent research. Henjewele *et al*. (2022) argue for the importance of continuous VfM assessment throughout the project lifecycle, from initial planning through to operation and transfer phases. This lifecycle approach recognizes that value creation and challenges evolve over time, necessitating dynamic assessment tools and methodologies. However, practical implementation of this approach, particularly in developing economies, remains a challenge and requires further investigation.

Critical factors influencing VfM in PPP projects have been extensively studied, but their specific relevance to the North Central Nigerian context requires further exploration. Grimsey and Lewis (2023) identify key drivers of VfM, including effective risk allocation, innovation, and operational efficiency. Barriers to achieving VfM, such as inadequate project preparation and lack of competition, have been highlighted by Wang *et al*. (2024). Success factors and key performance indicators (KPIs) for VfM have been proposed by various researchers, but their applicability to the specific context of North Central Nigeria needs to be validated.

The integration of multiple value dimensions into VfM assessment has gained prominence in recent literature. Li *et al*. (2023) emphasizes the importance of considering broader societal and environmental impacts alongside traditional financial metrics. The concept of the triple bottom line, incorporating economic, social, and environmental factors, has become increasingly central to comprehensive VfM assessments (Elkington, 2022). However, the practical integration of these multifaceted considerations into a coherent assessment framework remains a significant challenge, particularly in developing economies.

Stakeholder perspectives play a crucial role in VfM assessment, as highlighted by Liu *et al*. (2024). Their research emphasizes the importance of effective collaboration and alignment of objectives between public and private partners, as well as consideration of end-user perspectives. In the context of North Central Nigeria, where institutional frameworks for PPP management are still evolving, incorporating diverse stakeholder viewpoints into VfM evaluations presents both opportunities and challenges that require careful consideration.

The integration of sustainability principles and innovative value creation strategies into VfM assessment frameworks has emerged as a key area of focus. Kwak *et al*. (2024) highlight how technological advancements and innovative project delivery methods can significantly enhance project outcomes and overall value creation. However, quantifying the long-term impacts of innovation and sustainability initiatives within VfM assessments remains a challenge, particularly in the context of developing economies like Nigeria.

Examining the interrelationships between different elements of the VfM assessment framework is crucial for developing a holistic understanding of value creation in PPP projects. Cui *et al*. (2023) draws on a range of theories, including Value Creation Theory, Stakeholder Theory, and Systems Theory, to provide a more comprehensive understanding of how value is generated and assessed in PPP projects. However, the practical application of these theoretical insights to VfM assessment in the specific context of North Central Nigeria requires further investigation.

The development of both quantitative and qualitative assessment mechanisms for VfM is essential for capturing the full spectrum of value created through PPPs. Recent research by Zhang *et al*. (2024) proposes innovative approaches to quantifying social and environmental value in infrastructure projects, while emphasizing the importance of qualitative assessments for capturing intangible benefits. Incorporating continuous improvement and feedback

loops into these assessment mechanisms, as suggested by Verweij (2023), is crucial for ensuring the ongoing relevance and effectiveness of VfM assessments.

Providing recommendations for the practical implementation of VfM assessment frameworks in PPP projects is essential for bridging the gap between theoretical advancements and on-the-ground realities. Babatunde and Perera (2024) offer insights into the specific challenges faced in implementing VfM assessments in Nigerian PPP projects, highlighting the need for capacity building, improved data collection, and stronger institutional support. Addressing these practical considerations is crucial for ensuring that the developed VfM assessment framework can effectively contribute to improved outcomes in PPP projects across North Central Nigeria.

The conceptual framework for assessing Value for Money (VfM) in Public-Private Partnership (PPP) projects in North Central Nigeria figure 1.1 integrates multiple dimensions and stakeholder perspectives throughout the project lifecycle. Drawing on recent literature, the framework is structured around four key components: project lifecycle stages, value dimensions, stakeholder perspectives, and critical influencing factors. The project lifecycle stages, as outlined by Henjewele *et al*. (2022), include planning, procurement, construction, operation, and transfer, recognizing that VfM considerations evolve over time. Value dimensions encompass financial, social, environmental, and innovation aspects, aligning with the triple bottom line approach advocated by Elkington (2022) and extended to include innovation as per Kwak *et al*. (2024).

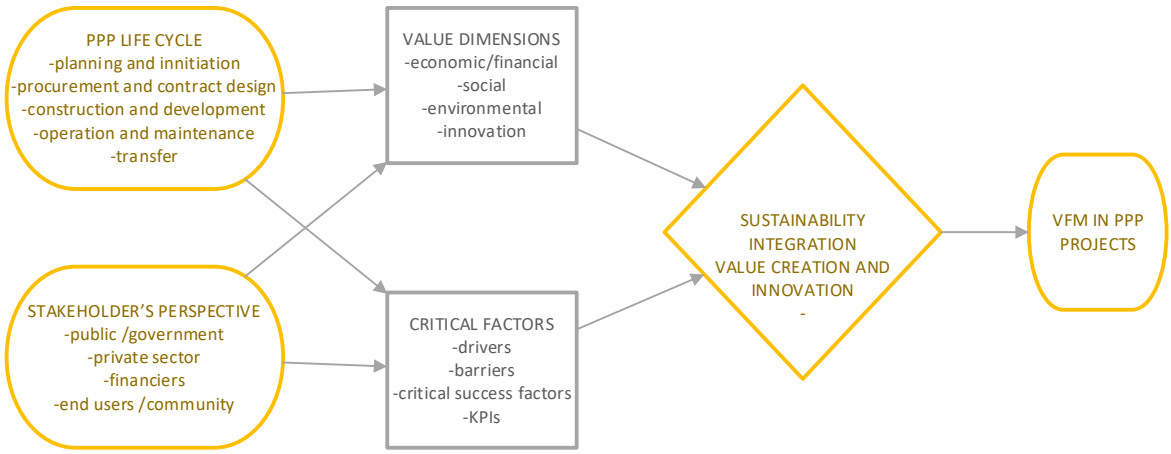

Figure 1: Conceptual framework of the Study
(Source: Researcher's construct 2024).

Stakeholder perspectives incorporate views from the public sector, private sector, end-users/community, and financiers/investors, reflecting the multi-stakeholder nature of PPPs emphasized by Liu *et al*. (2024). Critical influencing factors, identified through comprehensive literature review and empirical research, include risk allocation, governance structures, market conditions, and technological advancements (Osei-Kyei and Chan, 2023; Babatunde *et al*., 2023). The framework posits that VfM is a dynamic construct, influenced by the interplay of these components across the project lifecycle. It incorporates feedback loops and continuous assessment mechanisms, as suggested by Verweij (2023), to enable adaptive management and optimization of VfM. This integrated approach represented in figure 1.1 aims to provide a comprehensive and context-specific tool for assessing and enhancing VfM in PPP projects within the unique socio-economic and institutional environment of North Central Nigeria.

3. Research methodology

This study employs a quantitative research approach. Furthermore, the review of relevant literature resulted in the formulation of a structured questionnaire based on a 5-point Likert-scale measurement and the development of a framework for assessing Value for Money (VfM) in Public-Private Partnership (PPP) projects in North Central Nigeria. Data collection utilizes structured questionnaires for quantitative data ensuring a comprehensive understanding of VfM factors in the local context (Osei-Kyei and Chan, 2022a; Zhang *et al*., 2024). The study population comprises of 386 stakeholders. The census of the Stakeholders in the Public sector, Private sector, End users/community and Financial Institutions in North Central Nigeria were used as the sampling frame of the study. Data collected were analysed using descriptive statistical techniques which include Percentage, and Relative Importance Index (RII) and representation of data on tables and chart.

4. Results and Discussion

Based on the conceptual framework figure 1.1, a result of a Relative Importance Index (RII) analysis for the key constructs in the VfM assessment framework for PPP projects reveals varying levels of significance across different dimensions.

Table 1: RII results of lifecycle/phases of PPP projects

Rank	PPP project Lifecycle	RII value
1	Planning and initiation phase	89%
2	Procurement and contract design phase	85%
3	Construction phase	85%
4	Operation and maintenance phase	85%
5	Transfer phase	82%

The PPP Life Cycle stages in Table 1 emerged as highly influential, with the planning and initiation phase showing the highest RII value (0.89), followed closely by procurement and contract design, construction phase and operationphase (0.85). This underscores the critical nature of early project stages in determining overall Value for Money.

Table 2: RII results of the various value dimensions of PPP projects

Rank	Value Dimensions	RII value
1	Economic and financial	92%
2	Social value	78%
3	Environmental	76%
4	Innovation	76%

Among the Value Dimensions in Table 2, economic/financial factors demonstrated the highest RII (0.92), reflecting their fundamental importance in VfM assessments in line with the observation made by(Osei-Kyei and Chan, 2022). Social, environmental and innovation dimensions also showed significant importance (RII of 0.78 and 0.76 respectively), indicating a growing recognition of sustainability in PPP projects as opined by (Zhang *et al*., 2024).

Table 3: RII result for the integration of divers stakeholder perspective into VfM assessment framework

Rank	Stakeholders Perspectives	RII value
1	Public sector	88%
2	Private Sector	85%
3	End-usre/Community	79%
4	Financier/investors	79%

The Stakeholder Perspective construct Table 3 revealed interesting patterns, with public sector stakeholders ranking highest (RII 0.88), followed closely by private sector partners (0.85). End-users/community and financier/investors stakeholders showed a moderately high importance (0.79), suggesting an increasing focus on user-centric value creation in PPPs as advanced by (Babatunde and Perera, 2024).

Table 4: RII result for the critical factors in VfM assessment framework

SN	Critical Factors	RII value
1	Drivers	92%
2	Barriers	87%
3	Critical Success Factors	82%
4	Key Performance Indicators	82%

Table 4 present the result of Critical Factors analysis highlighted drivers as the most crucial element (RII 0.90), followed by barriers (0.82) and critical success factors (0.87). This emphasizes the need for a comprehensive understanding of both facilitating and inhibiting factors in VfM realization (Kavishe *et al*., 2023).

Figure 5: Sustainability Integration and Value Creation Innovation

Rank	Factors	RII Value
1	Stakeholder Engagement	92%
2	Environmental Sustainability	89%
3	Long-term Adaptability	87%
4	Social Impact	85%
5	Innovation Potentials	83%
6	Circular Economy Principles	81%

The RII ranking of sustainability and innovation factors in VfM assessments for PPP projects in figure 5 reveals a holistic approach to project evaluation. Stakeholder engagement emerges as the most critical factor (RII: 0.92), highlighting the importance of collaborative decision-making. Environmental sustainability (RII: 0.89) and long-term adaptability (RII: 0.87) follow closely, reflecting growing concerns about climate change and the need for future-proofing projects. Social impact (RII: 0.85), innovation potentials (RII: 0.83), and circular economy principles (RII: 0.81) also show high importance, indicating a balanced consideration of social, technological, and resource efficiency aspects. The close RII values (ranging from 0.81 to 0.92) suggest that these factors are viewed as interconnected and collectively significant in modern PPP project assessments, aligning with current best practices in sustainable development and project management (Osei-Kyei and Chan, 2022; Zhang *et al*., 2024; Liu *et al*., 2023; Babatunde and Perera, 2024; Kavishe *et al*., 2023; Molina-Azorin *et al*., 2023; Creswell and Creswell, 2023).

5. Conclusion

This study has developed and analyzed a comprehensive framework for assessing Value for Money (VfM) in Public-Private Partnership (PPP) projects in North Central Nigeria. Through a quantitative analysis, several key findings have emerged, the PPP Life Cycle stages, particularly the planning and initiation phase, have been identified as critical determinants of VfM. This underscores the importance of early-stage decision-making and planning in ensuring project success. Economic and financial factors continue to be paramount in VfM assessments. However, the significant importance placed on social and environmental dimensions reflects a growing recognition of the need for sustainable and socially responsible PPP projects. Stakeholder perspectives, especially those of the public sector and private partners, play a crucial role in shaping VfM outcomes. The increasing importance of end-user/community stakeholders suggests a shift towards more inclusive and user-centric PPP models as earlier opined by (Babatunde and Perera, 2024).

The identification of critical factors, particularly drivers and barriers, provides valuable insights for practitioners and policymakers in optimizing VfM in PPP projects. The high premium placed on sustainability integration and value creation innovation indicates a paradigm shift in PPP project design and implementation, aligning with global trends towards sustainable development as suggested by (Molina-Azorin *et al*., 2023).

The balanced importance of qualitative and quantitative VfM assessment mechanisms reinforces the need for a holistic evaluation approach, combining rigorous financial analysis with broader qualitative considerations (Creswell and Creswell, 2023).

These findings contribute to the body of knowledge on PPP project management and VfM assessment, offering practical implications for project planners, policymakers, and stakeholders in North Central Nigeria and potentially other developing regions. The framework developed in this study provides a robust tool for enhancing VfM in PPP projects, emphasizing the need for a balanced approach that considers the various stakeholders perspectives, economic, social, and environmental factors throughout the project lifecycle.

In conclusion, this study highlights the complex and multifaceted nature of VfM in PPP projects. By adopting a comprehensive and integrated approach to VfM assessment, stakeholders can better ensure the success and sustainability of PPP initiatives, ultimately contributing to improved infrastructure development and public service delivery in North Central Nigeria.

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Assessment of Barriers to Supply Chain Management Practice on Construction Projects in Abuja-Nigeria

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Abstract

The construction industry is one of the sectors that contribute meaningfully to every sector of the global economy and social development. However, the construction industry is often associated with poor performance such as time and cost overruns, poor quality and safety performance, product defects and high wastage due to lack of systematic and strategic approach to manage its supply chain. This study therefore seeks to assess the barriers to Supply Chain Management (SCM) practice in construction sector in Nigeria with a view to improve project delivery. The study adopted a quantitative research approach using questionnaires to sourced relevant information from respondents (Construction supply chain stakeholders). Simple random sampling technique was employed to select individual respondents within the selected study area. Data collection was done using questionnaire survey via self-administered questionnaires to construction stakeholders. Data was analyzed using descriptive statistics such as relative importance index. The study revealed barriers to SCM implementation amongst stakeholders in the study area, among factors identified was lack of col*labour*ation and communication and lack of supplier integration and development. Supply chain management practice is a management tool that aid smooth flow of material which aid project delivery. This study recommends that to achieve effective project delivery, it requires knowledge on effective communication and supplier col*labour*ation, attitudes and traditions in the construction industry, regulatory and legal constraints to effectively manage the adoption of SCM practice in the construction projects in Abuja, Nigeria.

Keywords: Supply Chain Management; Supply Chain; Construction projects; Barriers.

1. Introduction

Construction business globally is the second largest financial activity which is generally categorized into three market segments as Real Estate, Industrial and Infrastructure (Nkolika *et al*., 2020). The construction industry is also responsible for the development and maintenance of infrastructural projects such as roads, bridges, residential and commercial housing. (Temidayo *et al*., 2022). The construction industry in Abuja, Nigeria has experienced significant growth in recent years, driven by the city's rapid urbanization and infrastructure development (Adebisi *et al.,* 2016). Construction industry is one of the sectors that contribute meaningfully to every sector andf the global economy and social development. It also helps in generating wealth and development of the country. Globally, construction companies face a lot of inherent uncertainties and issues and experienced a decrease in output and an increase in costs (Dhruv *et al.,* 2018).

This sector is often associated with poor performance such as time and cost overruns, poor quality and safety performance, product defects and high wastage. Construction projects are becoming increasingly complex and the conventional methods of managing them are still not sufficient in managing it (Nkolika *et al*., 2020). The construction process is usually denoted as one-of-a-kind, construction industry relationship dynamic is usually about a client whose needs are directly served by the main contractor who in turn relies on services provided by various sub-suppliers, this makes each party seek to minimise its cost and risk exposure by passing them along the supply chain and relying on this contractual set-up, which further derails the entire endeavor (Chigozie *et al*., 2021).

Construction project has chains activities, these activities require various stakeholder for it to be successful. The backbone of most projects success is supplying chain management (SCM). Logistic affect efficient movement of materials, services funds and information in the supply chain. Effective SCM is crucial in the construction industry, as it ensures the timely availability of materials, equipment, and *labour*, which are essential for project completion within the planned timeline and budget (Akintoye *et al.,* 2018). SCM as it is a production-based project delivery approach that help to streamline all the experiences of extensive delays and abandonment that have bedeviled the Nigerian construction industry (Amade *et al.,* 2016). Unfortunately, supply chain management is poor in the study area due to numerous barriers associated with it implementation such as lack of supplier monitoring and evaluation, non-compliance with quality and delivery standards, and ineffective supplier relationship management and many others which lead to poor supplier performance which in turn result to poor project delivery (Shah, 2019; Benton,

2017; Cousins *et al.,* 2008). Despite various benefits associated with SCM, its success in the study is nothing to write home about. Difficulties experienced in the construction supply chain (CSC) can lead to waste and late delivery of construction materials on site (Temidayo *et al*., 2022). The aim of this study is to investigate the barriers to supply chain management (SCM) practice in the construction projects in Abuja with a view to improve project delivery.

2. Literature Review

2.1 Concept of Supply Chain Management.

The concept of supply chain management in the Nigerian construction industry can be traced back to the early 2000s when globalization and technological advancements prompted companies to seek more efficient ways of managing their resources and collaboration amongst stakeholder in the construction processes. Prior to this period, the construction industry relied heavily on traditional procurement methods, which often resulted in fragmented supply chains and inefficient resource utilization (Oseghale *et al*., 2015). Moneke *et al.,* (2016) defined SCM as a set of activities undertaken in an organization to promote effective management of its supply chain. Khalfan *et al.,* (2015) further defined supply chain management as a network of different organizations, linked upstream and downstream in a chain, aiming to products for the end consumers through integrated process and activities. SCM is the integrated management of all global business activities includes sourcing, procurement, conversion, and management logistics activities also SCM can be streamline as Integration of key business processes, coordination across organisational boundaries, focus on customer value and efficient flow of products, services and information (Chopra and Meindl, 2016).

However, it can be deduced that components of SCM practices include supply and material management issues, operations, information sharing and customer service. Construction logistics is one of the critical subset of the broader field of construction supply chain management that involves the efficient planning, execution, and control of the flow of materials, equipment, and personnel to and from the construction site. Effective construction logistics can significantly impact project success by ensuring timely delivery of resources, minimizing delays, reducing costs, and enhancing overall productivity (Aghaee and Zandieh, 2019). Offsite construction logistics is part of SCM, in which various industries work collaboratively in forming a network of inter-related procedures to move material, services, funds and information in an effective way that lessens total costs, cuts total lead time, and advances total profits, keeps customer's value above all goals (Malek *et al*., 2018). Construction projects involve numerous stakeholders, each with unique roles, responsibilities, and interests. Failure to properly manage stakeholders leads to conflicts, delays, and potential project failure. Effective stakeholder management is a crucial componenet for an effective SCM practice in the construction projects (Walker *et al.*, 2008). The Construction Industry adopt and maintain strong customer relationships as a crucial element for project success. Effective customer relationship management (CRM) involves understanding and meeting the needs and expectations of clients throughout the project lifecycle. Construction Customer relationship can be summarized into the following key aspects such as Clear and frequent communication to keep clients informed of progress, issues, and variations (Ozaki, 2003). Management of client target by setting realistic goals and timelines (Egan, 1998).

Construction projects involve complex supply chains that require effective management practices to ensure timely delivery of materials, minimize delays, and control costs. Ojo *et al*. (2015) opined benefits of adopting effective supply chain management (SCM) practices in the Nigerian construction industry to improve operational performance, enhanced compitive advantage and contribute positive impact in the industry**.** Therefore, in achieving effective project delivery, various SCM practices in the construction industry were identified, according to Bemardino *et al*., (2020) Strategic supplier partnership and collaboration. supply chain integration and information sharing (Akintan and Morledge, 2013; Oladinrin *et al*., 2020 and Olaniyi *et al*., 2020). Lean construction and just-in-time delivery (Vrijhoef and Koskela, 2000; Bamgbade *et al*., 2019 and Ogundipe *et al.,* 2021). Supplier prequalification and performance evaluation (Eadie *et al.,* 2013; Ogunbayo *et al*., 2018 and Ibem *et al*., 2016). Risk management and contingency planning (Lau and Kong, 2022). Sustainable and green supply chain practices (Ahn *et al*., 2019). Supply chain analytics and optimization (Papadonikolaki and Wamelink, 2017). Logistics management (Ogunde *et al.,* 2017; Oke and Ugoje, 2013). Effective supply chain management in construction requires a holistic approach that combines strategic planning, collaborative partnerships, process integration, risk management, and continuous improvement efforts. Additionally, embracing new technologies and sustainable practices can further enhance supply chain efficiency and resilience.

2.2 Barriers to Supply Chain Management (SCM) Practice on Construction Projects.

Supply chain management is one of the critical instruments that facilitates timely and efficient delivery of projects. However, SCM remains a less unappreciated domain in construction circles to the degree that its strategic level of it effectiveness is yet to be acknowledged (Hawkins *et al.*, 2011). Ineffective construction supply chain management

lead to poor project performance, excessive prices charged by suppliers; unreliable and substandard quality of goods and services contracted for and delivered; corruption and waste which largely affect project performance (Chengedzai, 2016). Implementing effective supply chain management (SCM) in construction projects can be challenging due to various barriers and obstacles. These barriers identified ranged from knowledge difference and infrastructural limitations to inherent issues of corruption and cultural resistance in the adoption of new development. According to Skitmore (2011) and Ojo *et al*. (2018), Lack of Collaboration and Communication, Fragmented Information and Systems, Lack of Suitable Technological Infrastructure can undermine the effectiveness of SCM principles. Pati *et al.,* (2019) on the other hand, pointed out that Resistance to Change, Uncertainty and Project Complexity, Lack of Suppliers' Integration and Development can hinder the implementation of SCM in the construction. According to Song *et al*., (2020), Cost and Resources Constraints Practices are barriers to SCM implementation in the construction industry. More also, Kumaraswamy *et al*., (2010) pointed out that Regulatory and Legal Constraints has a significant influence on SCM implementation in the construction industry. According to Othman and Rahman, (2010) in a study carried out on Supply chain management in the building construction industry highlighted that Lack of SCM Knowledge, Understanding and Commitment can hinder SCM implementation in the construction projects. Similarly, Ojo *et al*., (2014) highlighted lack of awareness on SCM benefits is one of the major hindrances to SCM implementation in the Nigerian construction industry. Lack of Performance Measurement Systems (Khalfan *et al*., 2015). Pal *et al*., (2017) identified Cultural and Organisational Barriers as hinderance to SCM implementation. Vrijhoef and Koskela, (2000) further pointed out that Lack of standardization in processes and materials create disorderliness and deter SCM practice. Ojo *et al*. (2018) Highlighted Lack of Trust and Poor Communication as the most severe barriers to SCM implementation in the construction projects. Implementation of Supply Chain Management in the construction projects in Abuja, Nigeria encounter complex difficulties. These barriers require all-inclusive approach that can link education, policy reform, technological investment, and cultural change aiming at achieving common predetermine goal. Most of these studies were conducted in developed country and scanty in the Nigeria context due to differences in geographical location, there is need to conduct similar study in the Nigeria context.

3. Methodology

Research methodology provides a structured approach to investigating the barriers to SCM practice in construction projects in Abuja, Nigeria. This study employed quantitative survey research design approach using, structured questionnaires to extract information on the barriers to supply chain management practice in the construction projects in Abuja Nigeria. This study target population are stakeholders in supply chain management in construction project, such as Quantity Surveyors, Architects, Engineers, Builders, Clients and Suppliers within Abuja. Data collected through self-administered questionnaire. 300 questionaires were administered, 273 were returned which represent 91% rate of returned and the all returned questionaires analysed. The respondents were purposively selected based on their working experience and their involvement in SCM projects. Years of experience of the respondents purposively selected for questinaires administration is more than ten years. This study adopted well-structured close-ended questionnaire which was divided into two parts. Part A Covers general information relating to the characteristics of respondents, and part B elucidates information on the barriers to supply chain management practice in the construction projects. Data collected through administered questionaires was analysed using descriptive statistic such as Relative Importance Index (RII). This study RII was determined using equation such as: $\Sigma W / (N * A)$ where W is the weightage given to each factor by respondents which range from 1 to 5 using Likert's scale, N is the total number of respondents and A is the highest weight (5) which was aided by statistical software package SPSS 16. The variables were ranked using decision rule ranging from point 0.00-0.20 least severe, 0.21-0.40 less severe, 0.41-0.60 severe, 0.61-0.80 very severe and 0.81-1.00 extremely severe.

4. Data Analysis and Discussion of Results

4.1 Background to the study

The composition of the respondents were Quantity Surveyors 17.9%, Engineers 16.8%, Suppliers 16.8%, Architects 16.5%, Clients 16.5, and Builders with lowest percentage of 15.4%. The respondents professional status reveal that 11% of the respondent were Members Nigerian Institute of Quantity Surveyors (MNIQS), 6.9% of the respondents were Fellow Nigerian Institute of Quantity Surveyors (FNIQS), 16.8% of the respondents were Members Nigerian Society Engineers (MNSE), 16.5% of the respondents were Members Nigerian Institute of Architects (MNIA), 15.4% of the respondents were Members Nigerian Institute of Building (MNIOB) and 33.3% of the respondents were others. The respondents' highest academic qualification revealed that 37% of respondents has Bachelor Degree, 29.3% of respondents has Higher National Diploma (HND), 17.6% of respondents has Master Degree, 11% of respondents has National Diploma (ND) while 5.1% of the respondents has Doctor of Philosophy (PhD).

4.2 Barriers to Supply Chain Management

The study identified thirteen (13) barriers to supply chain management practice on construction projects as in Table 4.1. The study revealed the most severe barriers to supply chain management practice was lack of collaboration and communication ranked 1st with RII value of 0.75, followed by lack of supplier integration and development ranked 2nd with RII value of 0.68, attitudes and tradition in the construction industry, regulatory and legal constraints were ranked 3rd with RII value of 0.66, resistance to change ranked 4th with RII value of 0.65, uncertainty and project complexity, cost and resource constraints were ranked 5th with RII value of 0.64, limited technology infrastructure, lack of guidance for creating strategic alliances, inability to integrate the company's internal procedure were ranked 6th with RII value of 0.63, fragmented information and systems, and poor level of logistical competency were ranked 7th with RII values of 0.62, and strong project focus was ranked 8th with RII value of 0.45. On the average, barriers to supply chain management practice is very severe and ranked with RII value of 0.64. The severity of the study agrees with the study according to Ojo *et al*. (2018) the study conducted on Barriers in implementing green supply chain management in construction industry highlighted that barriers to supply chain management practices in the Nigerian construction industry are indeed severe, with issues such as poor communication posing major challenges.

Table 4.1: Barriers to Supply Chain Management (CSM) Practice on Construction Projects.

Code	Barriers to Supply Chain Management	RII	Rank	Decision
B1	Lack of Collaboration and Communication	0.75	1st	Very Severe
B2	Lack of Supplier Integration and Development	0.68	2nd	Very Severe
B3	Attitudes and Traditions in the Construction Industry.	0.66	3rd	Very Severe
B4	Regulatory and Legal Constraints	0.66	3rd	Very Severe
B5	Resistance to Change	0.65	4th	Very Severe
B6	Uncertainty and Project Complexity	0.64	5th	Very Severe
B7	Cost and Resource Constraints	0.64	5th	Very Severe
B8	Limited Technological Infrastructure	0.63	6th	Very Severe
B9	Lack of Guidance for Creating Strategic alliances	0.63	6th	Very Severe
B10	Inability to Integrate the Company's Internal Procedure.	0.63	6th	Very Severe
B11	Fragmented Information and Systems	0.62	7th	Very Severe
B12	Poor Level of Logistical Competency	0.62	7th	Very Severe
B13	Strong Project Focus	0.45	8th	Severe
Average RII		**0.64**		**Very Severe**

Source: Researcher's Field Survey (2024)

6. Conclusion

This study identified; thirteen (13) barriers to SCM practice in construction projects in Abuja. Identifying and understanding these barriers is the foremost step towards overcoming the hinderance to supply chain management practice in the construction projects by adopting targeted management strategies to foster a culture of continuous improvement of construction supply chain management practice. In conclusion the construction industry in Abuja Nigeria can work towards more efficient, transparent, and effective supply chain management practices by adopting strategic supplier integration and development, stakeholder collaboration and effective communication culture which will in turn contribute in enhancing project outcomes, reduced costs, and improved overall performance in the entirety of construction sector in Abuja, Nigeria and this would require a determined effort from all stakeholders involve in the construction industry such as government regulatory bodies, construction firms, suppliers, educational institutions, and industry associations/union.

7. Recommendations

In view of the findings and conclusions of this study, the following recommendations were made:

i. To achieve effective project delivery, it requires knowledge on effective communication culture and supplier collaboration to effectively manage the adoption of SCM practice in construction industry in Abuja, Nigeria.

ii. All-inclusive knowledge on suppliers' integration and development is reqired to improve visibility and coordination across the supply chain management practices to further aid the effectiveness of SCM practices on the construction projects.

iii. To achieve optimal project performance, this study further reccomend on the influence of attitudinal and traditional cooperation and regulatory and legal constraints to the adoption of SCM practice on the construction projects.

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Assessment of Impact of Survival Management Strategies on Quantity Surveying Firms in Nigeria

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Abstract

The instability of the nation's economy often makes firms focus on their survival and growth throughout their lifetime in an increasing competitive business environment. This thereby, put firms under pressure to offer wider range of services to grow and survive. The rapid changes and increasing competition among the firms in every sector led them to be faced with challenges of how to remain relevant and remain in business of their field of operations, hence, survival became the order of the day for quantity surveying firms (QSFs) as they scramble for effective ways and strategies to survive. Flowing from this knowledge, this study aimed at assessing the impact of survival management strategies on quantity surveying firms (QSFs) in Nigeria. However, due to the constraints of time and logistics, the survey for this study was carried out in the Federal Capital Territory (FCT), Abuja which is well endowed with good number of required QSFs. The study assessed the level of awareness and adoption of identified survival management strategies as well as the possible impacts of these survival management strategies on the QSFs in Abuja, Nigeria. Using census sampling, 126 registered and practicing QSFs were sampled out of the 135 registered QSFs in FCT Abuja. Survey research approach was adopted, a well-structured questionnaire was designed and administered to quantity surveyors in the sampled 126 registered QSFs in FCT Abuja. A total of 109 questionnaires were returned and the data was analysed using mean item score (MIS) and standard deviation (SD). The result of the study showed that, improved service delivery, improved networking, proper financial management, retainment of experienced staff, technology usage and effective management of knowledge toped the essential survival management strategies adopted for the survival of QSFs in FCT. The study concluded that all the identified survival management strategies adopted by the QSFs in FCT, have significantly impacted the QSFs in FCT and Nigeria at large with improved credibility, improved decision making, more effective and efficient organizational management and improvement in technology adoption. Firms networking and col*labour*ation in sharing knowledge with each other, build credibility and foster a good relationship between firms and clients then ensure improved delivery of services.

Keywords: firms, impact, practices, strategies, survival management.

1. Introduction

Quantity surveying firm (QSF) is a professional service sector in the construction industry that provide consultancy services and manage financial related issues for their clients (Page, *et al.,* 2004; Abidin *et al.,* 2011). QSF employs the services of quantity surveyors (QS) and other resources to carry out quantity surveying activities. Aje and Awodele (2006) defined a quantity surveyor as a professionally trained, qualified and experienced in dealing with problems related to construction cost, management, and communication in the construction industry. The QS play a key role in the construction industry; tasked with managing the finances of projects, including estimation of costs and keeping projects on budget (Mbachu, 2011; NZIQS, 2020). Aluthwela and Perera (2016) opined that QSFs count heavily on the skills, expertise, and knowledge of QS to address clients' needs.

Quantity surveying firms (QSFs) are under pressure to offer wider range of services so as to grow and survive as a result of the rapid changes and increasing competition in the market (Okereke, *et al.,* 2022). This competition led firms in the sector to be faced with challenges of how to remain relevant and remain in business of its field of operations (Moyanga and Agboola, 2020). Therefore, survival became the order of the day for most QSFs as they scramble for effective ways and strategies to survive (Okereke, *et al.*, 2022).

While there are existences of studies on survival management strategies in the construction industry, a lot of them have focused on construction organisations generally in Nigeria (Ogbu, 2017). However, the QSFs which are one of the critical organisations in the delivery of construction projects, especially in areas of cost management of the built environment assets of the construction industry have been under explored (Okereke, *et al.*, 2022). Adegbembo, *et al.,* (2020) posits that QSFs occupy an appreciable proportion of construction organisations in the built environment; thus, their survival is critical to their continuous contribution to the nation's infrastructure development, and the

essential influence of the construction industry on national development. The survival of QSFs requires a strategic framework that will overcome their threats and weaknesses and embrace the strengths and opportunities of the profession to ensure they remain relevant in the ever-changing construction industry (Tashmika and Nishani, 2020). Githaiga, (2005) states that Quantity Surveying practices explore numerous survival practices that include exploiting strategic opportunities by diversifying to other areas such as prompt dispute resolution, project evaluation, project and contract management, project accounting and auditing, property valuation, keeping abreast with technological innovation in construction worldwide. Flowing from this knowledge, this study assesses the impact of survival management strategies on quantity surveying firms in Nigeria.

2. Literature review

2.1 Strategic management framework

According to Kennedy, *et al.*, (2015) strategic management encompasses the execution of the actions and putting in place measures that allow resources to be aligned and decisions to be assessed based on the long-term objectives. As an important practice, it gives a strong influence towards firms success. Barrack, (2018) stated that strategic management concerns with dealing with main issues of the firm's actions: the preferred business in which the firm will take on, and the preferred of competitive strategy that will grant the firm to profit. Strategic management as a process, comprises setting organization's goals, developing policies and strategies to achieve the goals and establishing a detailed implementation plan to ensure the ends are met (Kennedy, *et al.*, 2015).

2.2 Quantity Surveying Firm (QSFs) services in Nigeria

Oke *et al.,* (2016) stated that QSFs are professional oriented organisations that provide services that cover all aspects of project procurement, contractual and cost management in infrastructural development. QSF is a professional service sector in the construction industry that provide consultancy services and manage financial related issues for their clients (Abidin *et al.,* 2011; Moyanga and Agboola, 2020). In general, there are services offered by QSFs (Olanipekun, *et al.,* 2013) these are: preliminary cost advice and feasibility studies; cost planning and advising on contractual methods; advising on selection contractor and other consultants; tender documents preparation and other tendering activities; evaluating and estimating of construction works; preparing and agreeing accounts for or with contractors; preparing expenditure statements for tax accounting purposes; periodic financial reporting and technical auditing; replacement value for insurance; project management related services; giving expert evidence in arbitrations; value management related services and other cost, procurement and contractual responsibilities.

According to Adegbembo*, et al.,* (2020) the actions of QSFs in Nigeria are governed by the rules and regulations enacted by actors in the quantity surveying practice. The Nigeria Institute of Quantity Surveyors (NIQS) and Quantity Surveying Registration Board of Nigeria (QSRBN) regulate the professional and legal aspects of the profession in Nigeria.

QSFs mainly depend on the skills, expertise, and knowledge of Quantity Surveyors to address clients' needs. Hence, the recruitment of qualified employees, especially the Quantity Surveyors is critical to the success of the firm, while knowledge sharing between individuals also contributes to both individual and organizational learning. To retain and share knowledge among employees, the development of a portal that is readily accessible to all the employees is crucial (Adegbembo *et al.,* 2020).

2.3 Strategies for survival of QSFs

A developing country like Nigeria has always been experiencing several economic turbulences (Okereke, *et al*., 2022). The ups and downs in the economic situation in the country have both direct and indirect effects on the continuity, sustenance and survival of the construction industry as well as the construction organisations of which QSFs are a part (Ogbu 2017). Quantity surveyors need to enhance their skills further and help to develop technological innovations to achieve sustainable buildings. The drive towards sustainable development will offer opportunities for quantity surveyors to focus beyond costs and provide leadership in the relevant areas to ensure the overall economic viability of constructed items.

In a recessionary period, Adegbembo, *et al., (*2020) in a study conducted in Lagos, Nigeria, concluded that the top essential practices for the survival of construction firms are; improved service delivery, improved networking, effective knowledge management and retaining of experienced staff in the company. In a similar but different study, Abidin, *et al.,* (2014) in assessing competitive strategy and performance of QSFs in Malaysia, discovered that firms in Malaysia preferred strategies such as branding, relationship, marketing, reputation and innovation. Others include; effective knowledge management, financial management, improved project delivery, mergers, acquisitions, and joint ventures, technology usage, diversification, training, and retraining of employees. Babalola (2005), opined that the training of the younger generation is imperative for continuity of any profession, and further reiterated that

it is important for developing countries to consider available training methods to evolving technologies and challenges.

2.4 Effective knowledge management

Knowledge Management (KM) is considered as an essential factor to ensure increased and sustainable productivity and performance of organizations since knowledge plays a crucial role in creating, developing and retaining sustainable competitive advantage both in developed and developing countries (Santoso, 2020; Koochakzadeh and Behzadi, 2019). KM has been described as a key driver of organizational performance and one of the most important resources for the survival and prosperity of organisations (Omotayo, 2015). KM is an emerging concept area in several industries, of which the construction industry is not an exception. An efficient implementation of KM practices in any organization helps the organization uphold a competitive advantage through knowledge resources development (Nisha, 2018). Adegbembo, *et al.,* (2020) posited that nowadays, organisations can no longer compete solely based on financial capital and strength; knowledge is the new competitive advantage in business.

2.5 Proper Financial Management

Paramasivan and Subramanian (2009) argued that financial management helps to improve the profitability position of business organisations with the help of strong financial control devices such as budgetary control, ratio analysis, and cost volume profit (CVP) analysis. Similarly, in a study on small business in Vietnam, Kieu (2004) observed that efficiency in financial management practices such as accounting information system, financial reporting and analysis, working capital management, fixed asset management, financial planning and outstanding performances in financial characteristics had a positive impact on profitability.

2.6 Technology Usage

The use of IT and the integration of computer applications in QS services can help to increase the level of productivity in the construction industry and expand the range of information available and the services provided in addition to speeding up construction and reducing costs (Oyediran and Odusami, 2004). Ashworth and Hogg (2002) summarized the impact of IT in construction as increased speed of delivery and task execution, improved communications, enhanced quality and provision of a wider range of services.

2.7 Retainment of Experienced Staff

Retaining employees who possess valuable knowledge should be an important aspect of the human resource objective of any organization (Adegbembo, *et al.,* 2020). According to Ibironke (2014), QSFs in Nigeria perform poorly due to the high turnover of employees. This implies that employees are not retained by firms on a long-term basis and these employees leave the firms with the knowledge they have acquired. Ultimately, this results in leakage or total loss of knowledge.

2.8 Improved Networking

Empirical studies confirmed that col*labour*ating firms are more innovative than non-col*labour*ating ones, irrespective of their size (OECD, 2001a). However, research findings have shown that the tendency to engage in knowledge-based networks decreases with firm size. This is both a reflection and part of the explanation, of the fact, that the innovativeness of many small and medium enterprises (SMEs) is limited. The creation of appropriate conditions and incentives for increased participation of SMEs in innovative networks is thus a key policy challenge.

2.9 Improved Service Delivery

The delivery of high-quality services is an important pursuit for service providers that seek to create and provide value to their customers (Grönroos and Ravald, 2011). Through the provision of high levels of service quality, companies can achieve increased customer satisfaction, loyalty and therefore long-term profitability (Zeithaml and Bitner, 2000).

2.10 Diversifying

Some scholars have opined that the diversification of expertise has become important success factors to organisations in a recessed economy (Abu, *et al.,* 2018). Furthermore, organisations that diversify into a wide variety of fields become less vulnerable to uncertainty. Mac-Barango (2017) also noted that observers in the industry have attributed the diversification of services to structural changes in the construction sector; technological organizational as well as the dynamics of socio-economic and political factors. Ogbu (2017) suggested that strategic diversification into other construction-related businesses may help reduce the impact of the economic downturn on organisations.

3. Research methodology

To achieve the aim of this research, the study adopted a quantitative research approach using a questionnaire as the primary instrument for data collection, examining the relationship between realities and comparing findings with existing theories or previous research reports (Creswell and Creswell, 2005). The questionnaire was used because it is economical and it covers a broader audience, commonly used in social research instruments (Blaxter *et al.,* 2001).

The target population for this study is the quantity surveyors in the quantity surveying firms/companies in Nigeria. However, due to the constraints of time, logistics and some other uncontrollable problems, the survey for this study was carried out in the FCT Abuja which is well endowed with good number of required firms. According to the Quantity Surveyor Registration Board of Nigeria (QSRBN) (2019), the list of registered quantity surveyor's firm membership are 403 firms and the registered quantity surveyors (RQS) membership are 2774. Amongst this, 135 firms are based in the FCT Abuja, according to the Nigerian Institute of Quantity Surveyor (NIQS) (2024), representing 33.5% of the practicing firms in Nigeria. The sample size for the study was 126 firms. This is sufficient as noted in Gino and Gray, (2011), argument that a sample size of between 30% and 50% of the total populace is a representative and adequate for the analysis.

A closed-ended questionnaire type with a 5-point Likert scale rating was used. The questionnaire used was designed into four (4) sections which include, the respondents' background information, the level of awareness, the level of adoption of survival strategies and the impact of survival management strategies on the survival of QSFs performance in Abuja, Nigeria. The questions in the sections of the questionnaire were designed to measure specific aspect of the set objectives accordingly. The questionnaires were administered to the quantity surveyors in FCT Abuja by self, through face-to-face contact and email.

During the survey period that lasted for twelve (12) weeks, a total of 109 responses were received. The background information of the respondents was analysed using frequencies and percentiles. The data collected on the survival strategies were analysed using MIS. The reliability of the research instrument was determined using Cronbach's alpha test. The test showed an alpha value of over 0.70 for the assessed variables. This implies that the data is of good quality and unbiased.

The formula used for calculating MIS for data analysis is expressed in Equation 1 as follows:

$$MIS = \frac{\Sigma W}{N} \quad \text{Eqn. 1}$$

Where: Σ = Summation, W = Weight, and N = Total

MIS is being ranked from 1.00 to 5.00 and the decision rule adopted for the MIS analysis.

4. Data presentation and analysis

4.1 Response rate

A total of 126 questionnaires was issued out and 109 were filled and returned showing an effective response rate of 86.51%. The response rate for the questionnaire is sufficient as depicted in Fincham (2008) where it was highlighted that a survey should be greater than 80% for it to be unbiased. The remaining 13.49% not received are as a result of lack of interest on the part of the respondents. This is as indicated in table 4.1 below.

Table 4.1: Response rate

Questionnaires Issued Out	Frequency	Percentage (%)
Filled and returned	109	86.51
Non-response	17	13.49
Total issued out	**126**	**100**

4.2 Respondents' background information

The background information of the respondents is very important to ascertain the credibility of the results from the field survey. According to the survey, the respondents background information are hereby analysed as below.

From Table 4.2 the respondents' ranks/responsibility in their various organisations show that 22.02% are Project Managers, 15.60% are Contract Managers, 13.76% are Procurement Managers, 9.17% are Commercial Managers, 25.69% are Principal Partners/Managing Partners, 11.01% are Senior Estimators/Senior Quantity Surveyors while the remaining 2.75% fall under the other classifications. In terms of their years of experience in the industry, the survey revealed that 11.01% have between 1-5 years of experience, 13.76% have between 6-10years of experience, 38.53% have spent between 11-15years in the industry, 28.44% have spent 16-20years, and 8.26% have over 20 years of industry experience. The distribution of their years of experience shows that they have considerable industry experiences that can aid in meeting this study aim.

The literacy levels and comprehensive capability of the respondents revealed that the majority of respondents accounting for 40.37% had MSc./M.Tech while the next 30.28% had BSc/BTech. The 12.84% of the respondents had PGD, 9.17% had HND, while the remaining 7.34% had PGD. This implies that the respondents are educationally qualified to comprehend the questions asked and contribute meaningfully to the subject of this study. The professional status of the respondents shows that a larger proportion of them, 57.80% are corporate members of the Nigerian Institute of Quantity Surveyors, (NIQS) while 27.52% are Fellow members, NIQS. The remaining 14.68% are probationer members. This shows that the participants are professionally qualified and have the requisite knowledge and authority to make a meaningful contribution to this study's objective.

Table 4.2: Respondents' background information

Variables	Classification	Frequency	Proportion (%)	Cumulative (%)
Ranks/Responsibility	Project Managers	24	22.02	22.02
	Contract Managers	17	15.6	37.61
	Procurement Managers	15	13.76	51.38
	Commercial Managers	10	9.17	60.55
	Principal Partners/Managing Partners	28	25.69	86.24
	Senior Estimators/Senior Quantity Surveyors	12	11.01	95.41
	Others	3	2.75	100.00
	Total	**109**	**100.00**	
Years of Experience	1 – 5 Years	12	11.01	11.01
	6 – 10 Years	15	13.76	24.77
	11 – 15 Years	42	38.53	63.3
	16 – 20 Years	31	28.44	91.74
	Above 20 Years	9	8.26	100.00
	Total	**109**	**100.00**	
Highest Education Qualification	HND	10	9.17	9.17
	PGD	14	12.84	22.02
	BSc/BTech	33	30.28	52.29
	M.Sc./M.Tech	44	40.37	92.66
	PhD	8	7.34	100.00
	Total	**109**	**100.00**	
Professional Status	Fellow NIQS	30	27.52	27.52
	Corporate member of NIQS	63	57.8	85.32
	Probationer member	16	14.68	100.00
	Total	**109**	**100.00**	

4.3 Evaluating the level of awareness of survival strategies by Qs firms in Abuja Nigeria

Table 4.3 presents the opinions of respondents as regards their awareness of the identified survival practices in QSFs in Abuja, Nigeria. The top four (4) survival strategies includes; improved service delivery with (MIS=4.82), improved networking with (MIS=4.65), proper financial management with (MIS=4.57) and effective management of knowledge with (MIS=4.51). While the least two (2) ranked survival strategies are; change in geographical location with (MIS=3.01) and documentation of improvement in process with (MIS=2.84). However, the overall average of awareness of the QSFs in FCT Abuja, Nigeria on all the identified survival practices is 3.96 MIS.

Table 4.3: Evaluating the level of awareness of survival strategies by Qs firms in Abuja Nigeria

Survival Strategies Practices	MIS	S.D	Rank	Remark
Improved Service Delivery	4.82	0.4120	1st	Very High Awareness
Improved Networking	4.65	0.4977	2nd	Very High Awareness
Proper Financial Management	4.57	0.6568	3rd	Very High Awareness
Effective Knowledge Management	4.51	0.6752	4th	Very High Awareness
Retainment of Experienced Staff	4.43	0.6988	5th	High Awareness
Technology Usage	4.36	0.7394	6th	High Awareness

Improving organizational structure	4.32	0.8151	7th	High Awareness
Branding	4.30	0.8222	8th	High Awareness
Diversifying into other construction-related businesses	4.22	0.8092	9th	High Awareness
Staff layoff/downsizing	4.20	0.9106	10th	High Awareness
Reduction of service charges	4.17	0.9112	11th	High Awareness
Synergy among professionals and collaborations	4.14	0.8972	12th	High Awareness
Reduction of overheads	4.12	0.9101	13th	High Awareness
Going after work in new areas	4.02	1.0097	14th	High Awareness
Workforce training and retraining	3.59	1.0176	15th	High Awareness
Cost reduction and cost minimisation	3.38	1.0283	17th	High Awareness
Focus on enhancing products offered or services rendered	3.25	1.0378	16th	Fair Awareness
Mergers, acquisitions, and joint ventures	3.17	1.1291	18th	Fair Awareness
Project evaluation	3.04	1.1298	19th	Fair Awareness
Change in geographical location	3.01	1.1587	20th	Fair Awareness
Documentation of improvement in process	2.84	1.1318	21st	Fair Awareness
Overall Average	**3.96**			**High Awareness**

4.4 Assessing the level of adoption of survival management strategies by Qs firms in Abuja Nigeria

Table 4.4 shows the view of the respondents concerning their level of adoption of the identified survival practices in QSFs in Abuja, Nigeria. The top three (3) survival strategies includes; improved service delivery with (MIS=4.84), improved networking with (MIS=4.72) and proper financial management with (MIS=4.69). While the least two (2) ranked survival strategies are; project evaluation with (MIS=3.18) and change in geographical location with (MIS=3.08). Meanwhile, the overall average means is 4.23, high adoption.

Table 4.4: Assessing the level of adoption of survival management strategies by Qs firms in Abuja Nigeria

Survival Strategies Practices	MIS	S.D	Rank	Remark
Improved Service Delivery	4.84	0.3645	1st	Very High Adoption
Improved Networking	4.72	0.4532	2nd	Very High Adoption
Proper Financial Management	4.69	0.5036	3rd	Very High Adoption
Retainment of Experienced Staff	4.62	0.4867	4th	Very High Adoption
Technology Usage	4.60	0.5631	5th	Very High Adoption
Effective Knowledge Management	4.57	0.6141	6th	Very High Adoption
Improving organizational structure	4.53	0.6607	7th	Very High Adoption
Branding	4.48	0.6610	8th	High Adoption
Diversifying into other construction-related businesses	4.43	0.6717	9th	High Adoption
Staff layoff/downsizing	4.41	0.7099	10th	High Adoption
Reduction of service charges	4.39	0.7189	11th	High Adoption
Synergy among professionals and collaborations	4.32	0.7313	12th	High Adoption
Reduction of overheads	4.30	0.7265	13th	High Adoption
Going after work in new areas	4.29	0.8199	14th	High Adoption
Workforce training and retraining	4.20	0.9927	15th	High Adoption
Cost reduction and cost minimisation	4.17	0.9760	17th	High Adoption
Focus on enhancing products offered or services rendered	4.08	0.9538	16th	High Adoption
Mergers, acquisitions, and joint ventures	3.75	0.9043	18th	High Adoption
Documentation of improvement in process	3.20	1.0522	19th	Fair Adoption
Project evaluation	3.18	1.0985	20th	Fair Adoption
Change in geographical location	3.08	1.1314	21st	Fair Adoption
Overall Average	**4.23**			**High Adoption**

4.5 Determination of the impact of survival management strategies on the survival of QSFs in Abuja, Nigeria

Table 4.5 shows the view of the respondents in respect of the extent to which the logistics management activities of their firms influence some identified critical success factors based on their experiences, thereafter, the general impact in QSFs in Abuja, Nigeria.

Maintaining credibility, improved decision making, more effective and efficient organisational management, improvement in technology adoption and improve ethical credibility ranked highest while constant cash flow, changing workforce, changing expectations and values of workers and constant job ranked least among the impact

of adopting survival practices by QSFs. This implies that QSFs are more concerned about their image and delivery of quality services to clients than the money or jobs they will acquire.

Table 4.5: Determination of the impact of survival management strategies on the survival of QSFs in Abuja Nigeria

Adopted Survival Strategies Practices on QSFs	MIS	S.D	RII	Rank	Remark
Maintaining credibility	4.86	0.3461	0.9725	1st	Very High Influence
Improves decision making of the organisation	4.78	0.4784	0.9560	2nd	Very High Influence
More effective and efficient organisational management	4.59	0.5646	0.9174	3rd	Very High Influence
Improvement in technology adoption	4.41	0.6833	0.8826	4th	High Influence
Improve ethical credibility	4.24	0.8623	0.8495	5th	High Influence
Improves competition strategy of the firm	4.13	0.9139	0.8257	6th	High Influence
Effective service delivery	4.01	0.9953	0.8018	7th	High Influence
Avoids bankruptcy	3.86	1.0043	0.7725	8th	High Influence
Constant cash flow	3.74	1.1005	0.7486	9th	High Influence
Changing workforce, changing expectations and values of workers	3.61	1.1708	0.7211	10th	High Influence
Provides constant job	3.53	1.1512	0.7064	11th	High Influence
Overall Average	**4.16**				High Influence

5. Results and discussion

5.1 Level of awareness and adoption of survival practices

Improved service delivery, improved networking, proper financial management, effective management of knowledge, retainment of experienced staff and technology usage top the essential survival practices QS in QSFs in FCT Abuja, Nigeria are aware of and have adopted in their respective firms. This finding supports the findings of Adegbembo, *et al., (*2020) in a study conducted in Lagos, Nigeria that concluded that the top essential practices for the survival of construction firms are; improved service delivery, improved networking, effective knowledge management and retaining experienced staff in the company. However, the overall average of the awareness and adoption of all the identified survival management strategies in QSFs in FCT Abuja, Nigeria are rated high awaereness and high adoption respectively.

5.2 Impact of the adopted survival practices

Maintaining credibility, improved decision making and more effective and efficient organisational management ranked highest among the impact of adopting the identified survival management strategies by QSFs. Maintaining credibility ranked the highest practices and this is in line with Adegbembo, *et al., (*2020) who stated that winning economic profile is accompanied by the struggle for values and maintaining a reputation. Improved decision making and more effective and efficient organizational management ranked next, and this is in line with Gino and Gray (2011) who stated that leadership style influences the success of the firm. Improvement in technology adoption ranked next and this is in line with Ashworth and Hogg (2002) who stated that the impact of IT (improved technology) in construction industry leads to increased speed of delivery and task execution, improved communications, enhanced quality and provision of a wider range of services.

6. Conclusion

The study concludes that the most critical survival management strategies been aware of and adopted by QSFs in FCT Abuja, Nigeria are improved service delivery, improved networking, proper financial management, retainment of experienced staff, technology usage, effective knowledge management, branding and adoption of innovative ideas. These assessed survival management strategies have high level of influence and play a critical role in ensuring that Quantity Surveying firms survive the economic downturn and the stiff competitive market of the construction sector. Finally, the study concluded that all these identified survival management strategies adopted by the QSFs in FCT, have significantly impacted the QSFs in FCT and Nigeria at large with improved credibility, improved decision making, more effective and efficient organizational management, improvement in technology adoption, improved ethical credibility and improved competitive strategy. The improved service delivery impacted improved credibility and foster good relationship between the clients and the firms. The collaborative efforts of QSFs in pooling resources together to tackle the prevailing challenges helps firm to maneuver its way to survive under harsh competitive and economic conditions.

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Fresh Properties of Self Compacting Concrete Containing Sorghum Husk Ash and Calcium Carbide Waste

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Abstract

This study investigates the fresh properties of self-compacting concrete (SCC) by incorporating Sorghum Husk Ash (SHA) and Calcium Carbide Waste (CCW) as supplementary cementitious materials (SCMs). The primary aim is to evaluate how varying replacement levels of Portland Cement (PC) with SHA (5% to 30%) and CCW (5% to 10%) influence the flowability and passing ability of SCC. A series of concrete mixes were prepared, and various tests, including slump flow, V-funnel, and L-box tests, were conducted to assess the fresh properties of each mix. The results demonstrated that incorporating up to 15% SHA significantly enhances flowability, with a maximum slump flow of 655 mm observed in the mix containing 80% PC, 10% SHA, and 10% CCW. However, increasing the SHA content beyond 15% resulted in a decline in flowability due to heightened water demand and increased viscosity. Moderate levels of CCW (5% to 10%) also contributed positively to flowability and passing ability, while excessive CCW content, particularly in high SHA mixes, adversely affected workability. The study concludes that an optimal combination of 10% SHA and 10% CCW provides the best balance of flowability and passing ability. These findings emphasize the importance of careful SCM proportioning to achieve desired fresh properties in SCC and highlight the potential for utilizing agricultural and industrial waste materials in sustainable concrete production.

Keywords: Self-Compacting Concrete (SCC), Fresh properties, Sorghum husk Ash (SHA), Calcium carbide waste (CCW)

1. Introduction

The basis of the concrete material is cement, which when mixed with water forms a paste that binds the aggregates together, solidifying into a hard material called concrete. Concrete is one of the most widely used construction materials worldwide and plays a crucial role in the development of infrastructure and buildings (Damineli *et al*., 2021). Its versatility, durability and cost-effectiveness have made it an essential material for various applications, from residential buildings to large civil engineering projects. The strength of concrete is generally considered the most valuable property as it typically provides an overall picture of concrete quality and is the most important structural design element specified for compliance purposes (Olawuyi *et al*., 2020, Mudashiru *et al*., 2021). However, as the demand for more complex and intricate designs continues to increase, the limitations of traditional concrete mixes are becoming more apparent (Yehia *et al*., 2019). One of the significant challenges faced in the construction industry is the proper consolidation of concrete, especially in heavily reinforced or geometrically complex sections. Inadequate consolidation can lead to the formation of voids, honeycombing, and poor encapsulation of reinforcement, compromising the structural integrity and durability of the concrete structure (Rao *et al*., 2018). To address this issue, self-compacting concrete (SCC) has emerged as an innovative solution, offering superior flowability and self-consolidating properties without the need for external compaction (Ghafari *et al*., 2022).

Self-compacting concrete is a highly flowable and non-segregating concrete mixture that can spread into place, filling formwork and encapsulating reinforcement solely by the action of gravity (EFNARC, 2005; Roussel, 2018). Unlike conventional concrete, which requires external vibration or compaction, Self – compacting concrete (SCC) can flow and consolidate under its own weight, ensuring a homogeneous and void-free fill. This unique property not only eliminates the need for extensive compaction efforts but also facilitates the construction of intricate and densely reinforced structures (Ghafari *et al*., 2022). The development of self-compacting concrete has been driven by the need for improved construction efficiency, quality control, and enhanced durability of concrete structures (Ting *et al*., 2019). By eliminating the potential issues associated with inadequate compaction, SCC offers numerous advantages, including reduced labour requirements, improved surface finish, and increased service life of structures (Khayat, 2018; Tayeh *et al*., 2019).

Given all the advantages of SCC in practice, emphasis has been placed on optimizing its constituent composition by incorporating supplementary cementitious materials (SCMs). SCMs are materials that can partially replace Portland

Cement (PC) in concrete, providing additional benefits such as improved workability, durability, and sustainability. A great deal of research has been conducted with various SCMs. The performance of concrete can be augmented by adding various SCMs in the concrete. Furthermore, most SCMs are industrial waste products and agricultural waste products, i.e., Fly ash, (FA), Sorghum Husk Ash (SHA), Calcium Carbide Waste (CCW), Rice Husk Ash, (RHA), Ground-granulated Blast-furnace slag (GGBFS), Millet Husk Ash (MHA), Silica Fume (SF), Metakaolin (MK), etc. These SCMs contain SiO2 and Al2O3, which react with calcium hydroxide in the presence of moisture to give cementitious properties (ASTM C595). However, for a more positive result the synergy between the SCMs is utilized when two or more SCMs are combined. Hence, this research focuses on the use of the locally available sorghum husk ash (SHA) and calcium carbide waste (CCW) as SCM in determining the fresh properties of SCC.

2. Material and Method

2.1 Materials

The materials used for this research work are binder (PC), SHA and CCW, fine aggregates (sand), coarse aggregate, superplasticizer, and water.

A. Binder (PC)

In conducting this experiment, Portland Cement (PC), ASTM Type 1, CEM 42.5N with brand name Dangote cement, was used throughout the whole series of test. PC is considered as one of the increasingly applied cements in general concrete construction for the conditions in which the concrete is not exposed to sulphates present in the soil or groundwater. PC which is produced by Dangote brand is found to be qualified in accordance with the requirements of the BS EN 197-1: 2000 Standard. Portland cement consists of three components. The largest portion belongs to Calcium silicate which makes up 66% of the cement, and the smaller remaining portion of the cement is mostly made up of aluminium and iron.

B. Sorghum Husk Ash (SHA)

The SHA that was used as (SCM) was obtained from the incineration of the Sorghum husk sourced locally from Kure Market in Minna, Niger state using the locally fabricated incinerator available at the Concrete *Labour*atory of the Department of Building, Federal University of Technology, Minna, Niger State. The burning took place in an open air for about 24 hrs. with a temperature below or equal to 700^{o}c and then allow to cool before harvesting and milling with grinding machine. The milled SHA was sieved with 75µm in accordance to ASTM C430- 2014 before storing in an airtight polythene bag.

C. Calcium Carbide Waste

The second SCM used for this study is CCW which was obtained from a local panel beater shop in keteren gwari Minna, Niger state. The CCW was sun dried in an open air for 4 days and later taken to the milling machine for grinding. The milled CCW was taken to the building department *labour*atory and sieved with 75µm in accordance with ASTM C430- 2014 before storing in an airtight polythene bag. The average specific gravity of CCW is 2.4 compared to 3.16 of cement indicating that CCW is lighter than cement.

D. Fine Aggregate

River sand of 5mm nominal maximum size fine aggregate (FA) was used in this study. It was tested for sieve analysis, specific gravity and bulk density both in saturated surface dry and oven dry basis in accordance with ASTM (C136). Furthermore, it was gotten from a building material dealer in Minna, Niger state.

E. Water

All through the study, a normal tap water supply was used for the concrete mixing, specimen curing and for other purposes that relate to the experiments. (ASTM C1602/ C1602M – 12).

F. Crushed coarse aggregate.

A crushed granite of 10 mm maximum aggregate size was be used as the coarse aggregate in accordance with typical SCC mixtures. The coarse aggregate was tested for specific gravity, bulk density on both the saturated surface dry basis and oven dry basis, absorption and sieve analysis in accordance with ASTM (C136) and ASTM (C127). Furthermore, in order to achieve a reduction in the dust content of the aggregate for less water demand by the mixtures, the crushed stone was washed and surface dried before the usage.

G. Super plasticizer

To achieve the desired and targeted slump with low water-cement ratio, A Sky 504, polymer-based polycarboxylic ether (PCE) super plasticizer supplied by Black Diamond Engineering Limited was used as the chemical admixture. It was applied at a dosage of 0.9% by the weight of the Total binder accordance with ASTM (C 494) Type A and F.

2.2 Methods

Materials characterization, proportioning of the materials, fresh property test was achieved using *labour*atory equipment in Building Department *labour*atory, Federal University of Technology Minna.

2.2.1 Material Characterization

The Materials characterization encompasses of various tests such as the chemical composition of binders, particle size distribution, specific gravity test, bulk density to determine the physicochemical properties of the constituent materials.

2.2.2 *Labour*atory Test

These comprise the tests that was conducted on the materials and procedures involved. The tests include the determination of properties of the materials to be used by (Sieve Analysis Test, Bulk Density Test), consistency test, setting time test, properties of fresh concrete (passing ability test, flow ability test).

2.2.2.1 Sieve Analysis

According to Neville (2012), Sieve analysis is defined as the grading material into fractions. In accordance with British Standards (BS EN 933-1, 2012). The analysis of the aggregate's particle size distribution as well as the binder was conducted using a sieving approach. The standard sieves set used for the coarse aggregate in descending order are 12.5 mm, 10 mm, 6.3 mm, and 4.75 mm while 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, 150 µm and 75 µm was used for the fine aggregate.

2.2.2.2 Specific Gravity

The specific gravity of the binder (PC), SCMs (SHA and CCW) and aggregates was determined in accordance with BS EN 933-1 – 2012. The apparatus used in conducting this test were: Empty bottle or Tubes, weighing balance (electronic scale), Glass plate, weighing plate. The following procedure was adopted:

1. Two empty bottles or tubes was selected and weighed on a scale and their weights was recorded as w_1,
2. The bottle or tubes was filled with water up to the 25ml mark, weighed and recorded as w_4.
3. A small quantity of the materials was placed in each of the tubes and weighed as w_2.
4. Water was added to the materials and filled up to the 25ml mark and weighed as w_3. All the results were obtained and recorded, then specific gravity was calculated using the Equation below.

The specific gravity equation = (2.1)

Where:

W_1= weight of empty bottle
W_2= weight of bottle + material
W_3= weight of bottle + material + water
W_4= weight of bottle + water

2.3 Consistency of Binders (PC, SHA, CCW)

The consistency of a material is defined as the percentage of water required to achieve a mixture that permits a penetration depth of 33–35 mm using the Vicat apparatus needle. In this study, each mixture's consistency was evaluated following the guidelines of ASTM-C40/C403 (2008). The samples were thoroughly mixed on a glass sheet before being placed into the mould of the Vicat apparatus to determine standard consistency, which was indicated by a penetration of 33–35 mm. The standard consistency reflects the amount of water necessary to attain this level of penetration and is represented by the following relation:

$$\frac{Mw}{Mm} X100 \quad \textbf{(2.2)}$$

2.3.1 Setting Time

The experiment was initiated immediately after achieving the desired consistency and was conducted on the binders, which includes Portland cement, calcium carbide waste, and sorghum husk ash, for all the mixes. The testing procedure followed was according to ASTM C40/403 (2008) standards using the Vicat apparatus. According to Neville (2012), the initial setting time is the duration from the moment water is added to the binders until the paste

begins to lose its plastic properties. This is identified when a 1 mm^2 needle penetrates the paste to a depth of 4–7 mm from the base or 5 mm from the surface of the Vicat mould. The minimum initial setting time specified by the code is 45 minutes, although 90 minutes is often preferred for practical applications. Similarly, Neville (2012) defines the final setting time as the point when the cement paste has fully lost its plasticity, signified by the inability of a 5 mm diameter circular attachment to leave any impression.

2.4 Mix Proportioning

For the study, proportion mix procedure (EFNARC, 2005) was adopted. This includes water content of 150 – 200 Kg/m^3, w/c was between 0.4 – 0.55 by mass. Coarse aggregate content is 28 -35 % by volume while fine aggregate content balanced the volume of the rest constituents. In total, 19 mixes were prepared, of which the first mix was the control mix (plain SCC) without any SCMs, other mixes contain binary blend and ternary blend of SCC containing PC, SHA and CCW in different percentage. The proportioning is illustrated in Table 2.1.

Table 2.1: Mix proportioning

S/N	Mix ID	Types of Paste	Total Binder kg/m^3	PC kg/m^3	CCW Kg/m^3	SHA Kg/m^3	Fine Agg. Kg/m^3	Coarse Agg. Kg/m^3	Water Kg/m^3	SP (%)	W/B Ratio
1	SCC	Control	470	470	0	0	883	553	180	0.91	0.41
2	95%PC+ 5% CCW	Binary	470	446.5	23.5	0	883	553	180	0.92	0.41
3	90% PC + 10% CCW	Binary	470	423	47	0	883	553	180	0.94	0.41
4	95% PC+ 5% SHA	Binary	470	446.5	0	23.5	883	553	180	0.94	0.41
5	90% PC + 10% SHA	Binary	470	423	0	47	883	553	180	0.94	0.41
6	85% PC + 15% SHA	Binary	470	399.5	0	70.5	883	553	180	0.94	0.41
7	80% PC + 20% SHA	Binary	470	376	0	94	883	553	180	0.94	0.41
8	90% PC + 5% SHA + 5% CCW	Ternary	470	423	23.5	23.5	883	553	180	0.94	0.41
9	85% PC + 5% SHA + 10% CCW	Ternary	470	399.5	47	23.5	883	553	180	0.94	0.41
10	85% PC + 10% SHA + 5% CCW	Ternary	470	399.5	23.5	47	883	553	180	0.88	0.41
11	80% PC + 10% SHA + 10% CCW	Ternary	470	376	47	47	883	553	180	0.94	0.41
12	80% PC + 15% SHA +5% CCW	Ternary	470	376	23.5	70.5	883	553	180	0.94	0.41
13	75% PC + 15% SHA + 10% CCW	Ternary	470	352.5	47	70.5	883	553	180	0.94	0.41
14	75% PC + 20% SHA + 5% CCW	Ternary	470	352.5	23.5	94	883	553	180	0.88	0.41
15	70% PC +20%SHA+10%CCW	Ternary	470	329	47	94	883	553	180	0.94	0.41
16	70% PC+25%SHA+5%CCW	Ternary	470	329	23.5	117.5	883	553	180	0.95	0.41
17	65%PC+25%SHA+10% CCW	Ternary	470	305.5	47	117.5	883	553	180	0.94	0.41
18	65%PC+30%SHA+5%CCW	Ternary	470	305.5	23.5	141	883	553	180	0.94	0.41
19	60%PC+30%SHA+10% CCW	Ternary	470	282	47	141	883	553	180	0.94	0.41

NB: PC=Portland Cement, SHA= Sorghum husk ash, CCW= Calcium carbide waste, SP= Superplasticizer

2.4.2 Specimen Preparation

The preparation of test specimen, the test procedure for evaluating the fresh properties of self-compacting concrete incorporating PC, SHA and CCW was discussed. In this study, targeted strength of the concrete was achieved through

material proportioning design method and the use of quality materials in the production of concrete. A mix proportion which is suitable for the production of PC, SHA and CCW were determined through preliminary test.

2.5 Fresh SCC Properties Test

The fresh SCC tests were conducted to determine the concrete viscosity, filling ability, passing ability, Segregation, and workability. The tests were conducted using the L- box Test and Slump Flow Test.

2.5.1 Slump Test (Flow ability) (ASTM C143/C143-15a)

The flow ability of each mix was assessed using the Slump Cone test in accordance to EFNARC (2005) guidelines. Freshly prepared mix samples of SCC were placed into the Slump Cone and allowed to rest for 30 to 60 seconds. The cone was then lifted vertically, enabling the mix to flow outward horizontally until it naturally ceased. The diameter of the flow spread was measured in two perpendicular directions, and the averages of these measurements were recorded as the spread flow for each mix. Each mix were tested twice, with the mean value taken as the final spread flow. EFNARC (2005) specifies that acceptable spread flow values range between 550 mm and 850 mm. The slump flow test is the only standardized test by the American Society for Testing and Materials (ASTM) for SCC. The test reveals information on passing ability and flow ability of fresh SCC mix.

2.5.2 L-Box Test (Passing Ability)

The L-box test was employed to assess the passing ability and flow characteristics of self-compacting concrete (SCC) through confined spaces and areas with congested reinforcement. Approximately six liters of freshly prepared SCC mix were carefully poured into the vertical section of the L-box over a period of sixty seconds (60s) to ensure uniformity across tests. Once the mix had settled, the slit cover separating the vertical and horizontal sections was removed, allowing the concrete to flow from the vertical section into the horizontal section by the force of gravity. The movement of the concrete between these sections indicates its flowability and ability to pass through restricted spaces. Upon completion of the flow, the heights of the concrete in the vertical section (H1) and the horizontal section (H2) were measured and recorded. The ratio of H2 to H1, referred to as the "blocking ratio," which was calculated to quantify the passing ability and flow ability of the concrete mix.
This ratio is defined as follows:

$$\textbf{Flow ability Ratio} = \frac{H_2}{H_1} \qquad (2, 1)$$

3. Results and Discussion

3.1 Characterization of constituent materials

The chemical composition and loss on ignition of CEM II, SHA and CCW as received using XRF are shown in table 3.1.
Table 3.1: Oxide Composition of Binder Constituents.

Oxides	CEMII (%)	SHA (%)	CCW
SiO_2	25.64	77.04	2.69
Al_2O_3	5.24	2.66	0.50
Fe_2O_3	7.15	4.87	0.17
CaO	64	1.55	64
MgO	0.41	0.73	0.80
SO_3	0.11	0.67	0.31
K_2O	0.05	5.21	0.47
Na_2O	0.31	1.16	0.00
M_2O_5	0.04	2.06	0.00
P_2O_5	0.03	1.19	0.00
LOI	0.67	2.86	31.07
$SiO_2 + Al_2O_3 + Fe_2O_3$	38.03	81.57	4.64

The outcome of the test revealed that the SHA contained majorly SiO_2 with the summation of $SiO_2 + Al_2O_3 + Fe_2O_3$ above 80%, while having the SO_3 below 4% and loss on ignition (LOI) of less than 10% which according to ASTM C618 (2015) affirmed to be a very strong reactive Class F Pozzolan. The CCW was detected to contain 64% CaO, a similar value to the CaO content (64%) of the CEMII sample. The CCW was however noted to be of lower in SiO_2 and Al_2O_3 when compared to the CEMII sample.

Table 3.2: physical properties of constituent material

Properties	Fine Agg	Coarse Agg	CCW	PC	SHA	superplasticizer
Bulk Density(kg/m^3)	2500	2200	2300	1440	2330	1070
Specific gravity	2.85	2.85	2.4	3.14	2.60	1.02

Table 3.3: Moisture Content of Constituent Material

Materials	Weight of material before oven dry (g)	Weight of material after oven dry (g)	Moisture content (%)
SHA	500	499	0.2
CCW	500	490	2.0
SAND	100	100	0.0

3.1.1 Particle Size Distribution of Aggregates.

Figure 3.1 and table 3.4 presents the summary of particle size distribution (PSD) of the aggregates (fine and coarse) used in this study. The results above shows that the fine aggregate used for the study conformed to medium sand classification according to Shetty (2004) with a uniformity coefficient (C_u) of 2.39, coefficient of curvature (C_c) of 0.94 and fineness modulus (FM) of 2.88 while the coarse aggregates used for the study are also classified as uniformly graded stone having 1.30 and 0.93 as the uniformity coefficient (C_u) and coefficient of curvature (C_c) respectively. The aftermath of the results of the physical properties shown in Table 2 affirmed that both the aggregates (fine and coarse) are suitable for SCC productions.

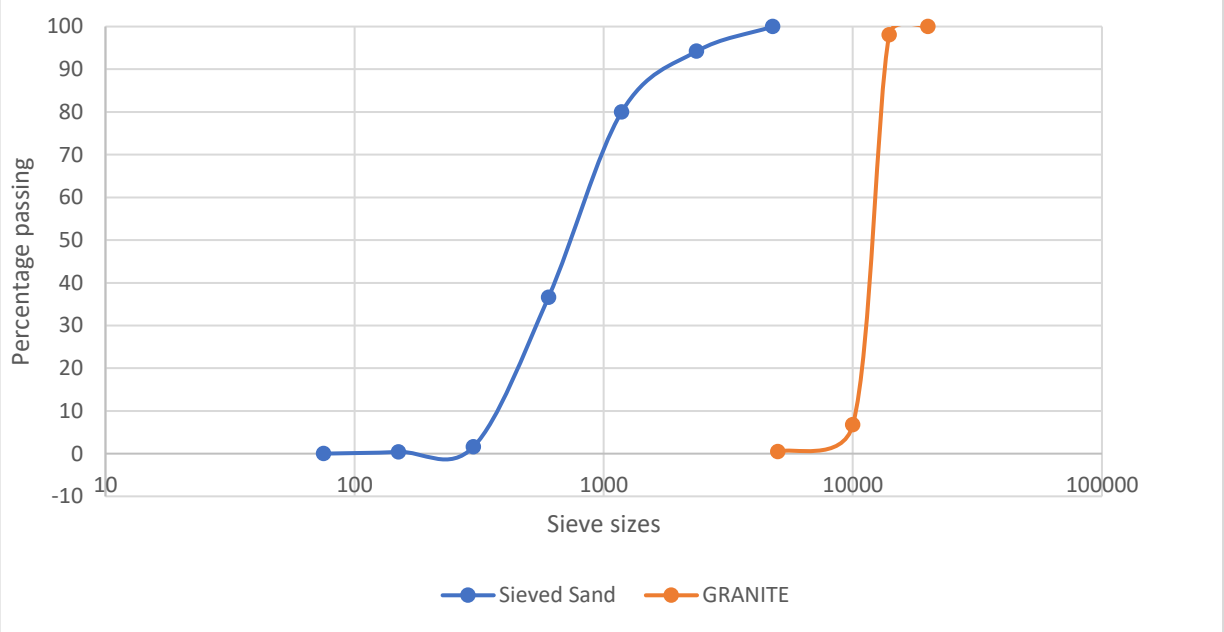

Figure 3.1: sieve analysis/particle size distribution of aggregates

Table 3.4: Summary of sieve analysis of aggregates

Item	Sand	Granite
D_{10}	360	10000
D_{30}	540	11000
D_{60}	860	13000
C_u	2.39	1.3
C_c	0.94	0.93
FM	2.88	

3.4 Consistency and Setting Time of mixes.

A consistency test was conducted on nineteen mixes, including a control mix (SCC), six binary mixes, and twelve ternary mixes, to assess the impact of various admixtures on water requirements. The control paste, composed of 100% Portland cement (PC), demonstrated a normal consistency of 28% as seen in Table 3.5. For binary mixes containing PC and sugarcane bagasse ash (SHA), consistency increased with higher SHA content due to the

amorphous silica in SHA, which reacts with calcium hydroxide ($Ca(OH)_2$) during cement hydration. This pozzolanic reaction increases water demand for forming secondary compounds like calcium silicate hydrate (C-S-H), necessitating more water for sufficient hydration and pozzolanic activity. In binary mixes with cement kiln dust (CCW), consistency also increased with higher CCW content, attributed to CCW's low reactivity index. For the ternary mixes containing both SHA and CCW, consistency ranged from 29% to 34%, remaining close to the control value of 28%. The low water demand of CCW contrasts with SHA's higher absorption due to its porous nature, which increases surface area and water demand. Additionally, the amorphous silica in SHA further enhances pozzolanic activity, requiring more water for complete hydration.

3.4.1 Setting Time (Initial (IS) and Final (FS))

In Setting Time of Binders (PC, SHA, CCW) two periods were used to assess the setting times (initial and final) respectively. The setting times results are shown in Table 3.5. The control mix has an IS and FS of 115 and 160 minutes. It was observed that the setting times of the binary pastes containing (PC and CCW) increased with increase in CCW content. At 5 % CCW content, IS increased by 8.4%, FS increased by 6.9% of the control value. At 10 % CCW content replacement, IS increased by 13 %, FS increased by 8.9 %. This result was due to the low reactivity of CCW. For binary mixes containing SHA, IS and FS also increased with increase in SHA content. For the binary mixes containing 5% -20 % SHA, there was increase in IS which ranged from 4.5 % to 15 % and FS increased from 7.5 % to 14 % of the control values respectively. The Ternary blend mixes (PC_{90}+ SHA_5+CCW_5) initial and final setting time value when compared to the control value, the IS increased by 14.80 % and FS increased by 12.30 % while Mixes containing (PC_{60} +SHA_{30} +CCW_{10} IS increased by 15.50 % and FS by 14.56 % respectively. From the setting times of the ternary mixes, it was deduced that ternary mix **PC_{70}+SHA_{20} +CCW_{10}** has the lowest increase IS of **8.63 %** and FS **10.08 %** while Mix **PC_{75}+SHA_{20} +CCW_5** has an IS of **11.45 %** and FS of **10.65%.** When the setting times values of ternary mixes was compared to values of the binary mixes, it was noted that the IS and FS values improved over that of binary mixes.

Table 3.5: consistency and setting time.

Mix ID	Consistency (%)	Setting Time	
		Initial (Mins)	Final (Mins)
PC- Control	28	115	160
PC + CCW_5	30	124.66	171.04
PC + CCW_{10}	31	129.95	174.24
PC + SHA_5	27	120.18	172
PC +SHA_{10}	26.5	121	175
PC +SHA_{15}	26.65	125	176
PC +SHA_{20}	26.75	126	178
PC + SHA_5 +CCW_5	26.85	127.35	179.68
PC + SHA_5 + CCW_{10}	29	132.02	186.5
PC + SHA_{10} + CCW_5	29.05	124	185
PC + SHA_{10}+ CCW_{10}	29	122	183.5
PC + SHA_{15} +CCW_5	31	128	184
PC + SHA_{15} +CCW_{10}	32	130	185
PC + SHA_{20} +CCW_5	29.25	124	185.05
PC +SHA_{20}+CCW_{10}	32.5	124.92	179.13
PC+SHA_{25}+CCW_5	31.05	125	186
PC+SHA_{25}+CCW_{10}	32.5	128.20	187
PC+SHA_{30}+CCW_5	31.5	129	187.5
PC+SHA_{30}+CCW_{10}	30	132.82	183.30

3.4.2 Flowability Test

To determine the flowability rate of SCC, the slump flow test was used. According to ENFARC 2005, the acceptable slump flow diameter rate ranges from 550 to 800mm. The slump flow test was conducted for each mix and the result was shown below.

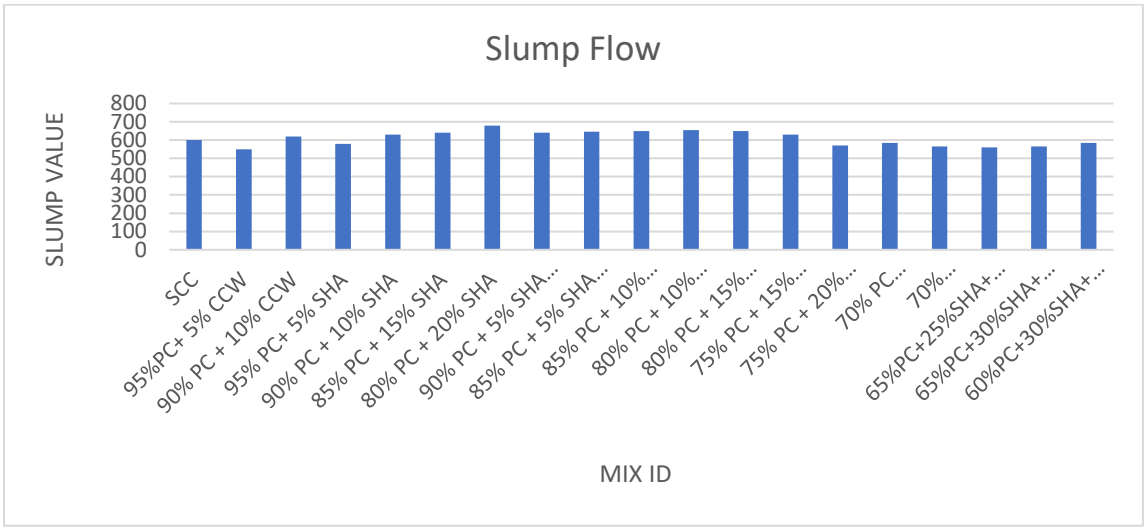

Figure 3.2: Slump values for various mixes tested.

From the result above, the control Mix (SCC) achieved a slump flow of 600 mm, indicating moderate flow ability. The binary mix of PC+ CCW_5 has a slump flow of 550mm, and the mix of PC+CCW_{10} has an increased slump flow of 3.34% compared to the control mix. From the result it was deduced that as the CCW content increases to 10%, the flowability rate also increases, this can be attributed to its fine particle size and filler effect, which can improve the paste density, and help reduce water demand, which contributes positively to the flowability of SCC. For binary mix of (PC+SHA) at 5% it was observed that the flowability rate reduced compared to the control mix, a slump flow of 580mm was recorded but as the SHA content increases from 5% to 20% replacement, it was observed that as the SHA content increase, the flowability rate of the mix increases too from 5% to 13.33% of the control mix. This change in the slump flow was because of the filler effect of the fine particles of SHA, reduced internal friction**,** and improved viscosity**.** This helps the mix maintain a smoother flow, which is essential for self-compacting concrete. The slump flow results of ternary mix indicate varying flowability across the mixes. The maximum slump flow observed was 655 mm for the mix PC_{80} +SHA_{10} + CCW_{10}, while the minimum was 560 mm for the mixes PC_{65} + SHA_{25} + CCW_{10} and PC $_{70}$ + SHA_{25} + CCW_5.

3.4.3 Passing Ability

L Box was used to measure the passing ability of the mixes tested. Concrete is filled in the vertical section and after 30 – 60 seconds, is allowed to flow from the vertical section unto the horizontal section until it stops. Table 3.6 shows the passing abilities of the various mixes.

Table 3.6: Passing Abilities of Mixes

S/NO	Mix ID	H1(mm)	H2 (mm)	H2/H1
1	SCC	107	86.00	0.800
2	PC + CCW_5	106	86.50	0.816
3	PC + CCW_{10}	106	87.00	0.821
4	PC + SHA_5	108	84.50	0.782
5	PC + SHA_{10}	105.5	86.50	0.812
6	PC + SHA $_{15}$	107	89.00	0.832
7	PC + SHA_{20}	100	79.00	0.79
8	90% PC + 5% SHA + 5% CCW	108	86.00	0.796
9	85% PC + 5% SHA + 10% CCW	107	88.50	0.883
10	85% PC + 10% SHA + 5% CCW	104	92.00	0.846
11	80% PC + 10% SHA + 10% CCW	104	92.00	0.883
12	80% PC + 15% SHA +5% CCW	80	65.00	0.813
13	75% PC + 15% SHA + 10% CCW	113	70.00	0.619
14	75% PC + 20% SHA + 5% CCW	90	60.00	0.67
15	70% PC +20%SHA+10%CCW	75	35.00	0.47
16	70% PC+25%SHA+5%CCW	85	65.00	0.76
17	65%PC+25%SHA+10%CCW	75	35.00	0.47

18	65%PC+30%SHA+5%CCW	75	55.00	0.73
19	60%PC+30%SHA+10%CCW	75	55.00	0.73

From the passing ability result above Seven mixes (PC +SHA_{20}, PC +SHA_{20} +CCW_5, PC + SHA_{20} +CCW_{10}, PC + SHA_{25} +CCW_5, PC +SHA_{25}+CCW_{10}, PC+SHA_{30}+CCW_5, PC +SHA_{30}+CCW_{10}) did not meet EFNARC, 2005; ACI 237-07) specification of 0.80 – 1.0 passing ability while the passing abilities of 12 mixes met the requirements of both codes. It was observed that mixes with high content of SHA have lower PA. This is because of the high viscosity of the mixes. Out of the six binary mixes, one failed EFNARC/ ACI 237-07 provisions, the mix with high SHA contents greater than 15 %) while for the ternary mixes, six fell short of the provisions of the aforementioned codes, with PA less than 0.80. by and large, 12 mixes have PA greater than 0.80 while five have PA less than 0.80. this implies that 12 mixes will have no issue in terms of segregation during transportation and placing, passing ability through reinforcements and curved surfaces of formworks while six of the mixes will be susceptible to segregation resistance during transportation, placing and filling of formworks. The mixes with 15% or less SHA exhibit better passing ability with higher H2 values, while mixes with 20-30% SHA have lower H2 values and a decreased H2/H1 ratio, showing reduced flow ability.

4. Summary of Finding

Based on the results of the experiment carried out to determine the flow ability and passing ability of self-compacting concrete containing PC, SHA and CCW the following findings were obtained;

1. As the SHA content increases up to 15%, there is a noticeable increase in the flow ability. With the slump flow reaching its peak at 655mm for the mix PC_{80}+SHA_{10} +CCW_{10}. This is consistent with the behaviour of fine pozzolanic materials like SHA, which can act as fillers, enhancing flow by reducing internal friction and increasing the lubricating effect within the mix.
2. When the percentage replacement of SHA is above 15%, there is a decline in flow ability rate of the mix, the slump flow value dropped as the SHA content increases. This reduction is due to the high ash content absorbing more water and increasing the viscosity of the mix, thereby reducing its ability to flow,
3. Mixes with 10% CCW shows better flow ability when combined with 5 to 10 % SHA.
4. As PC content decreases, a general trend of reducing flow ability was observed. This is especially pronounced in mixes where PC is replaced by both high levels of SHA and CCW, with slump flows dropping as low as 650mm. the loss of PC, which is crucial for hydration and mix cohesion, leads to a stiffer and less flow able concrete.

5. Conclusion

This research investigated the fresh properties of self-compacting concrete incorporating SHA and CCW. The study aimed to explore sustainable alternatives in concrete production by utilizing agricultural and industrial waste material. The following conclusions can be drawn from the experimental results and subsequent analysis.

1. The chemical and physical properties of SHA and CCW were thoroughly examined and presented; the results indicate that SHA possesses pozzolanic properties suitable for partial replacement of cement in concrete and that the inclusion of SHA and CCW enhance the overall sustainability of the concrete.
2. The slump flow test results reveal a clear trend in the effect of sorghum husk ash and calcium carbide waste on the flow ability of self-compacting concrete. Increasing SHA content up to 10-15% enhances the flow ability of SCC, likely due to SHA's fine particles filling voids and improving the overall viscosity and workability of the mix. However, beyond 15% SHA, the mix becomes less flow able, which can be attributed to the high ash content increasing the water demand and viscosity of the mix.
3. Similarly, moderate amounts of CCW (5-10%) combined with low to moderate SHA content (5-15%) improve flow ability. However, excessive replacement of PC with both CCW and SHA reduces the flow ability significantly, suggesting that there is an optimal balance of PC, SHA, and CCW for maintaining the desired SCC properties.

In conclusion, the use of Sorghum Husk Ash (SHA) and Calcium Carbide Waste (CCW) as supplementary cementitious materials (SCMs) significantly enhances the performance of self-compacting concrete (SCC) by improving flow ability and passing ability at optimal replacement levels. Specifically, moderate proportions of 5%-15% SHA and 5%-10% CCW strike the best balance. However, excessive replacements of SHA above 15% and CCW above 10% adversely affect both flow ability and passing ability due to increased water demand and mix viscosity. Therefore, careful control of SCM proportions, particularly favouring 10% SHA and 10% CCW, is essential for maintaining effective SCC characteristics. This study provides valuable insights for sustainable construction by demonstrating that optimal incorporation of these SCMs can reduce reliance on traditional Portland cement, thus

enhancing flow ability and promoting waste recycling. The findings offer guidelines for efficient mix design, enabling contractors to improve performance and reduce labour costs in complex structures. Future research should focus on the long-term durability of SCC with SHA and CCW, explore synergies with other SCMs, and assess the economic and environmental impacts through life cycle assessments. Overall, this research contributes to advancing sustainable concrete practices, benefiting both the construction industry and the environment.

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Framework for Integrating Biophilic Design in Cancer Treatment Centers in Ilorin, Nigeria

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Abstract

The design of healthcare environments plays a crucial role in patient recovery and overall well-being, particularly in cancer treatment centers where emotional support is vital. However, many modern hospitals in Nigeria focus primarily on sterile, technology-driven care, inadvertently neglecting the psychological needs of patients. his oversight can hinder recovery, as the integration of biophilic design—incorporating natural elements into built environments—has been shown to enhance mental and emotional healing. This study aims to bridge this gap by exploring the effective integration of biophilic design in cancer treatment centers, where patients often face heightened stress. Utilizing a case study methodology, three healthcare facilities were assessed based on the 14 Patterns of Biophilic Design. The findings reveal a limited application of these principles, particularly in areas such as sensory diversity, water features, and healing gardens, which restrict opportunities for restorative experiences. This research offers practical implications, providing actionable recommendations for incorporating biophilic elements—such as therapeutic gardens and enhanced natural lighting—into healthcare design. By highlighting the essential role of biophilic design in improving patient outcomes, this study contributes to the broader discourse on healthcare innovation, emphasizing the need for a more holistic approach to cancer treatment in Nigeria.

Keywords: biophilia, biophilic design, healthcare facilities, nature, recovery.

1. Introduction

Healthcare environments significantly impact patient recovery and well-being, particularly in cancer treatment centers. Modern hospitals often emphasize sterile, technology-driven care, inadvertently neglecting the psychological and emotional needs of patients (Davidson, 2013). Recent research, however, highlights the benefits of nature-based care, reintroducing biophilic design as a valuable component in healthcare settings (Downton, *et al.,* 2017). Biophilia, the innate human affinity for nature, has been shown to improve emotional, mental, and physical well-being (Tekin & Gutiérrez, 2023). Integrating natural elements into the built environment can reduce stress, enhance recovery, and promote positive mood changes. These effects are especially crucial for cancer patients, who face immense psychological and physical challenges.

1.1 Statement of the Research problem

Concrete Healthcare quality is one of the most frequently cited principles and is on top of the global agenda. One of the significant health issues in the Twenty-First Century is Cancer, the second primary cause of global mortality (Ferlay *et al.*, 2020). Cancer treatment in Nigeria faces a dual challenge: while medical advancements have improved survival rates, the psychological and emotional well-being of patients is often overlooked. Current cancer treatment centers in the country are designed with a focus on functionality and medical efficiency, neglecting the integration of nature-inspired elements that can promote mental and emotional healing (Iyendo *et al*, 2016). Research has shown that biophilic design—incorporating natural elements into the built environment—can reduce stress and enhance overall well-being (Wichrowski *et al*., 2021). However, the application of biophilic design in Nigerian healthcare facilities, especially cancer treatment centers, remains largely unexplored. There is a critical need to develop healthcare environments that address not only the physical but also the emotional and psychological needs of cancer patients in Nigeria.

1.2 Aim

This This study aims to develop a framework for integrating biophilic design into cancer treatment centers in Ilorin, Nigeria. The objective is to explore how nature-based design elements can improve the physical, emotional, and

mental well-being of cancer patients. This research will examine the potential of biophilic design to create a more healing-oriented environment that supports patient recovery and enhances the overall healthcare experience

2. Review of Relevant Literature

2.1 The Concept of Biophilia

Biophilia, as introduced by (Wilson, 1984), refers to the inherent human desire to connect with nature and living systems. This concept, grounded in evolutionary biology, suggests that humans are biologically predisposed to find comfort and well-being in environments that include natural elements (Kellert, 2008). The theory argues that exposure to nature can have profound effects on mental and physical health, making it a crucial consideration in the design of built environments (Browning *et al.*, 2014, Gillis & Gatersleben, 2015).

2.2 Principles of Biophilic Design

Biophilic design, derived from biophilia theory, seeks to incorporate natural elements into the built environment to foster human well-being (Browning *et al.,* 2014). As identified by (Kellert & Calabrese, 2015), this design approach revolves around three core experiences: direct experience of nature (e.g., light, water, plants), indirect experiences (e.g., natural materials, representations of nature), and spatial experiences (e.g., refuge and prospect). These principles allow for the design of spaces that promote a restorative connection to nature, leading to improved health outcomes, particularly in settings where stress reduction and mental health are critical.

2.3 The Application of Biophilic Design in Healthcare Settings

A successful biophilic design integrates natural elements into spaces in a way that is both inspiring and therapeutic, without compromising functionality. The approach can vary depending on the users. For example, cancer patients in a study by (Ebaid, 2022) preferred natural features over artificial ones but avoided strongly scented materials and stimulating nature sounds due to health sensitivities. However, when it comes to stress reduction, even artificial nature elements are preferable to no visual connection to nature at all, which aligns with findings from (Huelat, 2008) and (Ebaid, 2022). In healthcare environments, biophilic design has been shown to significantly benefit patient health. Studies by (Ulrich, 1984) and (Van den Berg & Custers, 2011) reveal that exposure to nature reduces stress, improves mood, and accelerates recovery. Hospitals that incorporate natural light, green spaces, and water features promote emotional well-being and reduce the need for medications (Jackson *et al*., 2013; Totaforti *et al*., 2018). For cancer patients, whose treatment is both emotionally and physically taxing, integrating biophilic elements into care settings can offer holistic support, enhancing healing beyond physical treatments.

2.4 Health Benefits of Biophilic Design for Cancer Patients

Cancer treatment is not only physically demanding but also emotionally overwhelming for both patients and their families. Research has consistently shown that exposure to nature has restorative effects, helping individuals manage stress, improve cognitive function, and foster a sense of well-being (Ratcliffe *et al*., 2013; Wichrowski *et al*., 2021). In particular, biophilic design—which integrates natural elements into the built environment—can alleviate the negative effects of stress, enhancing mental clarity and resilience during treatment. It has also been linked to faster recovery, improved patient mobility, and a reduced need for pain medication (Han, 2009; Interface, 2023). Figure 1 presents findings from a study by (Ebaid, 2022) that evaluated patient satisfaction before and after two phases of renovation. Prior to 2019, satisfaction was at 76%. The first phase of renovations, completed in 2021, introduced large windows to maximize natural light, views of outdoor greenery, and increased use of wood and stone materials, resulting in an 82% satisfaction rate. The second phase, which included the addition of indoor greenery, water features, and quiet, nature-themed relaxation areas, further improved satisfaction to 94%. Interviews in the study highlighted the profound impact of these changes, especially the indoor greenery added during the 2020 renovations. These results are particularly relevant in cancer treatment, where the integration of nature into healthcare environments promotes both mental and physical healing.

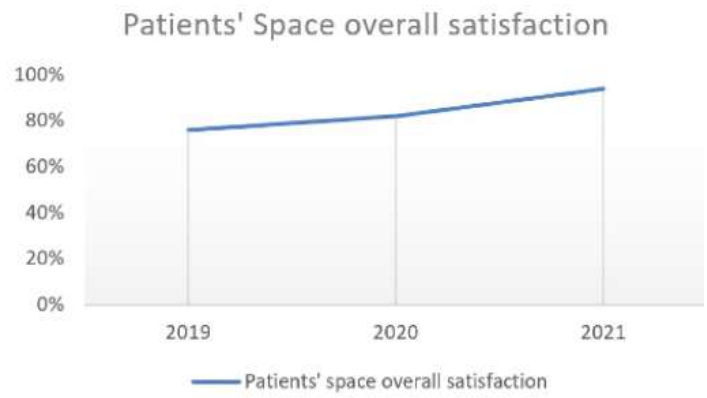

Figure 1: Users' satisfaction timeline improvement after the application of some biophilic design patterns in the hospital spaces, (Ebaid, 2022.)

2.5 Relevance of Biophilic Design to Nigerian Cancer Treatment Centers

Cancer treatment in Nigeria presents unique challenges, including limited access to care and facilities that are not designed with the patient's holistic well-being in mind (Adejoro, 2023). Biophilic design offers an opportunity to rethink these spaces, providing not only physical comfort but also addressing the psychological and emotional needs of patients. By introducing nature-inspired elements such as green spaces, natural light, and water features into Nigerian cancer centers, healthcare providers can enhance the patient experience, potentially improving both psychological resilience and physical outcomes.

2.6 General deductions

Despite the growing body of research supporting the benefits of biophilic design in healthcare, there is a clear gap in its application to cancer treatment centers, especially in low-resource settings like Nigeria. Most studies have focused on healthcare environments in high-income countries, where facilities are often equipped to incorporate biophilic elements. However, cancer treatment centers, which demand an even greater emphasis on psychological and emotional support for patients undergoing long-term treatment, are particularly suited to the application of biophilic principles. In Nigeria, the design of healthcare facilities tends to focus on functionality, often at the expense of holistic well-being. This presents an opportunity to explore how biophilic design can be integrated into the design of Nigerian cancer treatment centers to provide a more supportive healing environment.

3. Research Methodology

This study employed a qualitative research approach to explore the integration of biophilic design principles in cancer treatment centers. The primary aim was to develop a framework for incorporating biophilic design into cancer treatment centers in Nigeria, enhancing both the psychological and physical well-being of patients. A case study design was utilized, involving the observation of three healthcare facilities in Nigeria: Ahmadu Bello University Teaching Hospital (ABUAD) in Shika, National Hospital Abuja, and University Teaching Hospital (UITH) in Ibadan. Three healthcare facilities were selected based on their relevance to the study's objectives and their varying degrees of biophilic design integration. The hospitals selected represent a mix of public and teaching hospitals, providing a comprehensive overview of the healthcare environment in Nigeria. The National Hospital in Abuja is one of Nigeria's foremost healthcare institutions, while ABUAD and UITH are prominent teaching hospitals with established cancer treatment departments. These hospitals were chosen for their significant role in cancer care and the varying degree of architectural features that potentially incorporate biophilic design elements.

Data collection was carried out through direct observation of the selected healthcare facilities, focusing on physical and environmental features that align with biophilic design principles. An observation guide was developed to structure the data collection process. The guide focused on observing specific biophilic design patterns and parameters that influence patient experiences and emotional well-being in cancer treatment centers. The following biophilic design parameters were observed across the three case study locations: Visual Connection with Nature, Non-Visual Connection with Nature, Non-Rhythmic Sensory Stimuli, Thermal Airflow & Variability, Presence of Water, Dynamic & Diffuse Light, Connection with Natural Systems, Biomorphic Forms & Patterns, Material Connection with Nature, Complexity & Order, Prospect & Refuge and Peril. An observation schedule/checklist was created to ensure a systematic and detailed approach to gathering data. The checklist was designed to assess the presence and quality of each of the 12 biophilic design parameters listed above. For each parameter, specific criteria were included to guide observations and ensure consistency across the three case studies. The observations were

carried out over a period of two months, with on-site visits conducted at each of the three hospitals. Each hospital was visited twice to ensure comprehensive data collection, covering different times of day to observe how lighting, temperature, and patient activities varied. Field notes were taken to document the presence and quality of the observed biophilic design elements, and photographs were taken (with consent from hospital administrators) to visually record design features. The checklist was used to score each biophilic design element on a scale from 1 to 5, with 1 indicating no presence of the feature, and 5 indicating the excellent presence of the feature. The researcher noted any other observations that seemed relevant to the patient's emotional and psychological experience, including patterns in the behavior of patients or staff in relation to the biophilic elements. The study used a purposive sampling approach to select the three healthcare facilities, ensuring that each case study hospital was relevant to the study's focus on cancer treatment and biophilic design. The selection was based on the hospitals' role in cancer care, the diversity of their design approaches, and the presence of biophilic elements or the potential to integrate them. The purposive sampling method was chosen because it allows for targeted selection of relevant cases, ensuring that the findings are pertinent to the research objectives.

3.1 Data analysis

After data was collected, a thematic analysis approach was used to identify recurring themes and patterns related to the integration of biophilic design elements. The analysis focused on how these elements influenced the physical and emotional experiences of patients in the observed hospitals. Themes related to stress reduction, psychological comfort, and patient engagement with the environment were explored in relation to the presence or absence of biophilic design features. The findings from the three hospitals were compared to evaluate the diversity of biophilic applications and their effects on patient experiences. The analysis aimed to identify best practices for incorporating biophilic design into cancer treatment centers in Nigeria and provide insights for developing a framework for future healthcare facility designs.

3.2 Results and Discussion

This section presents the findings obtained from the case study observation guide, analyzed using Microsoft Excel, and displayed through tables. The results are discussed with a focus on how biophilic design patterns and attributes impact patient well-being, particularly within oncology departments. The analysis compares the extent of biophilic elements in three case studies: Ahmadu Bello University Teaching Hospital (ABUTH), National Hospital Abuja (NHA), and University College Hospital (UCH) Ibadan, offering insights into the practical implications of biophilic design for cancer treatment centers in Nigeria.

3.3 Case study 1: Ahmadu Bello Teaching Hospital (oncology department)

The Ahmadu Bello University Teaching Hospital incorporates several biophilic design elements within its oncology department, offering a strong visual connection to nature. The department is surrounded by carefully curated landscapes, allowing for uninterrupted outdoor views from many interior spaces. The longer axis of the building is oriented to optimize both solar alignment and natural ventilation, with windows positioned to enhance airflow and light diffusion. The hospital's architecture includes repeating symmetrical patterns and interconnected walkways that create harmony within the built environment. However, despite the integration of greenery, the lack of a dedicated therapeutic garden diminishes opportunities for patient engagement with healing spaces. In terms of sensory stimuli, there is an absence of water features such as aquariums or fountains, which could enhance the multisensory experience and provide a calming effect for patients. The hospital's lighting strategy, with windows providing varied diffusion of light, enriches the patient experience by reducing glare and maintaining a dynamic interplay between natural light and shadow. Nonetheless, the facility would benefit from more interactive nature analogues and water elements to foster a more immersive healing environment.

Table 1: Analysis of biophilic design elements and attribute - Ahmadu Bello University Teaching hospital (oncology department)

S/N	Patterns of biophilic design	Attributes	Level			
			Ab	low	Med	Hi
1	**Visual Connection With Nature**	• The availability of a variety of plants and landscape				✓
		• unhindered views of the natural world from the interior			✓	
		• presence of healing gardens	✓			
2	**Non-Visual Connection With Nature**	• Availability of natural sounds over noises from cities			✓	
		• Incorporating water and natural ventilation	✓			
3	**Non-Rhythmic Sensory Stimuli**	• Warm colour schemes are used for sensory stimulation			✓	
		• Clouds, Shadows, Water reflection.	✓			
4	**Thermal Airflow & Variability**	• Design considering the direction of the sun and wind		✓		
		• windows positioned to provide natural ventilation				✓
5	**Presence Of Water**	• Presence of water features for landscape (aquarium/fountain)	✓			
6	**Dynamic & Diffuse Light**	• windows positioned to provide dynamic and diffuse light			✓	
		• Reflective surfaces are used to improve illumination and reduce glare.		✓		
7	**Connection With Natural System**	• Visual access to the site's current natural system		✓		
		Nature Analogues				
8	**Biomorphic Forms & Patterns**	• Using indoor plant themes		✓		
		• Use of organic forms on the exterior of buildings	✓			
9	**Material Connection With Nature**	• Using eco-friendly construction materials		✓		
		• Using a natural colour scheme, such as green, inside of buildings	✓			
10	**Complexity & Order**	• Landscape design and intricate architectural expression		✓		
		• Integration of buildings parts into whole				✓
		Nature Of Space				
11	**Prospect**	• Arranging a structure, window, or hallway to maximise the view of exterior landscapes				✓
		• Incorporating savannah-like ecosystems into planned or existing designs	✓			
12	**Refuge**	• Variation in indoor light levels			✓	
13	**Mystery**	• A low-maintenance landscape with a meandering path			✓	
		• Curved edges preference over sharp corners in interior areas.	✓			
14	**Peril**	• Towering walls, floor to ceiling windows.	✓			

(Source: authors field work, 2024)

As shown in Table 1 above, the biophilic design elements are moderately implemented at Ahmadu Bello University Teaching Hospital, , creating a beneficial but limited impact on patient well-being. The Visual Connection with Nature is rated as medium, indicating the presence of plants and landscaping, though without dedicated healing gardens, the full therapeutic potential is not achieved. Visual connections to nature are essential for reducing stress, yet the hospital could enhance this with more open views of greenery. The Non-Visual Connection with Nature, such as natural sounds and ventilation, is also moderately present, suggesting that while patients experience some benefits from natural ventilation, additional sensory elements like water sounds could further reduce anxiety. The Thermal Airflow & Variability scores high, indicating well-planned natural ventilation, which significantly improves patient comfort and reduces reliance on artificial climate control. However, the Presence of Water is rated low, highlighting a missed opportunity to incorporate water features, which are known for their calming effects. Overall, while the hospital excels in terms of airflow, landscape design, and natural light, the absence of certain biophilic features, such as water elements and comprehensive healing gardens, limits its potential to fully maximize the positive impacts on patient recovery

3.2.2 Case study 2: University college hospital, Ibadan (oncology department)

The oncology department at the National Hospital Abuja integrates some biophilic design features but demonstrates notable gaps in patient engagement with nature. While the facility is surrounded by landscaping, there is no therapeutic garden, limiting opportunities for patients to benefit from restorative outdoor environments. The design lacks a coherent visual connection to nature, especially in public areas like waiting rooms, where patients are unable to view exterior greenery. Additionally, the use of artificial colors such as green and white helps create a calming atmosphere but is not enough to offset the lack of direct outdoor engagement. The department also lacks water elements and auditory connections to nature, further reducing its capacity to stimulate a non-visual connection to natural environments. Despite adequate lighting through dynamic and diffuse windows, the facility could improve by incorporating more natural sounds, water features, and healing gardens to enhance the healing experience for patients. Moreover, the compartmentalization of outdoor areas hinders the creation of cohesive spaces that support well-being.

Table 2 below reveals that the National Hospital, Abuja, incorporates many of the same biophilic design elements as Ahmadu Bello University Hospital, with moderate application across key features. Visual Connection with Nature is rated medium, signifying that while there is access to landscaping, views of nature are obstructed in some areas, particularly in public spaces, reducing the potential calming effect. The Non-Visual Connection with Nature and Non-Rhythmic Sensory Stimuli also receive medium scores, indicating that sensory elements like natural sounds or reflections are present but could be improved by incorporating more soundscapes and enhancing building layout for better cross-ventilation. Similar to Ahmadu Bello, the Presence of Water is low, showing a missed chance to introduce water features like fountains or aquariums that could enhance relaxation for patients. The hospital performs well in Thermal Airflow & Variability and Prospect, maximizing natural ventilation and providing expansive views of the landscape, but lacks dedicated therapeutic spaces and a rich sensory environment. These features, crucial for reducing stress and improving mental health, are underutilized, making the hospital's biophilic design less impactful than it could be.

Table 2: Analysis of biophilic design elements and attribute - University college hospital, Ibadan (oncology department)

S/N	Patterns of biophilic design	Attributes	Level			
			Ab	low	Med	Hi
1	**Visual Connection With Nature**	• The availability of a variety of plants and landscape				✓
		• unhindered views of the natural world from the interior			✓	
		• presence of healing gardens	✓			
2	**Non-Visual Connection With Nature**	• Availability of natural sounds over noises from cities			✓	
		• Incorporating water and natural ventilation	✓			
3	**Non-Rhythmic Sensory Stimuli**	• Warm colour schemes are used for sensory stimulation			✓	
		• Clouds, Shadows, Water reflection.	✓			
4	**Thermal Airflow & Variability**	• Design considering the direction of the sun and wind		✓		
		• windows positioned to provide natural ventilation				✓
5	**Presence Of Water**	• Presence of water features for landscape (aquarium/fountain)	✓			
6	**Dynamic & Diffuse Light**	• windows positioned to provide dynamic and diffuse light			✓	
		• Reflective surfaces are used to improve illumination and reduce glare.		✓		
7	**Connection With Natural System**	• Visual access to the site's current natural system		✓		
		Nature Analogues				
8	**Biomorphic Forms & Patterns**	• Using indoor plant themes		✓		
		• Use of organic forms on the exterior of buildings	✓			
9	**Material Connection With Nature**	• Using eco-friendly construction materials		✓		
		• Using a natural colour scheme, such as green, inside of buildings	✓			
10	**Complexity & Order**	• Landscape design and intricate architectural expression		✓		
		• Integration of buildings parts into whole				✓
		Nature Of Space				
11	**Prospect**	• Arranging a structure, window, or hallway to maximise the view of exterior landscapes	✓			✓
		• Incorporating savannah-like ecosystems into planned or existing designs				
12	**Refuge**	• Variation in indoor light levels			✓	
13	**Mystery**	• A low-maintenance landscape with a meandering path			✓	
		• Curved edges preference over sharp corners in interior areas.	✓			
14	**Peril**	• Towering walls, floor to ceiling windows.	✓			

(Source: authors field work, 2024)

3.2.3 Case study 3: National hospital, Abuja (oncology department)

The University College Hospital Ibadan exhibits significant weaknesses in terms of biophilic design. Though public areas are well-ventilated and airy, private and chemotherapy wards are less connected to natural environments, with one-sided windows preventing cross-ventilation. Patients in certain wards have limited views of nature, with

many overlooking sidewalks and parking lots, which undermines the restorative potential of the outdoor environment. The general color scheme of the hospital is also described as "drab and unwelcoming," and there is minimal greenery or façade greening, which could negatively affect patient recovery. Despite these shortcomings, the hospital does feature adequate provisions for circulation through verandas, balconies, and terraces. The atrium, however, provides insufficient lighting, especially for lower-level areas. Additionally, the hospital's rigid architectural design lacks organic forms and complexity, which could otherwise enhance the healing environment through a deeper connection to nature. To improve, the hospital could introduce more engaging natural elements such as therapeutic gardens, varied lighting schemes, and water features.

Table 3: Analysis of biophilic design elements and attribute – National hospital, Abuja (oncology department)

S/N	Patterns of biophilic design	Attributes	Level			
			Ab	low	Med	Hi
1	**Visual Connection With Nature**	• The availability of a variety of plants and landscape		✓		
		• unhindered views of the natural world from the interior		✓		
		• presence of healing gardens	✓			
2	**Non-Visual Connection With Nature**	• Availability of natural sounds over noises from cities	✓			
		• Incorporating water and natural ventilation	✓			
3	**Non-Rhythmic Sensory Stimuli**	• Warm colour schemes are used for sensory stimulation	✓			
		• Clouds, Shadows, Water reflection.	✓			
4	**Thermal Airflow & Variability**	• Design considering the direction of the sun and wind				✓
		• windows positioned to provide natural ventilation				✓
5	**Presence Of Water**	• Presence of water features for landscape (aquarium/fountain)	✓			
6	**Dynamic & Diffuse Light**	• windows positioned to provide dynamic and diffuse light				✓
		• Reflective surfaces are used to improve illumination and reduce glare.	✓			
7	**Connection With Natural System**	• Visual access to the site's current natural system	✓			
		Nature Analogues				
8	**Biomorphic Forms & Patterns**	• Using indoor plant themes	✓			
		• Use of organic forms on the exterior of buildings	✓			
9	**Material Connection With Nature**	• Using eco-friendly construction materials		✓		
		• Using a natural colour scheme, such as green, inside of buildings		✓		
10	**Complexity & Order**	• Landscape design and intricate architectural expression	✓			
		• Integration of buildings parts into whole				✓
		Nature Of Space				
11	**Prospect**	• Arranging a structure, window, or hallway to maximise the view of exterior landscapes	✓			✓

		• Incorporating savannah-like ecosystems into planned or existing designs		
12	**Refuge**	• Variation in indoor light levels		✓
13	**Mystery**	• A low-maintenance landscape with a meandering path	✓	
		• Curved edges preference over sharp corners in interior areas.	✓	
14	**Peril**	• Towering walls, floor to ceiling windows.	✓	

(Source: authors field work, 2024)

The University College Hospital, Ibadan, shows a strong application of biophilic design elements, particularly in providing patients with beneficial connections to nature. Data presented in Tbale 3 below shows Visual Connection with Nature is rated high, meaning patients enjoy ample access to views of plants and natural landscapes from interior spaces, a feature known to significantly reduce stress and promote healing. The Connection with Natural Systems is also high, further enhancing the patient experience by offering visual access to the surrounding natural environment. The hospital excels in Dynamic & Diffuse Light, with windows and reflective surfaces allowing natural light to fill indoor spaces, supporting circadian rhythms and reducing the need for artificial lighting. However, Presence of Water is rated low, indicating that despite the hospital's strengths, it lacks water features that could provide additional calming effects. Other sensory elements, such as Non-Visual Connections and Non-Rhythmic Sensory Stimuli, are moderately present, suggesting room for improvement in diversifying sensory inputs to create a richer healing environment. While the hospital has strong elements like light and natural views, it could further enhance patient well-being by incorporating more sensory features and water elements.

4.2.3 Comparative analysis and implications

Across the three case studies, the hospitals demonstrate a moderate application of biophilic design elements, which positively influence patient well-being but leave room for improvement. Common strengths include the presence of Visual Connections with Nature, natural ventilation through Thermal Airflow, and access to Dynamic & Diffuse Light, all of which contribute to reducing stress and promoting recovery. However, these hospitals also share common gaps in the Presence of Water and Non-Visual Sensory Stimuli, missing opportunities to incorporate water features and more diverse sensory experiences that could enhance relaxation and mental health. Among the three, Ahmadu Bello University Teaching Hospital demonstrates the strongest implementation of biophilic design principles, particularly in its thoughtful use of landscaping, window placement, and natural ventilation. In contrast, the National Hospital Abuja and University College Hospital Ibadan exhibit considerable weaknesses, particularly in terms of their Visual Connection to Nature and the lack of healing gardens or water features. The absence of key biophilic elements, such as water features and therapeutic gardens, in these facilities limits their ability to fully engage patients in restorative experiences. The use of nature in hospital design has been shown to significantly improve patient well-being by reducing stress, enhancing mood, and fostering a sense of calm. In the context of cancer treatment centers in Nigeria, where stress management and emotional well-being are critical for recovery, strengthening these biophilic features could significantly improve patient outcomes. The integration of more dynamic and interactive natural features is crucial for enhancing the healing environment. To strengthen biophilic design in these settings, hospitals should prioritize creating therapeutic gardens, improving natural ventilation, and incorporating multisensory elements such as water features and dynamic lighting. These interventions would contribute to better patient outcomes by aligning the built environment more closely with the principles of biophilic design, ultimately fostering spaces that promote both physical and emotional healing.

5. Findings

The findings of this study highlight the significant role of Nature in Space patterns in designing healthcare facilities that promote healing and reduce psychological stress. For instance, the case studies demonstrate these patterns through the presence of healing gardens, which offer patients a calming environment, as well as unrestricted views from interior spaces, allowing patients to visually connect with the outdoors. At Ahmadu Bello University Teaching Hospital, the thoughtful placement of windows ensures that patients can enjoy natural scenery, contributing to their emotional well-being. Similarly, the use of a variety of landscapes and plants across all three hospitals further strengthens this connection to nature, reinforcing the therapeutic potential of biophilic design. Furthermore, warm hues are strategically used in interior spaces, such as the chemotherapy wards of the University College Hospital

Ibadan, to stimulate the senses and create a soothing atmosphere. Additionally, buildings are carefully oriented to maximize exposure to natural sunlight and airflow, which not only enhances patient comfort but also fosters a healthier indoor environment. In terms of quantitative data, research has shown that patients exposed to natural elements and adequate lighting report lower stress levels and improved recovery times. Although specific patient surveys were not conducted in this study, the design features observed align with well-established principles of biophilic design, known to improve patient outcomes.

6. Conclusion and Recommendations

This study underscores the potential of biophilic design to significantly improve patient recovery and well-being in cancer treatment centers in Nigeria. The findings indicate that elements such as healing gardens, unrestricted views of nature, and natural ventilation are moderately incorporated in the healthcare facilities analyzed, contributing to reduced stress and enhanced patient outcomes. Despite these positive aspects, there remain notable gaps, especially in the lack of water features, non-visual sensory stimuli, and therapeutic gardens, which could further optimize the healing environment. The research objective of assessing the integration of biophilic design was largely achieved, providing insight into both the strengths and areas for improvement in the design practices of these centers. The findings emphasize the need for more comprehensive biophilic design strategies to maximize therapeutic benefits. Practically, this research offers valuable insights that can inform future healthcare facility designs in Nigeria. By integrating more diverse biophilic elements, such as sensory gardens, water features, and dynamic lighting systems, healthcare designers can create environments that foster not only physical recovery but also emotional well-being. Further research should focus on quantifying the impact of biophilic design on patient outcomes through patient surveys or clinical studies, to provide robust evidence for these design interventions.

The research recommendations Hospitals should prioritize strengthening both visual and non-visual connections to nature by incorporating healing gardens, courtyards, and indoor plants to offer patients direct access to natural elements. Ahmadu Bello University Teaching Hospital serves as a model in this regard with its well-designed landscapes and window placement, a strategy that other hospitals should adopt to enhance visual connections with nature. Furthermore, hospitals should introduce water features, such as fountains or reflecting pools, which provide calming sensory stimuli currently absent in the case study hospitals. The inclusion of water elements could play a critical role in reducing patient stress and enhancing relaxation. Moreover, the design of therapeutic spaces with improved natural ventilation should be a priority across all facilities, following the example of Ahmadu Bello University Teaching Hospital's effective use of natural breezes to optimize comfort. Hospitals should also incorporate dynamic lighting systems that mimic natural light cycles, which can help regulate circadian rhythms and improve overall patient well-being. Increased use of glass to allow for more natural light penetration would also enhance the indoor environment of healthcare spaces. Lastly, it is recommended that a comprehensive biophilic design framework be developed specifically for healthcare facilities in Nigeria. This framework should provide guidelines on spatial arrangements, material choices, and landscape design that cater to the therapeutic needs of patients, particularly those undergoing cancer treatment. By adopting these recommendations, healthcare facilities in Nigeria can create environments that more effectively support both the psychological and physical recovery of patients.

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Evaluation of the drivers of PPP infrastructure projects implementation in Nigeria

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Abstract

This study evaluates the drivers, barriers, and critical success factors influencing the implementation of Public-Private Partnership (PPP) infrastructure projects in Nigeria. Recognizing Nigeria's significant infrastructure deficit and the limitations of traditional public funding, the government has increasingly turned to PPPs to bridge the gap. The research identifies key drivers such as stable macroeconomic conditions, good governance, and project profitability that enhance the success of PPPs. However, several barriers, including lengthy bidding processes, unrealistic risk allocation, and procedural delays, continue to hinder project implementation. A quantitative approach was employed, with data collected through structured questionnaires administered to public sector authorities, concessionaires, and financial institutions involved in PPP projects. A total of 121 questionnaires were distributed, and 93 were returned for analysis. Descriptive statistics, relative importance indices, and exploratory factor analysis were used to analyse the data, highlighting the most significant factors affecting PPP implementation. The findings reveal that the success of PPPs in Nigeria depends heavily on factors such as good governance, the commitment of public and private sectors, and the availability of a transparent procurement process. Conversely, challenges like political interference and corrupt practices during procurement undermine the effectiveness of PPPs. The study recommends streamlining procurement processes, improving risk allocation, and building the capacity of professionals involved in managing PPP projects. Future research should explore the impact of macroeconomic fluctuations on PPP outcomes and investigate the role of governance reforms in improving project transparency and efficiency. By addressing these areas, Nigeria can better leverage PPPs for sustainable infrastructure development and economic growth.

Keywords: Public-Private Partnership (PPP), Infrastructure Development, Critical Success Factors, Procurement Barriers, Risk Allocation

1. Introduction

The world faces a significant infrastructure deficit, which is the gap between the current infrastructure and what is needed to meet the growing demands of populations and economies (Rezouki & Hassan, 2019, Anago, 2024). This deficit affects both developed and developing countries, though the severity and types of infrastructure lacking varies. Key sectors such as transportation, energy, water, and sanitation are particularly impacted (Wang & Ma, 2021).

In developed nations, aging infrastructure poses a challenge. Bridges, highways, rail systems, and water systems often require significant upgrades and maintenance to remain functional and safe (Jayasena, Chan & Kumaraswamy, 2021). The American Society of Civil Engineers (ASCE) reported that the U.S. needs to invest trillions to bring its infrastructure up to an acceptable standard. However, in many developing nations, basic infrastructure like roads, bridges, airports, railways, power generation and transmission plant, clean water and sanitation networks, and healthcare facilities are either underdeveloped or entirely absent (Lehman, 2022). The World Bank has estimated that emerging markets and developing countries need to invest trillions annually to meet infrastructure needs by 2030. These physical infrastructures are important for national development and for the benefit of the public (Infrastructure Concession Regulatory Commission [ICRC], 2017). Public-Private Partnership (PPP) infrastructure implementation in Nigeria faces several challenges that hinder its effectiveness. One major issue is the lengthy bidding and negotiation processes, which lead to delays and increased costs (Malek & Gundaliya, 2023, Arijeloye, Aje & Oke, 2024). Additionally, high bidding costs often deter private sector participation, limiting competition. Another critical problem is the unrealistic allocation of risks, where an excessive burden is placed on the private sector, making projects financially unfeasible and prone to disputes (Ebekozien *et al*., 2023). Furthermore, political interference and corrupt practices during the procurement process undermine transparency, causing inefficiencies and eroding trust between public and private stakeholders. These problems collectively contribute to delays, cost overruns, and project failures, limiting the success of PPP initiatives in Nigeria.

2. Literature Review

2.1 PPP Infrastructure Development in Nigeria

Like many developing countries, Nigeria has struggled with inadequate infrastructure, which has hindered economic growth and social development. Poor infrastructure affects various sectors, including transportation, energy, and telecommunications, leading to inefficiencies and increased costs. For instance, the power sector in Nigeria has been notoriously unreliable, with frequent outages affecting businesses and households alike. Similarly, the transportation sector suffers from poor road conditions and inadequate rail networks, which hamper the movement of goods and people (Wang & Ma, 2021).

Recognizing the limitations of traditional public funding methods, the Nigerian government has increasingly turned to PPPs to bridge the infrastructure gap. The formal adoption of PPPs gained momentum in the early 2000s, with the government actively seeking private sector involvement in key infrastructure sectors. This shift was driven by the need to leverage private sector expertise, efficiency, and capital to complement public resources (Leigland, 2020, Debela, 2021, Obieje, 2019)

To facilitate the implementation of PPPs, the Nigerian government developed policies and institutional frameworks. The establishment of the Infrastructure Concession Regulatory Commission (ICRC) was a significant step in this direction. The ICRC is responsible for developing guidelines, policies, and procurement processes for PPP projects, ensuring transparency and accountability. Additionally, the government has enacted various laws and regulations to create an enabling environment for PPPs, including the National Policy on Public-Private Partnerships (Borole, 2022, Anago, 2024). However, the procurement process often involves multiple criteria, including financial stability, technical expertise, and past performance. Ensuring transparency in the selection process is crucial but can be difficult to achieve. Lack of transparency can lead to perceptions of bias or corruption, weak or unclear legal and regulatory frameworks can hinder the selection process. This includes issues related to procurement laws, contract enforcement, and dispute resolution. Thus, this study seeks to evaluate the drivers, barriers and critical success factors of PPP procurement process.

3. Barriers to successful implementation of PPP

Despite the widespread recognition of Public-Private Partnerships (PPPs) and their growing utilization in infrastructure development, the experiences of both the public and private sectors with these partnerships have not always been favourable (Chan et. al, 2024). Numerous PPP projects, particularly in developing countries, have been delayed or terminated. Barriers to PPPs implementation by previous research studies focusing on barriers as it affects selection of successful partner for PPP projects. Lengthy bidding/negotiation process, High bidding costs, Lack of competition, Public opposition, Lack of flexibility, Difficulties in finding financial partners, Trust variation, Consultation delays, Procedural delay, Lack of innovation, Lack of appropriate skills/experience, Wrong expected return, Absence of sound legal framework, Scope of the PPP, Unattractive packaging of PPP offers, Unrealistic allocation of risks in the PPP, Political interference in procurement process, Shortage of professionals to manage procurement process, Poor evaluation, monitoring and due diligence by public sector and Corrupt practices during procurement (Babatunde & Perera 2017, Babatunde, Perera & Adeniyi 2019, Ampratwum, Tam & Osei-Kyei, 2023)

1. Critical success factors for adopting PPP

Critical success factors for adopting PPP have been studied by several researchers, these are meant in achieving the desired outcomes, ensuring that PPP projects are delivered on time, within budget, and to the required quality standards (Chileshe, *et al* 2024). In order to ascertain how they relate to the effectiveness and success of a project during the Project Development and Project procurement phase, the following factors were discovered from previous studies; Stable macroeconomic condition, Favourable legal framework, Sound economic policy, Available financial market or availability of suitable financial market, Multi benefit objectives, Appropriate risk allocation and risk sharing, Commitment and responsibility of public and private sectors, Strong and good private consortium/capable private partner, Good governance, Project technical feasibility, Shared authority between public and private sectors, Political and social support, Well-organised and committed public agency, Competitive procurement process, Transparent procurement process, Government support and guarantee, Project profitability, Clear project brief and client requirements, Dedicated team of professionals to oversee the PPP projects (Babatunde, Perera, Zhou & Udeaja, 2016, Hsueh & Chang, 2017, Muhammad & Johar, 2019, Chileshe, *et al* 2024).

2. Methodology

The study utilized a quantitative research strategy, employing a well-structured questionnaire for extensive data collection within a limited timeframe. This approach aimed to gather numerical data that could be analyzed using statistical methods, providing objective and measurable insights into the research scope. To identify the variables

or drivers for the study, a survey was conducted, involving a comprehensive review of existing literature, reports, and relevant documents. This literature review led to the identification of 20 Barriers in the selection process of private partners for PPP projects and 19 Critical success factors for adopting PPP which were incorporated into the formulation of the questionnaires used as the data collection instrument. This approach allowed for data observation beyond the physical presence of the observer, enabling participants to provide their responses independently. The data collection instrument consisted of two sections. The first section focused on collecting demographic data from the respondents, while the second section specifically investigated the key barriers and Critical success factors for adopting PPP in Nigeria. Abuja was chosen as the research site for this study due to its status as the capital of Nigeria and headquarters to most of the parastatals and agencies involved in PPP. Purposive and snowball sampling techniques were employed to gather data from various public sector authorities, including ministries, departments, and agencies, as well as to concessionaires and financial institutions such as lenders and banks involved in the implementation of PPP infrastructure projects. The purposive sampling approach ensured the selection of stakeholders with specific qualifications and experiences that aligned with the study's objectives, thereby enabling valuable insights. In addition, the snowball sampling technique was utilized, whereby initial participants were requested to refer other construction professionals who met the study's criteria. This method facilitated the expansion of the sample by tapping into the networks and connections of the initial participants. A total of 121 questionnaires were distributed, 93 were returned and deemed appropriate for analysis. The collected data were then analyzed using descriptive statistics, which helped in summarizing and interpreting the responses to provide insights into the stakeholders' perceptions and experiences with PPP projects in Nigeria. For the questionnaire, a five-point Likert scale was adopted, with 5 = high significance, 4 = high significance, 3 = moderate significance, 2 = low significance, and 1 = very low significance. This scale was chosen to enable respondents to express their perceptions and evaluations of the variables under investigation. The collected primary data from the study underwent analysis using various descriptive statistics tools such as mean values (X) and standard deviations (SD). Factor analysis was also employed to reduce data complexity, identify relationships and develop theoretical constructs, making it a vital tool in analyzing large sets of variables. The Eigenvalues and a rotated Component Matrix was also adopted which also allows for the identification of the most significant criteria based on the responses of the participants and it provides a suitable method for prioritizing the indicators assessed using the Likert scale employed in the study.

3. Results and Discussion

From Table 1, Lengthy Bidding/Negotiation Process with a Mean score of 4.35 and SD of 0.825. This barrier is the highest-ranked and is consistent with the findings of Ismail and Harris (2014). Prolonged bidding and negotiation processes increase transaction costs and can delay project implementation, leading to cost overruns and stakeholder frustration. High Bidding Costs of Mean = 4.20 and SD = 0.820. The costs associated with preparing PPP bids are significant, particularly in developing countries, where financial resources are scarce. These findings suggest a need for streamlining procurement processes to reduce costs and make PPPs more attractive to potential investors. Also, Unrealistic Allocation of Risks (Mean = 4.15, SD = 0.919) This barrier reflects issues with how risks are distributed between public and private partners. When risks are poorly allocated—often to the private sector—projects can become unfeasible, leading to disputes or failures (Chimauzom, 2024). These challenges that need to be addressed through policy reforms and improved project management strategies to enhance the feasibility of PPPs. This also corroborates the finding by Dandago *et al*., 2023, emphasizing the need to streamline the procurement and negotiation process to improve efficiency, reduce costs, and avoid unnecessary delays.

Table 1: Barriers in the selection process of private partners for PPP projects

No	Barriers in the selection process of private partners for PPP projects	Mean	SD
1	Lengthy bidding/negotiation process	4.35	.825
2	High bidding costs	4.20	.820
3	Unrealistic allocation of risks in the PPP	4.15	.919
4	Procedural delay	4.13	.922
5	Political interference in procurement process	4.08	.924
6	Scope of the PPP	3.98	.958
7	Poor evaluation, monitoring and due diligence by public sector	3.94	1.150
8	Shortage of professionals to manage procurement process	3.91	.938
9	Lack of innovation	3.87	.976
10	Trust variation	3.84	.752
11	Lack of flexibility	3.83	.904

12	Lack of appropriate skills/experience	3.80	.857
13	Consultation delays	3.77	.946
14	Difficulties in finding financial partners	3.73	1.219
15	Corrupt practices during procurement	3.64	1.120
16	Unattractive packaging of PPP offers	3.64	.952
17	Absence of sound legal framework	3.64	.897
18	Public opposition	3.29	1.138
19	Wrong expected return	3.26	.887
20	Lack of competition	3.14	1.195

6.1 Critical success factors for adopting PPP

Critical success factors are the elements that are necessary to ensure the success of PPP projects. The ranked list in the analysis is identified in Table 2. Stable Macroeconomic Conditions with a Mean score of 4.39 and SD 0.740 ranked first. The stability of the economy is crucial for PPP projects, affecting financing and long-term viability. Project Profitability having Mean of 4.26 and SD 0.965 ranked second. PPPs need to be profitable to attract private sector investment. Dedicated Team of Professionals (Mean 4.23, SD 0.879) which can be deduced that the success in PPP projects is highly dependent on having skilled professionals overseeing the process. Good Governance (Mean 4.21, SD 0.982), Governance structures that ensure transparency, accountability, and regulation are key. This emphasizes the implication that the government must maintain a stable macroeconomic environment—including stable inflation, interest rates, and currency value—to attract and retain private sector participation in PPPs.

Table 2: Critical success factors for adopting PPP

No	Critical success factors for adopting PPP	Mean	SD
1	Stable macroeconomic condition	4.39	.740
2	Project profitability	4.26	.965
3	Dedicated team of professionals to oversee the PPP projects	4.23	.879
4	Good governance	4.21	.982
5	Commitment and responsibility of public and private sectors	4.20	.795
6	Sound economic policy	4.18	.952
7	Clear project brief and client requirements	4.12	.836
8	Appropriate risk allocation and risk sharing	4.09	.809
9	Strong and good private consortium/capable private partner	4.04	.856
10	Multi benefit objectives	4.03	.814
11	Available financial market or availability of suitable financial market	4.02	.947
12	Transparent procurement process	4.02	.782
13	Project technical feasibility	3.97	1.005
14	Political and social support	3.94	.967
15	Well-organised and committed public agency	3.92	.804
16	Government support and guarantee	3.91	.656
17	Competitive procurement process	3.90	.942
18	Favourable legal framework	3.88	.895
19	Shared authority between public and private sectors	3.66	1.089

Table 3 provides information about the eigenvalues derived from a factor analysis of the critical success factors (CSFs), and barriers related to PPP (Public-Private Partnerships). Eigenvalues represent the variance explained by each component or factor in the analysis. The initial eigenvalues column shows the variance each factor contributes before extraction. The extraction sums of squared loadings column show the variance after the factors have been extracted and rotated to maximize interpretability.

The key details are: Component 1 explains 18.36% of the total variance with an eigenvalue of 11.016, meaning it contributes the most variance. Component 2 explains 15.14% of the variance, and together with Component 1, they explain 33.49% of the total variance. This continues until Component 12, which explains 1.84% of the variance,

bringing the cumulative total variance explained to 94.85%. Eigenvalues greater than 1 typically indicate a meaningful factor or component, and the total cumulative variance (94.85%) indicates that the model explains most of the variability in the data.

Furthermore, a rotated Component Matrix was conducted. This table provides the factor loadings for each variable on the extracted components. Factor loadings are correlations between the variables and the factors. Higher absolute values indicate a stronger association between a variable and a component.

Table 3: Eigenvalues

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.016	18.360	18.360	11.016	18.360	18.360
2	9.081	15.135	33.494	9.081	15.135	33.494
3	8.173	13.621	47.115	8.173	13.621	47.115
4	6.367	10.612	57.727	6.367	10.612	57.727
5	4.200	6.999	64.726	4.200	6.999	64.726
6	3.831	6.386	71.112	3.831	6.386	71.112
7	3.669	6.116	77.227	3.669	6.116	77.227
8	2.765	4.609	81.836	2.765	4.609	81.836
9	2.532	4.220	86.057	2.532	4.220	86.057
10	2.238	3.731	89.787	2.238	3.731	89.787
11	1.930	3.217	93.004	1.930	3.217	93.004
12	1.107	1.844	94.848	1.107	1.844	94.848

In Table 4, the factors are organized across components, allowing identification of clusters or groups of variables that are strongly related. Variables such as Good Governance (.839), Strong and Capable Private Consortium (.716), and Commitment and Responsibility of Public and Private Sectors (.624) have high loadings, indicating that governance structures and the capability of the private sector play a critical role in PPP success. These variables suggest that transparent, well-organized governance (high factor loading of .839) and strong private sector partnerships (.716) are central to ensuring that projects are delivered effectively, emphasizing the importance of accountability and commitment.

Political and Social Support (.544) and Consultation Delays (.806) show strong loadings under this component, indicating the influence of political backing and the effect of delays caused by lengthy consultation processes. For instance, Consultation Delays (.806) being highly correlated with this component underscores how bureaucratic inefficiencies can hinder timely project implementation, highlighting the need for smoother processes in PPP setups. Variables like Appropriate Risk Allocation and Risk Sharing (.613) and Available Financial Market (.386) are associated with Component 3, showing the importance of both risk management and access to financial resources in the success of PPP projects. For instance, the factor loading of Risk Allocation (.613) illustrates that well-structured risk distribution between public and private sectors significantly impacts project feasibility and sustainability.

Stable Macroeconomic Condition (.634) has a strong loading, indicating that economic stability is crucial for ensuring successful PPP implementation. A stable economy reassures private investors and affects long-term project viability. Project Profitability also loads moderately (.519) on Component 4, reinforcing the idea that profitability remains an important motivator for private sector involvement.

Transparent Procurement Process (.785) is strongly loaded under this component, highlighting that transparency in procurement is key to reducing corruption and ensuring fair competition in PPP projects. The relatively high loading of Project Technical Feasibility (.628) also shows that the technical soundness of a project is a decisive factor in its successful execution.

Unrealistic Allocation of Risks (.518) and Absence of Sound Legal Framework (.450) reflect barriers linked to poor risk-sharing practices and weak legal structures. The high loading for Unrealistic Allocation of Risks indicates that improper risk management often derails projects, as risks are often inappropriately assigned to the private sector, making projects financially unfeasible.

Table 4: Rotated Component Matrix

		Component											
	Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	Stable macroeconomic condition		.634										
2	Favourable legal framework		.637										
3	Sound economic policy		.580										
4	Available financial market or availability of suitable financial market	.386											
5	Multi benefit objectives										.515		
6	Appropriate risk allocation and risk sharing	.613											
7	Commitment and responsibility of public and private sectors	.624		.425									
8	Strong and good private consortium/capable private partner	.716		.445									
9	Good governance	.839											.154
10	Project technical feasibility	.628										.244	
11	Shared authority between public and private sectors	-.002											.255
12	Political and social support	.674		.544									
13	Well-organised and committed public agency									.495			
14	Competitive procurement process	.433		.254									
15	Transparent procurement process	.785	.125										
16	Government support and guarantee	.354						.521					
17	Project profitability	.276						.519					
18	Clear project brief and client requirements	.126					.530						
19	Dedicated team of professionals to oversee the PPP projects	.298						.388					
20	Lengthy bidding/negotiation process	.266		.684									
21	High bidding costs	-.308							.392				
22	Lack of competition	-.740		.380									
23	Public opposition	.009		.585									
24	Lack of flexibility	-.557	.405										

25	Difficulties in finding financial partners	-.391				.562	
26	Trust variation	-.037	.586				
27	Consultation delays	-.004		.806			
28	Procedural delay	.250				-.618	
29	Lack of innovation	-.500					.641
30	Lack of appropriate skills/experience	-.009	.532				
31	Wrong expected return	.263			.546		
32	Absence of sound legal framework	.387	.450				
33	Scope of the PPP	-.031		.583			
34	Unattractive packaging of PPP offers	-.431			.596		
35	Unrealistic allocation of risks in the PPP	-.229	.518				
36	Political interference in procurement process	.197		.581			
37	Shortage of professionals to manage procurement process	-.173	.748				
38	Poor evaluation, monitoring and due diligence by public sector	-.078	.743				
39	Corrupt practices during procurement	.118	.526				

7. Conclusions, recommendation and area for further study

7.1 Conclusion

The successful implementation of Public-Private Partnership (PPP) infrastructure projects in Nigeria is heavily influenced by various drivers, including stable macroeconomic conditions, good governance, and professional expertise. Despite these positive drivers, the sector faces several barriers, such as lengthy bidding processes and improper risk allocation, which can delay or derail projects. Addressing these challenges through effective policies and transparent practices can greatly improve the efficiency and success of PPP projects, fostering economic growth and infrastructure development in the country.

7.2 Recommendation

To enhance the effectiveness of PPP infrastructure projects, it is recommended that the Nigerian government focus on streamlining the procurement process to reduce delays and costs. There should also be a concerted effort to improve the legal and regulatory frameworks that govern PPPs, ensuring transparency and reducing the risk of corruption. Furthermore, building the capacity of professionals managing these projects is essential for improving oversight and execution, while ensuring that risks are appropriately shared between public and private partners.

7.3 Area for Further Study

Future research could explore the impact of macroeconomic fluctuations on the long-term success of PPP projects in Nigeria. Additionally, there is a need to investigate how governance reforms and transparency measures have affected the outcomes of PPP projects in the country. Finally, examining the role of private sector participation and risk allocation in enhancing project sustainability would provide valuable insights for policy-makers and practitioners in the field.

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Assessment of Yoruba Cultural design elements in the design of a community cultural centre for Ibadan, Oyo State, Nigeria

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Abstract

Cultural heritage and architectural traditions are valuable reflections of a society's identity and culture. In the case of Yoruba culture, it has greatly influenced art and architecture, and also impacted the religious and social aspects of the community. However, the absence of traditional Yoruba housing elements in modern structures poses a threat to the promotion of Yoruba history and cultural heritage, and creates a disconnection between past traditions and the present, leading to a loss of cultural identity. This study aims to assess the level of acceptance of traditional Yoruba architectural elements into the design of a community cultural centre in, Ibadan, Oyo State. The goal was to identify the design elements of Yoruba culture that can be incorporated in community cultural centres in Ibadan, Oyo state. Case studies were conducted in existing community cultural centres in Nigeria. A structured survey questionnaire was administered to 400 respondents, including building industry professionals and market women, and traditional leaders in Oyo state. The data analysis revealed preference for certain cultural elements in Yorubaland, such as courtyard use, ornamentations and the inclusion of wood, mud or adobe bricks particularly favoured amongst the Yoruba traditional building materials. This study emphasized the enduring significance of Yoruba traditional architectural elements and their ability to enrich modern architectural practices. It highlights the importance of promoting cultural heritage in the face of urbanization, ensuring that these architectural treasures continue to inspire future generations. The study recommends design practitioners to incorporate characteristic features of identified Yoruba traditional design elements in their designs, as a means to promote the cultural identity of the Yoruba-speaking people in southwestern Nigeria.

Keywords: Community cultural centres, Culture, Public buildings, Ibadan.

1. Introduction

Architecture is often seen as a tangible reflection of a society's cultural heritage, encapsulating the values, traditions, and identity of its people (Tweed and Sutherland, 2007). Contemporary studies continue to affirm this view, illustrating how architectural design serves as a repository of cultural memory and a medium for expressing societal values. For instance, the promotion of cultural heritage buildings are recognized as key to sustaining cultural identity and place attachment in urban environments. Moreover, architecture's role in reflecting cultural traditions is evident in various global contexts, from the incorporation of ancient design principles in modern buildings to the Promotion of traditional architectural practices (Tweed and Sutherland, 2007; Tan and Tan, 2020). The essentiality of heritage to humankind globally is imperative and cannot be undermined owing to its relevance in varying aspects such as, historical, economical, tourist, aesthetic, educational as well as the research significance (Onyima, 2016). According to Agboola (2021) and Bello and Jolaoso (2017), the failure to integrate and promote the lost elements of Yoruba traditional architecture in contemporary structures can be largely attributed to the decline of Yoruba cultural heritage and the inadequate promotion of resources in Nigeria. Historically, Yoruba culture has been closely linked to art and architecture, both of which play vital roles in the religious, social, and cultural fabric of the society. Consequently, Yoruba traditional architecture embodies the socio-cultural values of the Yoruba people, yet several factors have contributed to its neglect (Sonaiya & Dincyurek, 2009). One significant factor is the susceptibility of natural building materials to the humid and rainy climate of the West African rainforest, which has led to the deterioration and eventual destruction of many traditional Yoruba structures. Moreover, the lack of imposing architectural landmarks among the Yoruba has led researchers to overlook their building practices, focusing more on other architectural traditions (Auwalu, 2019; Umoru-Oke, 2010).

In addition, the influence of Western education and lifestyle has progressively eroded indigenous knowledge, values, and architectural practices within Yoruba society. From a Western perspective, traditional architectural practices are often viewed as incompatible with modernization, further alienating Yoruba architectural heritage from

contemporary designs. This has resulted in disconnect between modern architecture and the cultural, socio-economic, geo-political, and religious expressions of the Yoruba environment (Sonaiya & Dincyurek, 2009).
The exclusion of these lost elements not only diminishes the promotion of Yoruba history and cultural identity but also creates a gap between the architectural past and the present. It is imperative to address this gap in knowledge and practice to ensure the survival and celebration of Yoruba architectural heritage. By exploring and identifying Yoruba traditional design elements that can be adopted into contemporary projects, such as a community cultural centre, architects and designers can create spaces that honour both the aesthetics of tradition and the functionality of modernity. Bridging this gap in knowledge and practice is crucial to promoting and celebrating Yoruba architectural heritage.

2. Literature Review

2.1 General Review

According to Adeosun (2017), the architectural practices of the ancient Yoruba in Southwest Nigeria were a communal endeavour, with the design of their homes reflecting their ideological, economic, and social status within the larger urban landscape. Traditional Yoruba housing incorporated a blend of design features, materials, and cultural practices that embodied the lifestyle, social hierarchy, and environmental adaptations of the Yoruba people (Agboola, 2021). These architectural elements are intricately connected to the cultural identity and historical development of the Yoruba community, underscoring their importance in preserving and promoting Yoruba heritage.

2.2 Significance of courtyards in Yoruba culture

In Yoruba culture, polygamy played a significant role in shaping traditional architectural practices, as families were structured around extended households. This led to the design of large compounds with multiple rooms to accommodate numerous family members (Adeosun, 2017). The design of a community cultural centre that adapts these Yoruba cultural elements can draw inspiration from structures like the Akodi, which symbolises unity and harmony, fostering a peaceful atmosphere devoid of conflict (Umoru-Oke, 2010).
In these traditional compounds, rooms were arranged around a central courtyard, which served as a hub for both social and domestic activities. The covered verandas surrounding the courtyard were spaces where communal tasks and local crafts, such as cooking, were carried out. This arrangement not only promoted interaction among family members but also reinforced cultural heritage by safeguarding family trades and crafts.

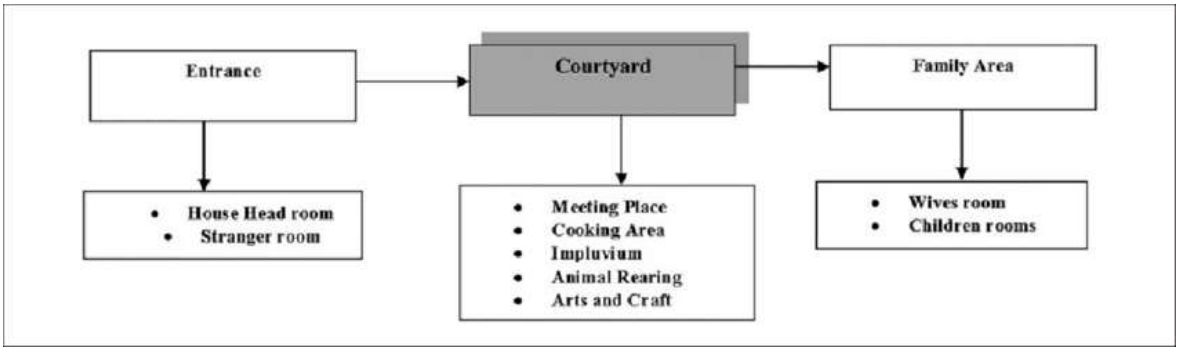

Fig 1: Culture adaptation in Yoruba traditional buildings
Source: Research gate, 2019

2.2.1 Significance of ornamentation in Yoruba culture

In Yoruba traditional architecture, ornamentation is not just an aesthetic addition but a reflection of cultural identity. Intricate designs, particularly those from the pre-colonial era, adorn indigenous structures in cities like Oshogbo and Ife, Osun State, with decorations often concentrated at the heart of these early settlements (Adefila & El-Hussain, 2022; Adegoke, 2016). These artistic expressions, including patterns, carvings, pottery, beadwork, and metalwork, are integral to the architectural character of Yoruba buildings. Ornamentation plays a pivotal role in the architectural design. Though not essential to a building's function, ornaments serve to highlight or soften structural elements, transforming them into distinct features. These decorative elements, which may include graphic representations, symbolic motifs, or purely aesthetic enhancements, have long been part of Yoruba architectural heritage (Adegoke, 2016). Various cultures, including the Yoruba, have developed their own unique ornamentation, drawing inspiration from nature, animals, human forms, and symbols.

Examples such as the ornate designs in Ife and the Palace door from Ekiti exemplify the intricate beauty of Yoruba ornamentation, showcasing the culture's rich creative legacy (Adefila & El-Hussain, 2022; Adeosun, 2017). This integration of artistry into the architecture of the centre would reinforce its role as a space for cultural heritage promotion.

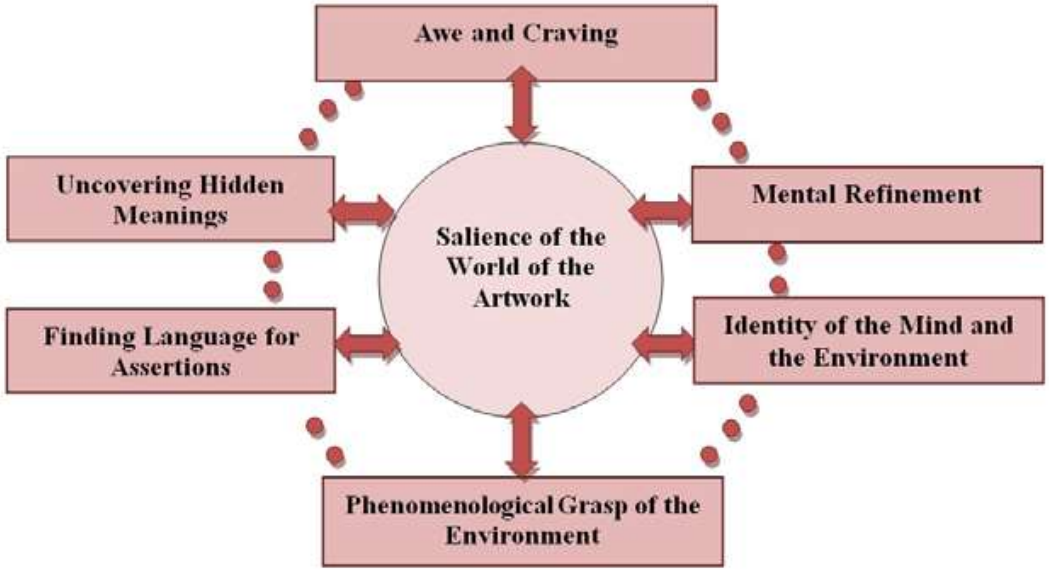

Fig 1.2: Conceptual strategic diagram of meanings of ornaments
Source: Researchgate, 2022.

2.2.2 Social Hierarchy and Family Structure

The family compound is a fundamental aspect of Yoruba culture, deeply intertwined with the social hierarchy and family structure. Typically organised around a central courtyard, the compound serves as a communal space for gatherings and shared activities among family members, with surrounding rooms designated for various purposes such as sleeping, cooking, and storage (Adenaike *et al*., 2020). The layout of these traditional Yoruba homes also reflects the social hierarchy, where the head of the family occupies the largest, centrally located room, symbolising his authority. This room is not only a private space but also a venue for important family meetings and decision-making (Okeyinka & Odetoye, 2015).

Additionally, the form of the house was influenced by the family structure. Nuclear families typically resided in enclosed villa-style homes, while extended families lived in open-plan compounds, signifying the adaptability of architectural design to social structures. The traditional Yoruba house form, influenced by extended family systems, underscores the importance of social and economic relations in the spatial configuration of homes. This emphasis on hierarchy and unity could be reflected in the design of a cultural centre, with larger, more ornate spaces for high-ranking individuals or families and communal areas that promote unity and shared cultural values.

2.2.3 Spatial Organization and house form

According to Akande (2020), traditional Yoruba houses follow the Agbo Ile (family compound) design, which reflects a well-organized pattern centred on family life. These compounds are often composed of multiple units arranged in cyclical, square, or rectangular shapes, forming a courtyard at the centre. This layout is not only common in residential architecture but is also applied in the design of palaces and shrines, reinforcing the social order of the society. Yoruba buildings are characterized by spatial divisions that serve distinct functions, with areas for private living, sleeping quarters, and communal activities thoughtfully arranged to meet family needs while adhering to cultural norms.

Ancestry plays a key role in shaping both the organisation of living spaces and the architectural design, reinforcing the collective identity and traditional social structure of the Yoruba people. Two primary architectural forms are prevalent in traditional Yoruba dwellings: the rectangular form, which represents societal conduct (Iwa), and the conical form, symbolising individual destiny or essence (Ori) (Agboola, 2021). This deep connection between genealogy and architectural style highlights the intrinsic relationship between Yoruba culture and the built environment.

In the context of designing a community cultural centre that adapts Yoruba cultural elements, these traditional forms offer valuable insights. The courtyard arrangement, with its focus on communal life, could serve as the heart of the centre, while spatial divisions could reflect cultural norms and social hierarchies. Incorporating the symbolic architectural forms of Iwa and Ori into the design would further emphasise the cultural significance of ancestry and social conduct, creating a space that embodies both individual and collective identity within the Yoruba community.

2.2.4 Spatial Organization and house form

According to Adedokun (2014), traditional Yoruba houses are defined by their thick mud walls, constructed using cob materials with thicknesses ranging from 6 to 12 inches. These robust walls serve as excellent thermal and acoustic insulators, providing comfort in the hot climate. In the northern parts of Yoruba territory, walls were built even higher, reaching heights of 3 to 6 meters, and were constructed in layers with thicknesses of 30 to 60 centimetres (Dmochowski, 1990). A widely used indigenous construction method during the early periods was the Wattle and Daub technique.

One prominent feature in Yoruba house and palace compounds is the high-pitched, gabled entrance porch at the main entryway. The steeply inclined pyramidal roof, with an angle between 40 to 60 degrees, is designed to efficiently channel heavy tropical rainwater into containers in the courtyard. Other roof styles, such as hip roofs and lean-to roofs, were also common in Yoruba architecture. Traditional homes often featured smaller windows (Adelaja, 2020), but modern adaptations have introduced larger windows to improve ventilation and comfort.

In designing a community cultural centre that incorporates Yoruba cultural elements, these architectural features provide valuable inspiration. The thick mud walls and steeply pitched roofs could be adapted to create an energy-efficient, climate-responsive structure that respects traditional building techniques. The use of courtyards and rainwater collection systems could also be incorporated to promote sustainable practices. Additionally, blending traditional window sizes with modern design elements can help create a harmonious balance between cultural heritage and contemporary comfort.

2.2.5 Spatial Organization and house form

According to Adelaja (2020) and Akande (2020), early Yoruba housing utilised a range of natural building materials that were both functional and closely tied to the region's environment and culture. Mud or earth bricks were a staple of traditional Yoruba architecture, made by mixing mud with water, shaping the mixture into bricks, and allowing them to dry in the sun before use. Sometimes, these bricks were attached to wooden frameworks in layers. The construction process often involved young boys and girls transporting the formed mud to the site, where skilled masons compacted and smoothed it onto the frame structures that defined the walls (Adelaja, 2020). Bamboo, another commonly used material, was highly versatile, employed in both roofing and the construction of walls and partitions. Wood also played a significant role in traditional construction. It was used for structural components like posts, beams, and rafters, as well as for decorative elements such as carved embellishments, which demonstrated the artistic craftsmanship of the Yoruba people. Roofing materials like thatch, made from dried grass or plant fibres, were widely used to create roofs that were both functional and aesthetically pleasing, offering protection from the elements while enhancing the beauty of Yoruba houses (Adelaja, 2020). Palm fronds were another key material in roofing, often used to create durable and attractive thatched roofs that contributed to the architectural elegance of traditional Yoruba homes (Adelaja, 2020).

These traditional building materials can serve as inspiration for sustainable and locally-sourced construction methods. Using mud or earth bricks and natural roofing materials like palm fronds or thatch would reinforce the connection to Yoruba heritage, while bamboo and wood could be used for both structural and decorative purposes, reflecting the craftsmanship that is deeply embedded in Yoruba architectural traditions

3. Methodology

The research employed a quantitative design approach for this study. Descriptive survey using quantitative methods was used to explore the level of preference for Yoruba architectural elements in the design of a community cultural centre that promotes cultural heritage. 200 structured questionnaires were distributed to participants, including cultural centre managers, architects, designers, visitors, and local residents knowledgeable about traditional Yoruba architecture. The data collected were analysed using SPSS software, and descriptive statistical tools such as tables and charts were utilized to present the results. Of the 200 questionnaires distributed, 131 were successfully collected, reflecting a 70.5% response rate. The reliability of the data was assessed using the Cronbach Alpha coefficient, which yielded a strong result of 0.874, indicating robust internal consistency and dependability of the findings for the study's objectives.

4. Data Preparation and Reliability

Table 1: Summary of data preparation and reliability

Sent	Received	Response rate	Cronbach's Alpha
200	131	70.5%	0.874

5. Results and discussion

Table 2: Agreement on possibility of adaptation of Yoruba cultural design elements.

Statement	Frequency	Percent	Cumulative Percent
Yes	128	97.7	97.7
No	3	2.3	100
Total	131	100	

Table 2 shows the findings as regards the level of agreement of the respondents on whether Yoruba architectural elements can be integrated in a contemporary art gallery or public building. 97.7% of the respondents stated yes, and 2.3% stated otherwise.

Table 3: The results of the mean item score (MIS) employed to rate the preference of the respondents on Yoruba architectural elements to be integrated into a community cultural centre are summarised in Table 3.

S/No	Statements	VL(1)	L(2)	M(3)	H(4)	VH(5)	Mean	Rank	Decision
P1	Traditional	4(3.1)	12(9.2)	34(26.0)	41(31.3)	40(30.5)	3.77	1st	High
	Materials	2(1.5)	11(8.4)	44(33.6)	44(33.6)	30(22.9)	3.68	2nd	High
P2	Ornaments (Murals)								
P3	Relief sculpture	3(2.3)	15(11.5)	44(33.6)	39(29.8)	30(14.0)	3.58	3rd	High
P4	Sculpted columns	4(3.1)	14(10.7)	42(32.1)	46(35.1)	25(19.1)	3.56	4th	High
P5	Symbolic motifs	3(2.3)	17(13.0)	42(32.1)	4(33.6)	25(19.1)	3.54	5th	High
P6	Building configuration with courtyard	5(3.8)	10(7.6)	53(40.5)	45(34.4)	18(13.7)	3.46	6th	Moderate

Table 3 shows the preference of the respondents for the inclusion of the following traditional building materials in community centres: Inclusion of wood had high preferences, with a mean score of 3.77 ranked first. This was followed by inclusion for Mud or Adobe Bricks with a mean score of 3.70 (ranked 2nd). Stone was ranked 3rd (3.58), while Thatch had the lowest inclusion with a mean score of 3.29 and was ranked 5th. On average, the inclusion of traditional building materials in art galleries had a high preference, with a mean score of 3.56.

Table 4: Preference for inclusion of the following building materials to cultural centres.

S/No	Statements	VL(1)	L(2)	M(3)	H(4)	VH(5)	Mean	Rank	Decision
P1	Wood	4(3.1)	12(9.2)	34(26.0)	41(31.3)	40(30.5)	3.77	1st	High
P2	Mud or Adobe bricks	2(1.5)	11(8.4)	44(33.6)	44(33.6)	30(22.9)	3.70	2nd	High
P3	Stone	3(2.3)	15(11.5)	44(33.6)	39(29.8)	30(14.0)	3.58	3rd	High
P4	Bamboo	4(3.1)	14(10.7)	42(32.1)	46(35.1)	25(19.1)	3.46	4th	Moderate
P5	Thatch	3(2.3)	17(13.0)	42(32.1)	4(33.6)	25(19.1)	3.29	5th	Moderate
							Average	3.56	High

Table 4 shows the preference for the traditional building materials to be integrated in a community cultural centre. High preference was indicated for wood as the most preferred building material to be integrated, mud or adobe bricks, stone, bamboo and thatch were selected respectively.

6. Conclusion and Recommendation

The diminishing utilization of cultural Yoruba housing elements in modern buildings compounds the inability to promote and preserve Yoruba historical and cultural heritage, and it also mitigates cultural identity and severs the connection between old traditions and modernity. The objective of this study was to identify cultural Yoruba design elements that can be adapted into the design of community cultural centres in Ibadan, Oyo state. The design elements of Yoruba culture identified are arranged according to their level of preference, Traditional building materials, Ornamentation of facades, use of relief sculpture for columns, window hoods, and sculpted columns as in the Mokola cultural centre, Ibadan, symbolic motifs, and building configuration around a common courtyard. Also, high preference for traditional materials including, wood, Mud or adobe bricks, Stone, Bamboo, and Thatch in respective order were identified. It is hence recommended that these identified elements should be adopted in community cultural centres, although the durability of these materials could be further assessed to ensure longevity and disallow deterioration due to weathering agents.

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Influence of Social Responsibility on Construction Project Management Performance

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Abstract

The performance of social responsibility continues to be unsatisfactory in many industries, and the construction industry is no exception. This study investigated the influence of social responsibility in construction project management with a view to proposing strategies for enhancing project performance. Data was collected from 150 out of 177 professional construction companies listed in the Abuja business directory using structured questionnaire. The analysis of the data was carried out with the use of percentage, mean item score, and multiple regression. The finding revaled that corruption tendencies borne from a lack of transparency between companies and the government (MIS = 4.40) and failure to engage key stakeholders (MIS =4.30) are the most significant factors inhibiting the implementation of social responsibility in construction project management. The study indicated that developing a social responsibility policy (MIS = 4.80) and promoting fair employment practices (MIS =4.50) are the most effective strategies to improve social responsibility in construction project management. The study concluded that social responsibility positively influences construction project management and enhances project performance. It was recommended that construction professionals should involve stakeholders, including local communities, workers, suppliers, and regulatory authorities, in project decision-making processes. This ensures that diverse perspectives are considered and concerns are addressed throughout the project lifecycle

Keywords: Construction; Influence; Project Management; Social Responsibility; Performance

1. Introduction

Social responsibility (SR) is a fast-growing phenomenon that influences organisations to account for any Social responsibility (SR) is a concept that is based on the notion that, in the conduct of business, there is an implied agreement between businesses and society (Ajibike *et al.,* 2021). Such agreement represents the expectation of society from businesses to operate in a particular manner that protects the long-term interests of society instead of chasing after immediate profits (Kurniawati and Mujiyati, 2023). As a result, the concept of SR is widely embraced across different sectors whose business activities generate substantial societal interests. Some of these sectors are financial services, trade and retail, and the extractive sectors. Equally, the construction sector is part of this group because its activities impact society negatively.

Abbass (2020) and Zhang *et al.* (2022) have found that companies in the construction sector are becoming more mindful of the societal consequences of their operations. This is driven by environmental concerns as well as the need to safeguard their reputation and align with social expectations. Daily practices are associated more with the environmental dimension than with the social dimension. Specifically, the construction industry undertake actions in the fields of energy efficiency and management of construction and demolition waste from the projects they execute (Ogunmakinde *et al.,* 2022). Some companies publish their mission and vision statements but do not comply with a formal SR commitment (Lim and Loosemore, 2017). Professionals in the construction sector are beginning to think that it is necessary to make commitments regarding social rights and environmental impacts (Domínguez-Herrera, 2017). According to Ye *et al.* (2019), a method to encourage the shift towards a sustainable and responsible (SR) approach is to develop SR indices. These indices would evaluate the effectiveness of each constructive solution by measuring its sustainability. Studies highlight that social factor like safety, health, and education, along with economic factors such as productivity and market access, impact project outcomes (Khahro *et al*., 2023). Additionally, social responsibility (SR) practices like safety management systems and material waste reduction positively affect business benefits in construction firms (Zhang *et al.,* 2023). Furthermore, the implementation of social responsibility measures is crucial for enhancing construction enterprise social responsibility behavior, leading to improved project performance (Ajibike *et al.,* 2021).

Construction project performance is a key measure of success in the construction industry. Various criteria, including time, cost, quality, safety, and customer satisfaction, evaluate this multidimensional concept (Unegbu *et al.,* 2023). According to Okereke *et. al*. (2022), construction project performance refers to the ability of a project to meet its objectives and deliverables while satisfying the needs and expectations of its stakeholders.

Project management requires the application of knowledge, skills, techniques, tools, and procedures to project activities and the planning, organising, coordinating, leading, and controlling of project resources to achieve objectives and meet requirements, generally in terms of scope, cost, and time (Uribe Macas, 2020).

SR mainly aims for excellence performance in organisation with particular attention paid to diverse stakeholders, including employees and their working conditions, customers and suppliers, and also the quality of production processes or service provision, using the framework of three dimensions of sustainable development: economic, social, and environmental (Briones Peñalver *et al.,* 2018). SR is considered an important element of strategy or even a basis for strategic business performance improvement (Javed *et al.,* 2020).

The link between social responsibility and project management is significant and multifaceted. Social responsibility refers to the ethical and moral obligations of organizations to contribute positively to society, the environment, and stakeholders beyond their financial interests (Trocki *et al.,* 2020). Project management, on the other hand, involves planning, organizing, and executing projects to achieve specific objectives within defined constraints(Uribe Macas, 2020).

Overall, integrating social responsibility principles into project management practices promotes ethical behavior, enhances stakeholder relationships, fosters sustainability, and contributes to positive social outcomes. By recognizing the link between social responsibility and project management, organizations can deliver projects that create long-term value for society while achieving project objectives efficiently and responsibly (Javed *et al.,* 2020). Thus, the aim of this study is to examine the influence of social responsibility on construction project management performance.

2. Literature Review

2.1 Concept of Social Responsibility (SR)

Social responsibility (SR) describes how a company manages its industry and takes responsibility for its social impact. Social responsibility encompasses various characteristics like economic dependence, legal conformity, ethical requirements, and societal influences (Wong and Kim, 2020). SR has been suggested to benefit reciprocally advantageous long-term and reliable relations with its participants (Fatma *et al.,* 2016). Social responsibility additionally operates as a marketing instrument since it provides a constructive corporate image (Wong and Kim, 2020). Numerous investigations have recognised the growing association between corporate image and social responsibility initiatives. Social responsibility is a crucial component in enhancing corporate image. According to a study performed in Korea, corporate achievements of financial and legal social responsibility policies had an immediate and significant impact on the corporate image (Park *et al.,* 2014). Moreover, a significant association between social responsibility and corporate image was exhibited to impact market share (Famiyeh *et al.,* 2016; Khuong *et al.,* 2021). Social responsibility has a significant influence on business interactions with customers, and disreputable marketing conduct negatively affects the attitudes of customers, social conduct, and satisfaction. The business and its customers can be deemed corporate allies, and their relationships are significantly influenced by their belief in mutual trust (Singh *et al.,* 2012; Iglesias *et al.,* 2018). Furthermore, service industries have to handle several additional interactions with their customers in comparison to fast-moving consumer goods (FMCG) industries (Iglesias *et al.,* 2018). Therefore, in a service commerce's competitive framework, businesses can not merely introduce trust via truthful and honest communication initiatives, but they also need to produce trust at each particular interaction phase, which forms a positive customer experience in the minds of customers, specifically when customers communicate with the frontline staff (Markovic *et al.,* 2015). Hence, service industries have to build and represent their dedication to social responsibility policies and programmes thoroughly at all the various interaction points that create the customer experience (Sierra *et al.,* 2017). In addition, the innovative digitalized and linked atmosphere additionally presents customers with the likelihood of networking considerably more immediately with businesses (Ramaswamy and Ozcan, 2016). Moreover, corporate social responsibility's relationship with customers and the company's characteristics (Ramaswamy and Ozcan, 2016) cause mediation in the relationship between social responsibility programmes and the company's assessments (Ghaderi *et al.,* 2017).

3. Methodology

This study adopted survey design approach and quantitative method was used. for the purpose of the study the unit of analysis are construction professional. FCT listed in the Nigeria Directory Online website (www.directory.org.ng). The total number of construction firm in this list is 25 while the number of professionals is 669. Therefore, the population size for the is 669. Samples were selected from the list in order to determine the study's sample size and

information on construction companies that are registered with the Abuja Business Directory. As a result, the population size that was utilised is 669. The research population was also be made up of professionals in charge of project supervision and assessment. Therefore, the sample size for the study was 177 respondents. Research data can either be primary or secondary in nature. Primary data are raw data that was obtained through the use of a questionnaire. It was extracted directly from the various sources, such as the respondent and the area(s) under study. Secondary data are the processed information kept on record for different purposes. The analysis of the data was carried out with the use of percentage and mean item score,

4. Results and Discussions

4.1 Background to the study

This section presents and discusses the results of the demographic analysis of the respondents in the field survey carried out during this study. A total of four (4) demographic variables were examined.

Table 4.1: Demographic Information of the Respondents

Demographic information	**Frequency**	**Percent**
Designation on site		
Safety Officer	20	13.3
Site Engineer	60	40.0
Construction Manager	30	20.0
Project Manager	40	26.7
Total	150	100%
What is your profession?	Frequency	Percent
Architect	25	16.7
Builder	15	10.0
Engineer	40	26.7
Quantity Surveyor	70	46.6
Total	150	100%
Highest academic qualification	Frequency	Percent
HND	15	10.0
B.Tech/B.Sc	80	53.3
M.sc/M.Tech	50	33.3
PhD	5	3.4
Total	150	100%
Years of experience	Frequency	Percent
0 – 5	10	6.7
5 – 10	40	26.6
10 – 15	60	40.0
15- 20	30	20.0
above 20 years	10	6.7
Total	150	100%
Does your company practices social responsibility	Frequency	Percent
Yes	130	86.6
No	15	10.0
Not sure	5	3.4
Total	150	100%
Does social responsibility influence construction project costs	Frequency	Percent
Yes	120	80.0
No	20	13.3
Not sure	10	6.7
Total	150	100%

Does social responsibility influence construction project quality	Frequency	Percent
Yes	110	73.3
No	15	10.0
Not sure	25	16.7
Total	150	100%
Does social responsibility influence construction project time	Frequency	Percent
Yes	140	93.3
No	10	6.7
Total	150	100%

Source: Authors field survey (2024).

Table 4.1 presents the designations of the respondents on site. The findings revealed that 40.0% of the respondents were principal site engineers, 26.7% were project managers, and 20.0% and 13.3% were safety officers and site engineers, respectively. As regards the profession of the respondents, 46.6% were quantity surveyors, 26.7% were engineers, 16.7% were architects, and the remaining 10.0% were builders. The findings on highest academic qualification revealed that 53.3% were B.Tech/B.Sc degree holders, 33.3% were M.Sc/M.Tech degree holders, 10.0% were HND degree holders, and the remaining 3.4% were PhD holders. Therefore, the respondents are adequately knowledgeable aboutthe impact of social responsibility on construction project management performance in their various firms.

In addition, Table 4.1 shows the results of the years of experience of respondents in the construction industry. The results revealed that 6.7% of the respondents had 0–5 years of experience, 26.6% of respondents had 5–10 years of experience, 40% of the respondents had 10–15 years of experience, 20% of the respondents had 15–20 years of experience, and 6.7% had more than 20 years of experience in the construction industry. In summary, about 93.0% of the respondents had 5 years or more of experience in the construction industry. This shows the majority of the respondents have a vast level of experience in their field.

Additionally, Table 4.1 presents the findings on respondents' awareness of the practices of social responsibility in their firm. The findings show that 86.6% of the respondents indicated that their firm practices social responsibility; 13.3% of the respondents stated otherwise; and 6.7% were not sure. Furthermore, the findings show that all the respondents (80.0%) opined that social responsibility influences construction project quality; 73.3% opined that social responsibility influences construction project costs; and 93.3% opined that social responsibility influences construction project time.

4.2 Influence of social responsibility in construction project management.

The MIS analysis results on the influence of social responsibility in construction project management are summarised in Table 2. The findings revealed that the most important influence of social responsibility in construction project management is Social responsibility contributes to the reputation and credibility of construction projects and companies (MIS = 4.60); social responsibility practices help identify and mitigate risks related to community relations, environmental impacts, health and safety, and ethical compliance (MIS = 4.55); and social responsibility requires construction project managers to uphold ethical business practices and values throughout project execution (MIS = 4.52). While social responsibility entails understanding and mitigating the impact of construction projects through community outreach, consultation, and engagement (MIS = 3.80), and social responsibility encompasses environmental sustainability in construction project management (MIS = 3.60), the least important influence of social responsibility in construction project management. Averagely all the identified influences of social responsibility in construction project management were important (MIS = 4.22). The results of this study corroborate the findings of Zhang *et al*. (2024). Construction project management is greatly influenced by social responsibility. Research has shown that incorporating social responsibility (SR) principles in construction companies may result in a range of positive consequences. The results include enhanced project success, heightened efficiency and quality of projects, and better overall SR performance. The primary components of social responsibility practices in construction enterprises include the protection of shareholders' interests, the commitment of the government, the preservation of the environment, and the behaviour of project citizenship.

Table 2: Influence of social responsibility in construction project management.

SN	Influence of social responsibility in construction project management.	MIS	Rank	Decision
1	Social responsibility contributes to the reputation and credibility of construction projects and companies.	4.60	1st	Very important
2	Social responsibility practices help identify and mitigate risks related to community relations, environmental impacts, health and safety, and ethical compliance.	4.55	2nd	Very Important
3	Social responsibility requires construction project managers to uphold ethical business practices and values throughout project execution.	4.52	3rd	Very Important
4	Social responsibility entails compliance with relevant laws, regulations, codes, and standards governing construction activities.	4.46	4th	Important
5	Socially responsible construction projects generate positive social and economic benefits for local communities, including job creation, skills development, infrastructure improvements, and economic opportunities.	4.40	5th	Important
6	Social responsibility initiatives promote a positive work environment and corporate culture, leading to higher levels of employee engagement, satisfaction, and retention.	4.35	6th	Important
7	Social responsibility contributes to the corporate reputation and brand image of construction companies.	4.20	6th	Important
8	Social responsibility prioritizes the health and safety of workers, contractors, and the public involved in construction projects..	4.00	8th	Important
9	Social responsibility requires construction project managers to engage with and consider the interests of various stakeholders.	3.90	9th	Important
10	Social responsibility entails understanding and mitigating the impact construction projects through community outreach, consultation, and engagement.	3.80	10th	Important
11	Social responsibility encompasses environmental sustainability in construction project management	3.60	11th	Important
	Average MIS	***4.22***		**Important**

5. Conclusion and Recommendations

This study investigated the influence of social responsibility in construction project management with a view to proposing strategies for enhancing project performance. The results imply that construction project time has a significant influence on social responsibility. The results imply that construction project quality has a significant influence on social responsibility. The findings revealed that corruption tendencies borne from a lack of transparency between companies and the government and failure to engage key stakeholders were ranked as the 1st and 2nd most significant factors inhibiting the implementation of social responsibility in construction project management. The study revealed that developing a social responsibility policy and promoting fair employment practices were ranked as the 1st and 2nd most effective strategies to improve social responsibility in construction project management. Averagely, strategies to improve social responsibility in construction project management were effective. It can therefore be concluded that social responsibility positivity influences construction project management and enhances project performance. As a result of the conclusions made in this study, the following were recommended:

i. Construction professionals should involve stakeholders, including local communities, workers, suppliers, and regulatory authorities, in project decision-making processes. This ensures that diverse perspectives are considered and concerns are addressed throughout the project lifecycle.

ii. Construction firms should prioritise worker health and safety by implementing robust safety protocols, providing adequate training, and ensuring proper supervision. Create a culture of safety awareness and empower workers to report hazards and near-misses.

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Influence of Fluctuation in the Cost of Building Materials on Residential Property Development in Minna, Niger State

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Abstract

This study investigates the Influence of fluctuations in the cost of building materials on residential property development in Minna. Data were collected from 242 individuals belonging to building material sellers association and civil servants from: Niger State Housing Cooperation, Niger State Ministry for Works and Infrastructural Development, Niger State Urban and Rural Development and Contractors with professionalism in property development and construction. The study comprehensively analyses historical data on annual average prices of various building materials and the construction costs of different types of residential properties which include one-bedroom flats, two-bedroom flats, and three-bedroom flats for eight-year period from 2015 to 2022 in Minna. The study revealed a critical upward trends in rising costs of building materials and a general increase in the construction costs of the different types of residential properties over the study period, which can pose substantial challenges to residential property development in the study area. Based on the statistical analysis conducted using Pearson chi-square test, the study shows that there is a significant relationship between the building material cost and construction cost of residential property development. In light of these findings, it is imperative that industry stakeholders, including builders, developers, government bodies, and professionals, collaborate to devise and implement effective measures to mitigate the impact of rising building material costs on residential property development. These measures should include diversifying material choices, exploring cost-effective alternatives, implementing risk management strategies, promoting sustainable practices, and advocating for government support and policies to stabilize material prices. Furthermore, continued market research, education, and training are essential to ensure the long-term sustainability and growth of the construction industry in Minna, Niger State.

Keywords: Fluctuations, cost, building materials, residential property, development

1. Introduction

The residential property development is a critical component of the global economy, contributing significantly to both urbanization and housing supply. However, this sector is highly susceptible to the volatility of building material costs, which can disrupt development timelines, affect property feasibility, and alter housing affordability (Babatunde *et al*., 2021). Key materials such as cement, steel, and timber have experienced significant price fluctuations due to global supply chain disruptions, changes in energy costs and inflationary pressures (Li *et al*., 2023). The relationship between material costs and property development is direct: as material prices rise, developers face increased financial burdens, leading to either scaled-back projects, delayed completions, or higher selling prices for residential units (Ofori and Toor, 2022). Conversely, unexpected drops in materials prices may encourage rapid project completions but also introduce uncertainties in long-term cost forecasting (Eithag *et al*., 2022). These price variations often result from external economic shocks, currency exchange fluctuations and geopolitical factors, all of which can destabilize construction markets (Abioye and Oni, 2023). The fluctuation in the cost of building materials presents a significant challenge to the construction industry, thereby affecting various aspects of property development. Supporting this perspective, Jagboro and Owoeye (2014) highlighted that increases in building material prices have ripple effects across the industry. Based on the aforementioned, this paper aims to explore the extent to which building material cost fluctuations impact residential property development in Minna Nigeria. Building materials are essential components used in the construction of buildings. They encompass a variety of materials such as sand, gravel, wood, nails, clay, ladders, plywood, doors, reinforcement materials, cement, bricks, and various types of sand. Building and construction activities form the foundation upon which the infrastructural development of any nation is built (Ganiyu, 2016). Baker, Smith, and Evans, (2022) highlighted that it is undeniable that building materials play a pivotal role in property development. Property development, construed as a comprehensive business process, encompasses a multitude of activities. These activities range from the refurbishment and subsequent leasing of existing structures to the acquisition of undeveloped land and the subsequent sale of developed plots or parcels to other parties. By examining historical data and industry trend, this study seeks to offer insights into how stakeholders can mitigate risks associated with these fluctuations and

exploring potential strategies for maintaining stability in the residential property sector. Based on the aforementioned, this paper investigates the Influence of fluctuations in the cost of building materials on residential property development in Minna, Niger State.

2. Literature Review

Ogun, Ogunsina, and Ugochukwu (2022) examine the causes and effects of fluctuating construction material prices on project delivery in Abuja Metropolis. Semi-structured questionnaires were distributed to 331 construction professionals within Abuja. Utilizing Mean Index Score (MIS), the study ranked the severity of identified causes and effects of fluctuating construction material prices on project delivery. The study identified building material price inflation, crude oil price instability, and material hoarding by suppliers as the primary factors influencing changes in construction material prices, with mean scores of 4.78, 4.76, and 4.66, respectively. The study recommended giving due consideration to these mitigating measures to enhance project delivery within the Abuja Built Environment (BE) from the contractor's perspective.

Nkeiruka, Okey-Ejiowhor, and Amakiri (2022) investigate the effect of rising building material costs on the construction industry in Port Harcourt. The study employed a survey method, distributing structured questionnaires to 1125 participants. Analyzing data using simple mean and standard deviation, the study revealed that inflation, government policy, dual taxation, and lack of production capacity as key factors driving material prices. The study recommended an enabling environment for private sector participation in building material production to enhance competitiveness.

Alabi and Fapohunda (2021) explore the effects of increased building material costs on the delivery of affordable housing in South Africa. The study employed a sequential mixed methods approach, surveyed construction professionals (project managers, site managers, architects, site engineers, quantity surveyors, contractors, building material suppliers, and government workers) in Cape Town, South Africa. The study revealed that fluctuations in construction costs and rising maintenance costs (attributed to poor workmanship) has significant effects of increased building material costs on affordable housing delivery. Adu and Ekung (2019) investigate the primary causes and potential effects of increased building construction material prices on project delivery in Uyo Metropolis. Data were collected through structured questionnaires from project participants, including project managers, quantity surveyors, procurement managers, and construction materials merchants. Findings revealed inflation, manufacturing costs, exchange rates, lack of locally produced materials, and transportation and distribution costs as major factors driving the increase in building material prices. The study recommended effective implementation of government policies to mitigate inflation's effects on material prices.

Ufuoma and Stanley (2019) examine the effects of building material costs on housing delivery in Akure. Through simple random sampling, data were collected from 125 participants with use of questionnaire in the city's core area. Findings indicated government policy, the country's economic situation, and building material sellers' attitudes as factors contributing to rising building material costs. The study recommended the government formulate policies encouraging research in local building material production to reduce dependence on imports.

Amos, Umbugala, Aminu, Yahaya, and Orjiako (2018) investigate the causative factors, effects, and inflationary trends of building material price fluctuation in Adamawa state, Nigeria. Primary data were collected through structured questionnaires from 210 respondents and mean ratings was used for the analysis. Results revealed general inflation between 2014 and 2016 due to the country's recession, leading to increased building material prices. They recommended reinforcing stability in the naira exchange rate to prevent material price instability.

Akanni, Oke, and Omotilewa, (2014) assessed the implications of rising building material costs in Lagos State, Nigeria. Data were obtained through questionnaire surveys from contractors, builders' merchants, and consultants, as well as from archival sources. Factors such as exchange rate fluctuations, fuel and power costs, and changes in government policies were found to be responsible for rising costs, with implications for the nation's GDP.

Yun, and Wong, (2017) highlighted that The cost of building materials plays a critical role in residential property development as it directly affects the overall budget and project feasibility. High material costs can lead to increased construction expenses, making it challenging for developers to maintain affordable pricing for homes. This, in turn, can reduce demand, especially in markets sensitive to housing prices. When costs rise, developers may scale back on the size or quality of projects to stay within budget, which can impact the desirability and value of the property. Additionally, fluctuating material prices introduce financial uncertainty, potentially delaying projects and causing developers to seek alternative, cost-effective materials or methods. Ultimately, material costs shape the scope, design, and accessibility of housing developments.

3. Methodology

This study utilized quantitative research design. This is a design in which groups of items or objects are studied, by collecting and analyzing data from only a few people considered being an exact representative of the entire group.

The use of descriptive design in this study is to understand what is in a specific situation with an identified population. Also, it was used to gain knowledge in identifying the problem in this study. The study population comprises of individuals belonging to building materials sellers association and civil servant from the Niger State Housing Cooperation, Niger State Ministry for Works and Infrastructural Development, Niger State Urban and Rural Development and Contractor with professionalism in property development and construction. These participants selected are believed to have the necessary and adequate experience in construction, with adequate years of experience and responsibilities in the construction sector. The historical data for the cost of residential property development from 2015 – 2022 were collect from data from Niger state Housing cooperation as well as data from building development contractors in Minna. While the data as regard cost of building materials where retrieved from sellers within the Minna Building material market. A closed ended questionnaire was used to collect data from the study population on the effects of rising cost of building materials on residential property development. Out of the total 242 questionnaires that were administered a total of 147 were well completed and found useful for analyses after accounting for missing information. The well completed questionnaires represent an overall 61% response rate as showed in Table 1.

Table 1: Breakdown of questionnaires administered to respondents in the study area

S/N	Description	Study Population	Questionnaires Administered	Questionnaires Retrieved	Percentage Retrieved
1	Niger State Ministry of Works	43	43	36	14.9**%**
2	Niger State Housing Cooperation	58	58	47	19.4**%**
3	Niger State Urban and Rural Development	37	37	29	12.0**%**
4	Business material Sellers	96	96	27	11.2**%**
5	Contractors at Maikunkele Housing Estate	8	8	8	3.3**%**
	Grand Total	242	242	147	61**%**

Source: Author's Field Survey (2023)

Aside the use of descriptive statistics such as frequency counts, percentages and mean. The extent of the effect of Rising Cost of Building Materials on Residential Property Development was measured using the Relative Importance Index. The Relative Importance Index was employed to determine the importance of each factor or attribute in the context. Below is the Relative Importance Index formula used.

$$\frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{A * N}$$

Where n_5 = Number of Respondents for Strongly Agree

n_4 = Number of Respondents for Agree

n_3 = Number of Respondents for Neutral

n_2 = Number of Respondents for Strongly Disagree

n_1 = Number of Respondents for Disagree

A (Highest Weight) = 5

N (Total Number of Respondents) = 147

Pearson Chi-Square was also employed to tests for the relationship between building material cost and residential property development in the study area.

4. Results

Table 2: Demographic Data of the Respondents

Item	Frequency	Percentage	Mean	Standard Deviation
Educational Background			2.10	1.167
Bachelor's Degree	64	43.5		
Higher National Diploma	34	23.1		
National Diploma	20	13.6		
Master's Degree	29	19.7		
Gender			1.30	0.460
Male	103	70.1		
Female	44	29.9		
Marital Status			1.47	0.715
Married	97	66.0		
Single	31	21.1		
Widowed/ Divorce	19	12.9		
Years of Experience			2.29	1.073
1-4 years	43	29.3		
5-9 years	45	30.6		
10-14 years	33	22.4		
15 years & Above	26	17.7		
Occupation			1.03	0.182
Public Servant	142	96.6		
Private Servant	5	3.4		

Source: *Author's Field Survey, (2023)*

This study had 147 respondents, 64 respondents with (43.5%) have attained Bachelor's Degree, 34 with (23.1%) have attained Higher National Diploma, 20 with (13.6%) have attained National Diploma, 29 with (19.7%) have attained Master's Degree 103 with (70.1%) of the respondents were males, 44 with (29.9%) were females, 97 (66%) were married, 31 (21.1%) were single, 19 (12.9%) were widowed/divorced, 43 (29.3%) were 1-4 years, 45 (30.6%) were 5-9 years, 33 (22.4%) were 10-14 years, 26 (17.7%) were 15 years and above, 142 (96.6%) were public servant and 5 (3.4%) were private servants respectively.

Table 3: Historical Data on Building Material Prices in Minna from 2015-2022

SN	MATERIALS	UNITS	PRICE PER YEAR (₦)								
			2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**ANNUAL AVERAGE**
1	Cement	50kg Bag	1,950	2,200	2,650	2,750	2,950	3,300	3700	3,950	**2,931**
2	Sharp Sand (Fine Aggregate)	5Ton (1 Tipper)	9,000	10,500	12,500	13,000	13,700	14,000	15,500	17,500	**13,213**
3	Smooth Sand (Plaster)	5Ton (1 Tipper)	8,500	10,700	12,800	14,750	15,500	17,000	21,000	22,700	**15,369**
4	Granite Stones	5Ton (1 Tipper)	10,000	11,700	12,500	13,700	15,300	17,500	19,700	24,500	**15,613**
5	225 mm Sandcrete Blocks	1piece	120	135	170	195	230	250	275	300	**209**
6	150 mm Sandcrete Blocks	1piece	90	115	135	155	180	215	240	265	**174**
7	Asbestos Ceiling	1piece (4ftx4ft)	1,050	1,200	1,350	1,550	1,700	1,950	2,400	2,700	**1,738**
8	Emulsion Paint	1bucket	N2,900	3,000	3,200	3,500	3,700	4,000	4,500	5,700	**3,812**
9	Corrugated Iron Sheet	1 Bundle	15,500	17,000	17,500	18,500	19,000	22,500	24,500	26,000	**20,063**
10	Long Span Aluminum	Meter square of (0.45mm)	1,100	1,350	1,650	1,900	2,100	2,400	2,650	2,900	**2,006**
11	Mild Steel Rode	1piece of 12mm	1,350	1,500	1,750	1,900	2,400	2,700	3,800	4,800	**2,525**
12	Mild Steel Rode	1piece of 16mm	2,850	3,300	3,700	3,950	4,400	4,700	5,200	6,350	**4,306**

Source: *Author's Field Survey, (2023)*

The above table shows the annual average of the price of building materials from year 2015-2022 in the study area. From the table, the study revealed that cement have an annual average price of ₦2,931, Sharp Sand (Fine Aggregate) with annual average price of ₦13,213, Smooth Sand (Plaster) with annual average price of ₦15,369, Granite Stones with annual average price of ₦15,613, Sandcrete Blocks (225mm) with annual average price of ₦209, Sandcrete Blocks (150mm) with annual average price of ₦174, Asbestos Ceiling with annual average price of ₦1,738, Emulsion Paint with annual average price of ₦3,812, Corrugated Iron Sheet with annual average price of ₦20,063, Long Span Aluminum with annual average price of ₦2,006, Mild Steel Rode (12mm) with annual average price of ₦2,525, Mild Steel Rode (16mm) with annual average price of ₦4,306 respectively.

Implication of findings is that, cement maintained a relatively stable price over the eight years' period of study, with an annual average price of N2,931. This suggests that cement prices were less susceptible to significant fluctuations during this time frame. More so, it was found that different types of sand had varying price trends. Sharp Sand (Fine Aggregate) was relatively expensive, with an annual average price of N13,213, while Smooth Sand (Plaster) was even more expensive, averaging at N15,369. This indicates that construction projects relying heavily on these sand types may have faced increased material costs.

Additionally, the study found that granite stone had an annual average price of N15,613, which was comparable to smooth sand. This suggests that materials like granite were also relatively costly and could significantly contribute to construction expenses. So also, the study found that sandcrete blocks (225mm) had an annual average price of N209, while sandcrete blocks (150mm) were somewhat cheaper, with an average price of N174. These variations may be indicative of differences in demand or production costs between the two block sizes.

Furthermore, the study found that asbestos ceiling had a relatively low annual average price of N1,738, which might make it an attractive choice for ceiling materials due to its cost-effectiveness. So also, emulsion paint was moderately priced, with an annual average of N3,812, suggesting that painting projects were relatively affordable in Minna during this period.

In addition, the study found that roofing materials like corrugated iron sheets (N20,063) and long-span aluminum (N2,006) had varying costs, but both were relatively expensive. This indicates that roofing could be a significant contributor to the overall construction budget. So also it was found that the annual average prices of steel rods also varied. Mild Steel Rods (12mm) had an annual average price of N2,525, while Mild Steel Rods (16mm) were pricier, with an average of N4,306. This difference could affect the structural costs of construction projects. The aforementioned residential properties are all constructed using modern building materials mention from the above table.

Table 4: Historical Data of Construction Cost for Residential Properties in Minna from 2015-2022

Year	One Bed Room Flat	Two Bed Room Flats	Three Bed Room Flats
2015	550,000	1,850,000	2,750,000
2016	680,000	2,170,000	3,100,000
2017	700,000	2,500,000	3,790,000
2018	950,000	2,840,000	4,200,000
2019	1,010,000	3,070,000	5,700,000
2020	1,110,000	4,400,000	6,130,000
2021	1,330,000	4,870,000	6,600,000
2022	1,580,000	5,050,000	7,000,000

Source: *Author's Field Survey, (2023)*

The table above shows the construction cost of residential properties in the study area, which is as follows; one bedroom flats, two bedroom flats and three bedroom flats. There is a consistent upward trend in construction costs for all three types of residential properties from 2015 to 2022. This indicates a general increase in the cost of construction in Minna over these years. The high-end residential properties consistently have the highest construction costs, followed by mid-range and low-end properties. The gap between the costs of low-end and high-end properties has widened over the years. While there is an overall upward trend, there are variations in the rate of increase from year to year. For example, there is a significant increase in costs from 2020 to 2021, especially for mid-range and high-end properties. Implication of findings is that there is a significant variation in the construction costs of different types of residential properties in Minna, including one-bedroom flats, two-bedroom flats, and three-bedroom flats. This suggests a consistent upward trend in construction costs over the study period eight years, from 2015 to 2022, This indicates that the cost of building these residential properties has been on the rise during the study period.

Table 5: Effect of Rising Cost of Building Materials on **Residential Property Development using Relative Importance Index**

S/N	Effects of Rising cost of Building Material on Residential Property	Strongly Agree (5)	Agree (4)	Neutral (3)	Strongly Disagree (2)	Disagree (1)	Total	Total Number N	A * N	RII	Ranks
1	Its leads to delay in projects or complete termination of building projects.	325	220	0	36	9	590	147	735	0.802721	**7**
2	Brings about long term abandonment of construction projects.	345	232	0	26	7	610	147	735	0.829932	**6**
3	The rising cost of building materials significant impact on the overall feasibility of residential property development.	415	184	0	18	9	626	147	735	0.851701	**4**
4	Increased building material costs have led to a noticeable reduction in profit margins for residential property developers.	245	248	0	48	12	553	147	735	0.752381	**9**
5	Decrease the number of individual bidder as completed project attracts higher price of disposal.	450	176	0	26	0	652	147	735	0.887075	**1**
6	Brings about developers facing challenges in managing budget overruns due to the volatile nature of building material prices.	490	108	0	28	8	634	147	735	0.862585	**3**
7	It leads to decline in the number of professionals employed in constructions projects.	355	156	0	40	17	568	147	735	0.772789	**8**
8	It decreases the volume of construction output.	320	128	0	48	27	523	147	735	0.711565	**10**
9	It causes building collapse were materials are not used to the right ratio.	425	204	0	12	5	646	147	735	0.878912	**2**
10	The quality of residential properties would be compromised as developers look for cheaper building materials.	425	160	0	32	6	623	147	735	0.847619	**5**
11	The increased cost of building materials has led to a shift towards smaller, more efficient residential property designs.	165	128	0	116	24	433	147	735	0.589112	**11**

Source: *Author's Field Survey, (2023)*

From table 4 above, it could be seen that item 1 has a Relative Importance Index value of 0.802721, item 2 with Relative Importance Index value of 0.829932, item 3 with Relative Importance Index value of 0.851701, item 4 with Relative Importance Index value of 0.752381, item 5 with Relative Importance Index value of 0.887075, item 6 with Relative Importance Index value of 0.862585, item 7 with Relative Importance Index value of 0.772789, item 8 with Relative Importance Index value of 0.711565, item 9 with Relative Importance Index value of 0.878912, item 10 with Relative Importance Index value of 0.847619, and item 11 with Relative Importance Index value of 0.589112 respectively. From the above, it could be depicted that the following finding "Decrease the number of individual bidder as completed project attracts higher price of disposal." has the highest importance index and the implication that the number of prospectus to bid for properties decreases or decline more and more.

Table 6: Pearson Chi-Square Tests Relationship Between Building Material Cost and Residential Property Development cost

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	24.540[a]	1	.000		
Continuity Correction[b]	21.771	1	.000		
Likelihood Ratio	20.376	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	20.317	1	.000		
N of Valid Cases	8				

Source: Author's Field Survey, (2023)

a. 1 cells (20.0%) have expected count less than 5. The minimum expected count is 3.36.
b. Computed only for a 2x2 table

As showed in table 4 above, the Pearson chi-square value is 20.317, with a significance or probability (p) value of .000 which is smaller than the alpha level of .05. This means that the probability of this distribution of values occurring by chance is less than .01 – or 1 in 100, so probability (p) = .000. This shows that there is significant relationship between building material cost and construction cost for residential property development in the study area.

This finding of this research confirmed the earlier findings of Ayodele and Alabi (2011) who revealed that building materials price fluctuations have very important effect on the real estate development and project abandonment because when there is a hike in the price of building materials, a lot of projects get abandoned due to insufficient funds, thus affecting construction output and economy growth (GDP). More the findings of Oghenekevwe, Olusola, and Chukwudi, (2014) corroborates that of this research where they stated and indicated that inflationary increases in building material cost are the main cause of construction cost overrun. The finding also indicated that exchange rate of Rand and interest rates are additional factors responsible for increase in the cost of building materials and thus affect building development.

5. Conclusion and Recommendations

The study analyzed fluctuations in the cost of building materials and effects on residential property development in Minna, Niger State, this study sheds light on several significant findings that bear important implications for the construction industry in the region. The study comprehensively analyzed the annual average prices of various building materials over eight-year period from 2015 to 2022 and revealed several critical trends. The rising costs of these building materials can pose substantial challenges to residential property development, emphasizing the need for strategic cost management and alternative material exploration. The research findings also pointed to a consistent upward trend in construction costs over the study period. This long-term trend highlights the need for the construction industry to adapt and innovate in the face of escalating costs, emphasizing the importance of cost-effective material selection and resource management. Furthermore, from the statistical analysis conducted, using the Pearson chi-square test shows a significant relationship between building material cost and construction cost for residential property development in the study area.

In light of these findings, it is imperative that industry stakeholders, including builders, developers, government bodies, and professionals, collaborate to devise and implement effective measures to mitigate the impact of rising building material costs on residential property development. These measures should include diversifying material choices, exploring cost-effective alternatives, implementing risk management strategies, promoting sustainable practices, and advocating for government support and policies to stabilize material prices. Furthermore, continued

market research, education, and training are essential to ensure the long-term sustainability and growth of the construction industry in Minna, Niger State.

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The Impact of Supplementary Cementitious Materials on the Sustainability and Performance of Self-Compacting Concrete: A Literature Review

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Abstract

This paper presents a comprehensive literature review on the impact of supplementary cementitious materials (SCMs) on the sustainability and performance of self-compacting concrete (SCC). SCMs, including fly ash, silica fume, ground granulated blast furnace slag, rice husk ash, and calcium carbide waste, have gained significant attention due to their ability to enhance concrete properties while promoting environmental sustainability. This review highlights how these materials contribute to improved workability, compressive strength, and durability in SCC. Key findings indicate that incorporating SCMs leads to enhanced flowability, increased resistance to chemical attacks, and long-term strength gains, particularly when utilized within optimal replacement levels. Emerging SCMs, such as ultra-fine fly ash and calcium carbide waste, present promising alternatives in regions with limited access to traditional materials). However, the literature reveals critical gaps concerning the long-term performance of these materials, necessitating further research to establish their efficacy in various environmental conditions. Standardized testing protocols and long-term field studies are recommended to validate *labour*atory findings and ensure practical applicability in construction The review concludes that optimizing the use of SCMs in SCC can significantly contribute to sustainable construction practices, ultimately reducing the carbon footprint of concrete production while enhancing performance. Future research should focus on the synergistic effects of hybrid SCM systems and the environmental implications of using these materials to advance the understanding of their role in modern concrete technology.

Keywords: Ground Granulated Blast Furnace Slag, Environmental Impact, Fly Ash, Self-Compacting Concrete (SCC), Silica Fume, Rice Husk Ash, Calcium Carbide Waste (CCW), Sustainability, Supplementary Cementitious Materials (SCMs)

1. Introduction

Self-compacting concrete (SCC) represents a breakthrough in the construction industry due to its ability to flow under its own weight and completely fill formwork without the need for mechanical vibration (Hamzah *et al.,* (2015). This unique property not only improves the ease of placement but also ensures high-quality finishes, reduced *labour*, and shorter construction times. However, the production of SCC, like all cement-based materials, faces significant environmental challenges, most notably the large carbon footprint associated with cement manufacturing. Cement production contributes approximately 8% of global CO_2 emissions, making it imperative to explore alternatives that reduce cement consumption while maintaining or enhancing concrete performance (Schneider *et al*., 2011).

One promising solution is the incorporation of supplementary cementitious materials (SCMs), which are industrial byproducts or naturally occurring pozzolanic materials that can partially replace cement (Onyenokporo, 2022). SCMs such as fly ash, silica fume, ground granulated blast furnace slag (GGBFS), rice husk ash (RHA), and calcined clays have gained attention for their ability to improve the mechanical and durability properties of SCC while reducing its environmental impact. By replacing a portion of cement, SCMs not only lower the carbon footprint of SCC but also contribute to enhanced properties like improved flowability, increased strength, and better resistance to chemical attacks (Justnes, 2016).

While SCMs present numerous benefits, there are challenges to their widespread adoption, particularly in terms of optimizing early strength development and ensuring the consistency of rheological properties. Fly ash, for instance, improves fluidity and long-term strength but is known for delaying early strength gain, which can affect construction schedules. Similarly, silica fume increases strength but raises the water demand of the mix. Emerging SCMs, such as ultra-fine fly ash (UFFA) and calcined clays, have shown promise in overcoming these limitations, but their effects on SCC properties require further investigation (Sideris *et al.,* 2018).

1.1 Statement of the Problem

Despite the proven benefits of SCMs in enhancing the sustainability and performance of SCC, challenges persist in optimizing their use to achieve a balance between sustainability, workability, and mechanical properties. Specifically, the delayed early strength development in fly ash-based SCC and the increased water demand in silica fume-modified SCC pose significant obstacles. Moreover, while emerging SCMs such as UFFA and calcined clays offer potential solutions, there is limited research on their long-term performance and environmental implications. Therefore, a comprehensive review of the impact of various SCMs on the performance and sustainability of SCC is necessary to address these challenges and guide future research.

1.2 Aim of the Study

This study aims to critically evaluate the impact of supplementary cementitious materials on the sustainability and performance of self-compacting concrete. This review will explore the effects of both traditional and emerging SCMs on key properties of SCC, including flowability, strength development, durability, and environmental impact. By synthesizing existing research, the study seeks to identify the most effective SCMs for optimizing SCC performance and propose strategies for overcoming the challenges associated with their use.

1.3 Significance of The Study

This study is significant for several reasons. First, it contributes to the growing body of knowledge on sustainable construction practices by highlighting the role of SCMs in reducing the carbon footprint of SCC. Second, it provides valuable insights for engineers and researchers seeking to optimize the performance of SCC, particularly in terms of workability, strength, and durability. Third, the study addresses the current research gaps by investigating the potential of emerging SCMs like UFFA and calcined clays, offering alternative solutions for regions where traditional SCMs are scarce. Ultimately, this study will help inform best practices in the design and production of sustainable, high-performance SCC for the construction industry.

2. Literature Review

The escalating need for sustainable construction materials has driven the integration of supplementary cementitious materials (SCMs) in self-compacting concrete (SCC). Among the commonly used SCMs are fly ash, silica fume, ground granulated blast furnace slag (GGBFS), rice husk ash (RHA), calcined clays, and more recently, calcium carbide waste (CCW) (Nandanam *et al.,* 2021). These materials play a pivotal role in enhancing the mechanical and durability properties of SCC while also reducing the environmental impact associated with cement production (Gupta *et al.,* (2021). This literature review explores the contributions of various SCMs to the sustainability and performance of SCC, focusing on their effects on rheological properties, strength development, durability, and environmental impact. Furthermore, it identifies existing gaps in research and highlights emerging trends in the field.

2.1 The Role of SCMS In SCC

SCMs are increasingly utilized as partial replacements for cement in SCC to achieve multiple objectives, including lowering cement content, enhancing workability, improving durability, and reducing carbon emissions. The application of SCMs typically involves replacing 10–50% of the cement content, depending on the specific characteristics of the SCM and the desired concrete properties (Pang *et al*., 2022). Each SCM possesses unique chemical and physical characteristics that influence the performance of SCC, impacting its workability, strength, and durability.

A. Fly Ash:

Fly ash, a byproduct of coal combustion, is one of the most commonly used SCMs in SCC. It is classified into two categories: Class F (low-calcium) and Class C (high-calcium). Fly ash exhibits pozzolanic properties, which contribute to the formation of additional calcium silicate hydrates (C-S-H) in concrete, thereby enhancing its long-term strength (Mohamed Lamine Zeggar *et al*., 2019). Studies indicate that fly ash improves fluidity and workability, while also enhancing durability by reducing permeability and increasing resistance to chloride ingress (Lan Pang *et al*., 2022).

However, a significant drawback of using fly ash is its tendency to delay early strength development, which can be a concern for projects requiring rapid strength gain. Higher replacement levels (above 30%) can exacerbate this issue, leading to slower hydration rates and prolonged setting times. To mitigate this, researchers have explored chemical activators, such as calcium hydroxide, to accelerate the pozzolanic reaction and enhance early strength (Guanlei Li *et al*., 2022). Furthermore, combining fly ash with other SCMs, such as silica fume or GGBFS, has been shown to balance workability and early strength development.

B. Silica Fume:

Silica fume, a byproduct of silicon and ferrosilicon production, is characterized by its extremely fine particle size and high pozzolanic activity. When utilized in SCC, silica fume significantly increases compressive strength by promoting the formation of additional C-S-H, thereby improving the overall microstructure of the concrete matrix (Hamzah *et al*., 2015). However, the high surface area of silica fume can lead to increased water demand, negatively impacting workability.

Research has shown that silica fume is particularly effective in enhancing the mechanical properties and durability of SCC in aggressive environments, such as those exposed to chemicals or high chloride concentrations. Its high pozzolanic activity results in a dense microstructure, which reduces permeability and enhances resistance to sulfate and chloride attacks (Muhammad *et al*., 2021). Despite these advantages, the cost of silica fume can limit its widespread use, especially in regions where access to affordable SCMs is constrained.

C. Ground Granulated Blast Furnace Slag (GGBFS):

GGBFS is a byproduct of the iron and steel industry and serves as a widely used SCM in SCC. Like fly ash, GGBFS possesses pozzolanic properties, contributing to long-term strength development by reacting with calcium hydroxide to form additional C-S-H. Research indicates that GGBFS enhances the durability of SCC by decreasing permeability and increasing resistance to chemical attacks (Hamzah *et al*., 2015). Furthermore, GGBFS helps mitigate the risk of alkali-silica reaction (ASR) in concrete, making it a suitable SCM for regions with reactive aggregates.

One of the primary benefits of GGBFS is its ability to improve long-term mechanical properties without significantly compromising early strength development. However, similar to fly ash, GGBFS can slow hydration, leading to extended setting times. Researchers have investigated the use of chemical activators and hybrid SCM systems (e.g., GGBFS combined with silica fume or fly ash) to accelerate hydration and improve early strength (Lan Pang *et al*., 2022).

D. Rice Husk Ash (RHA):

Rice husk ash (RHA), obtained from the combustion of rice husks, is an emerging SCM that offers several sustainability advantages. RHA is rich in silica, making it a highly pozzolanic material that contributes to the development of additional C-S-H in SCC. Studies demonstrate that RHA improves compressive strength, tensile strength, and durability by enhancing microstructure and reducing permeability (Muhammad *et al*., 2021).

RHA is particularly attractive in regions with abundant rice production, providing a sustainable waste management solution while minimizing the environmental impact of cement production. However, the variability in RHA quality (due to different combustion processes) presents challenges in ensuring consistent performance in SCC applications, necessitating further research.

E. Calcined Clays:

Calcined clays, especially those rich in kaolinite, have gained attention as promising SCMs due to their availability and pozzolanic properties. Research indicates that calcined clays enhance the mechanical and durability properties of SCC, particularly in regions where traditional SCMs like fly ash and GGBFS are scarce (Suprakash *et al*., 2021). Calcined clays contribute to the sustainability of SCC by reducing the carbon footprint of concrete production. However, the high calcination temperature required to activate the pozzolanic properties of clays raises concerns about energy consumption and cost, warranting further investigation.

F. Calcium Carbide Waste (CCW):

Calcium carbide waste (CCW) is a lesser-known SCM that has emerged as a potential sustainable alternative in concrete production. It is generated during the production of calcium carbide, a compound used in various industrial processes. CCW contains a high proportion of calcium silicate and other minerals, making it suitable for use as a pozzolanic material.

Recent studies have shown that incorporating CCW into SCC can enhance the mechanical properties of concrete, including compressive strength and durability. The pozzolanic activity of CCW contributes to the formation of C-S-H, similar to traditional SCMs. Additionally, the use of CCW helps reduce the carbon footprint of concrete by recycling industrial waste, thereby addressing environmental concerns related to waste disposal (Muhammad *et al*., 2021).

However, the effects of CCW on the rheological properties and long-term durability of SCC are still not fully understood, necessitating further research to optimize its incorporation into concrete mixtures and evaluate its performance over time.

2.2 Rheological Properties of SCC With SCMS

The rheological properties of SCC, including its flowability, viscosity, and resistance to segregation, are critical factors that influence its application in construction. SCMs significantly affect these properties, with each material influencing the mix design in unique ways (Rasekh, *et al.,* 2020).

A. Fly Ash and Flowability:

Fly ash is recognized for its ability to enhance the flowability of SCC due to its spherical particle shape, which reduces friction among particles and improves fluidity (Pang *et al*., 2022). This reduction in friction facilitates easy flow under its weight, making SCC ideal for applications involving complex formwork or dense reinforcement. Additionally, fly ash reduces the water demand of the mix, further contributing to workability.

However, the effects of fly ash on rheological properties are highly dependent on replacement levels and specific characteristics of the fly ash used. While low replacement levels (10–20%) typically improve flowability, higher replacement levels can lead to segregation and bleeding, compromising the quality of the mix (Lan Pang *et al.,* 2022).

B. Silica Fume and Viscosity:

Silica fume, due to its fine particle size, increases the viscosity of SCC, enhancing cohesion and resistance to segregation. While this improved cohesiveness prevents bleeding and segregation, it also elevates the water demand of the mix, potentially affecting flowability. To counteract this, high-range water-reducing admixtures (HRWRAs) or superplasticizers are frequently used (Hamzah *et al.,* 2015).

The high viscosity of silica fume-modified SCC is particularly beneficial in vertical applications, where segregation and bleeding are more pronounced. However, the increased water demand and cost of silica fume can limit its application in large-scale projects.

C. GGBFS And Workability:

GGBFS, when used in SCC, enhances workability due to its fineness and pozzolanic properties. Like fly ash, GGBFS reduces the water demand of the mix, facilitating the achievement of desired flowability without compromising cohesiveness. Studies show that GGBFS-modified SCC exhibits good flowability, even at high replacement levels (up to 50%), making it a preferred SCM in workability-sensitive applications (Pang *et al.,* 2022).

Nevertheless, GGBFS can also lead to slower setting times and delayed early strength development, which can pose challenges in time-sensitive construction projects. Researchers have explored hybrid SCM systems, combining GGBFS with faster-reacting materials to accelerate hydration and improve early strength (Guanlei Li *et al.,* 2022).

D. CCW And Rheological Behavior:

The rheological behavior of SCC incorporating CCW is an area of growing interest. Preliminary studies suggest that CCW can enhance the flowability and cohesiveness of SCC while reducing the risk of segregation. Its fine particle size contributes to a more stable microstructure, which enhances the overall performance of SCC (Muhammad *et al.,* 2021).

However, further research is needed to fully understand the rheological effects of CCW and optimize its incorporation into SCC mixtures.

E. Strength Development In SCC with SCMS

The compressive strength of SCC is a critical performance metric, and SCMs significantly influence strength development over time (Mohamed, 2018). While some SCMs contribute to enhanced long-term strength, others can delay early strength development, necessitating the use of chemical activators or hybrid SCM systems to optimize performance.

F. Fly Ash And Strength Development:

Fly ash enhances the long-term strength of SCC due to its pozzolanic reaction with calcium hydroxide, which leads to the formation of additional C-S-H. However, high replacement levels can delay early strength development, particularly in construction projects requiring rapid strength gain. To mitigate this issue, researchers have explored the use of chemical activators and hybrid SCM systems that combine fly ash with faster-reacting materials, such as silica fume, to optimize strength development (Guanlei Li *et al.,* 2022).

G. Silica Fume and Compressive Strength:

Silica fume is recognized for its ability to significantly increase the compressive strength of SCC due to its high pozzolanic activity and fine particle size, which promotes the formation of a dense microstructure. Research has

demonstrated that silica fume-modified SCC exhibits higher compressive strength than conventional SCC, particularly at early ages (Hamzah *et al.,* 2015). This makes silica fume an ideal SCM for applications where early strength is critical.

H. GGBFS and Strength Development:
GGBFS enhances the compressive strength of SCC over time, contributing to improved long-term performance. However, similar to fly ash, GGBFS can slow early hydration, necessitating careful consideration of replacement levels and potential hybrid mixtures to achieve the desired strength development (Pang *et al.,* 2022).

I. CCW And Strength Properties:
Emerging research on CCW suggests that it can improve the compressive strength of SCC due to its pozzolanic activity and mineral composition. While the long-term effects of CCW on strength development require further investigation, preliminary studies indicate that CCW can contribute positively to both early and long-term strength when used in optimal proportions (Muhammad *et al.,* 2021).

2.3 Durability of SCC with SCMS

The durability of SCC is critical for ensuring the long-term performance of concrete structures, especially in harsh environments. SCMs contribute to the durability of SCC by improving resistance to chemical attacks, reducing permeability, and mitigating the risk of ASR and other durability-related issues.

A. Fly Ash and Durability:
Fly Ash Enhances The Durability Of SCC By Reducing Its Permeability And Increasing Resistance To Chloride Ingress And sulfate attacks. The pozzolanic reaction of fly ash leads to the formation of a denser microstructure, which reduces capillary pores in the concrete matrix and improves resistance to chemical penetration (Lan Pang *et al.,* 2022). This makes fly ash-modified SCC ideal for applications in aggressive environments, such as marine structures or wastewater treatment plants.

B. Silica Fume and Chemical Resistance:
Silica fume improves the chemical resistance of SCC by reducing permeability and increasing resistance to sulfate and chloride attacks. The fine particle size of silica fume contributes to the formation of a dense microstructure, which limits the penetration of aggressive chemicals (Muhammad *et al.,* 2021). However, the high cost of silica fume remains a limiting factor in its widespread adoption.

C. GGBFS and Durability:
GGBFS enhances the durability of SCC by reducing permeability and increasing resistance to chemical attacks, including chlorides and sulfates. Its contribution to long-term strength and reduced ASR risk further underscores its effectiveness as an SCM in durable concrete applications (Pang *et al.,* 2022).

D. RHA and Durability:
RHA has demonstrated potential in improving the durability of SCC by enhancing microstructural properties and reducing permeability. However, the variability in RHA quality and its impact on durability performance necessitate further investigation to establish standardized practices for its use in SCC (Muhammad *et al.,* 2021).

E. CCW And Durability:
CCW has shown promise in improving the durability of SCC by enhancing the resistance to chemical attacks and reducing permeability (Okokpujie, *et al.,* 2023). However, further research is needed to assess the long-term durability performance of SCC incorporating CCW, particularly under exposure to aggressive environments.

2.4 Emerging Scms In Scc

In recent years, researchers have explored emerging SCMs to address the limitations of traditional SCMs and improve the sustainability and performance of SCC.

A. Ultra-Fine Fly Ash (Uffa):
Ultra-fine fly ash (UFFA) is a finely ground version of conventional fly ash that exhibits enhanced pozzolanic activity. Research indicates that UFFA improves the workability and compressive strength of SCC while reducing water demand (Suprakash *et al*., 2021). UFFA also accelerates the pozzolanic reaction, leading to improved early strength development compared to conventional fly ash.

B. Calcined Clays:

Calcined clays have gained attention as viable SCMs in SCC due to their pozzolanic properties and availability. Research shows that calcined clays improve the compressive strength and durability of SCC, particularly in regions where traditional SCMs are scarce (Suprakash *et al*., 2021). However, optimizing the calcination process and assessing the long-term performance of calcined clays in SCC remains a challenge.

C. CCW As an Emerging SCM:

CCW has emerged as a promising SCM, offering benefits similar to traditional SCMs while addressing environmental concerns related to industrial waste. Its pozzolanic properties can enhance the mechanical performance and durability of SCC, making it a viable alternative in regions where conventional SCMs are limited (Muhammad *et al*., 2021).

2.5 Research Gaps and Future Directions

Despite significant progress in the use of SCMs in SCC, several research gaps remain. One key challenge is optimizing SCM usage to balance workability, strength, and durability. While hybrid SCM systems have shown promise in addressing these challenges, further research is needed to fully understand the synergistic effects of different SCM combinations.

Additionally, the long-term performance of emerging SCMs like UFFA and CCW requires further investigation, particularly regarding durability, shrinkage, and environmental impact. More studies are needed to assess the life cycle sustainability of SCMs, considering factors such as energy consumption, raw material availability, and waste management.

SCMs significantly impact the sustainability and performance of SCC. Traditional SCMs like fly ash, silica fume, and GGBFS provide numerous benefits in enhancing workability, strength, and durability while reducing the carbon footprint of SCC. Emerging SCMs like UFFA and CCW offer exciting possibilities for addressing the limitations of traditional SCMs, particularly in regions where conventional SCMs are scarce.

However, challenges remain in optimizing SCM use to achieve a balance between workability, strength, and durability. Further research is needed to fully understand the synergistic effects of different SCM combinations and assess the long-term performance of emerging SCMs. Ultimately, continued exploration of SCMs will contribute to the development of more sustainable, high-performance SCC for the construction industry.

3. Methodology

The methodology for this literature review is structured into distinct phases aimed at systematically examining the impact of supplementary cementitious materials (SCMs) on the sustainability and performance of self-compacting concrete (SCC). The phases include the identification of relevant literature, analysis and synthesis of the findings, and the assessment of research gaps and future directions. Below are the detailed steps undertaken in this study:

3.1 Literature Identification

A. Database Selection:

A comprehensive search of scientific literature was conducted using various academic databases, including Google Scholar, Scopus, Web of Science, and ResearchGate. These platforms were chosen for their extensive repositories of peer-reviewed journal articles, conference papers, and technical reports in the field of civil engineering and materials science.

B. Keyword Search:

The search employed a combination of keywords and phrases relevant to the topic, such as “self-compacting concrete,” “supplementary cementitious materials,” “fly ash,” “silica fume,” “ground granulated blast furnace slag,” “rice husk ash,” “calcined clays,” and “calcium carbide waste.” Boolean operators (AND, OR) were utilized to refine the search results and ensure a comprehensive collection of relevant studies.

C. Inclusion And Exclusion Criteria:

The selected literature was filtered based on specific criteria:

1. **Inclusion Criteria:**
   i. Articles published in peer-reviewed journals.
   ii. Studies focusing on the effects of SCMs on SCC properties, including workability, strength, and durability.
   iii. Research articles published within the last two decades to capture recent advancements in the field.

2. Exclusion Criteria:

i. Non-English publications.
ii. Studies lacking empirical data or that did not directly address the impact of SCMs on SCC.

3.2 Data Extraction and Analysis

A. Data Extraction:

Relevant data from the identified literature were extracted systematically, focusing on the following key aspects:

i. Types and proportions of SCMs used in SCC mixtures.
ii. Experimental methodologies and testing protocols employed to assess SCC properties.
iii. Findings related to workability, compressive strength, durability, and other relevant performance metrics.
iv. Environmental impact assessments and sustainability analyses related to the use of SCMs in concrete.

B. Qualitative Analysis:

The extracted data were subjected to qualitative analysis to identify trends, similarities, and differences among the various studies. The analysis focused on understanding how different SCMs affect the performance of SCC and their contributions to sustainability.

3.3 Synthesis Of Findings

A. Thematic Organization:

The findings from the literature were organized thematically to address specific aspects of the research objectives:

i. Effects of individual SCMs on SCC properties.
ii. Comparative performance analysis of traditional versus emerging SCMs.
iii. Influence of SCM proportions on rheological and mechanical properties.

B. Critical Analysis:

A critical analysis of the synthesized findings was conducted to identify gaps in knowledge and areas needing further research. This included examining conflicting results, limitations in existing studies, and opportunities for future investigation.

3.4 Assessment of Research Gaps and Future Directions

A. Identification Of Gaps:

The literature review highlighted several research gaps, particularly concerning the long-term performance of emerging SCMs like calcium carbide waste and ultra-fine fly ash. Areas requiring additional investigation, such as the synergistic effects of hybrid SCM systems and the environmental implications of using these materials in SCC, were identified.

B. Future Research Directions:

Based on the identified gaps, future research directions were proposed to guide subsequent investigations in the field. These included recommendations for experimental studies that explore the combined effects of various SCMs, long-term durability assessments, and life cycle analyses to evaluate the sustainability of SCC incorporating SCMs.

4. Findings

The literature review and analysis of the impact of supplementary cementitious materials (SCMs) on the sustainability and performance of self-compacting concrete (SCC) yielded several key insights.

a. Consistency of Material Properties: The properties of SCMs used in various studies adhere to established standards, with variations in performance primarily arising from interactions between SCMs and other concrete constituents rather than material inconsistencies.
b. Experimental Conditions: Findings from the literature are valid within the specified experimental conditions, such as curing methods, environmental factors, and standardized testing procedures. These conditions are crucial for determining the performance of SCC modified with SCMs.
c. Proportion and Optimization of SCMs: The proportions of SCMs used in SCC mixtures across the reviewed studies reflect practical applications in real-world construction. Common replacement levels, such as 10-30% for fly ash and 5-10% for silica fume, have been shown to optimize both workability and strength, providing a practical framework for SCM use.
d. Homogeneity and Mixing of Concrete Mixtures: The concrete mixtures evaluated in the studies were thoroughly mixed, ensuring uniform distribution of SCMs and other constituents. This uniformity is critical for achieving consistent results in the performance of SCC.

e. Workability and Rheological Properties: Incorporating SCMs, particularly fly ash and silica fume, significantly improved the flowability of SCC. Optimal replacement levels of these materials enhanced slump flow values, facilitating easier placement and consolidation during construction. The addition of calcium carbide waste (CCW) also improved the rheological properties by reducing the risk of segregation and enhancing the cohesiveness of the concrete matrix due to its fine particle size.
f. Compressive Strength Development: SCMs, including fly ash and ground granulated blast furnace slag (GGBFS), have been observed to improve long-term compressive strength due to pozzolanic reactions that contribute to the formation of additional calcium silicate hydrates (C-S-H). However, high fly ash replacement levels above 30% can delay early strength development, which is critical for projects with rapid construction timelines. The use of hybrid SCM systems, combining fly ash with silica fume or chemical activators, has been suggested to address this concern.
g. Durability Performance: SCC incorporating SCMs demonstrates superior durability compared to conventional concrete. Fly ash and silica fume have been shown to reduce permeability, increasing resistance to chloride ingress and sulfate attacks. This enhancement is particularly beneficial for structures exposed to aggressive environments, such as marine applications. Preliminary studies suggest that CCW could also improve durability by enhancing resistance to chemical attacks and reducing permeability, although more comprehensive studies are needed to confirm its long-term performance.
h. Environmental Impact and Sustainability: The use of SCMs, particularly waste-derived materials like fly ash, GGBFS, and CCW, significantly reduces the carbon footprint of SCC. By replacing a portion of cement, these materials lower greenhouse gas emissions and promote the recycling of industrial by-products. Emerging SCMs, such as ultra-fine fly ash (UFFA) and calcined clays, have been identified as viable alternatives in regions lacking access to traditional SCMs, thereby enhancing sustainability through local material utilization.
i. Research Gaps and Future Directions: The literature reveals gaps in understanding the long-term performance and environmental impacts of emerging SCMs, particularly CCW. Comprehensive research is needed to explore their synergistic effects when combined with traditional SCMs. Furthermore, there is a need for standardized testing protocols to ensure reliable comparisons across studies and validate findings on SCC containing various SCMs.

5. Conclusion

This literature review has underscored the profound influence of supplementary cementitious materials (SCMs) on the sustainability and performance of self-compacting concrete (SCC). The analysis demonstrates that the incorporation of SCMs such as fly ash, silica fume, ground granulated blast furnace slag, rice husk ash, and calcium carbide waste significantly enhances critical properties of concrete, including workability, compressive strength, and durability. Importantly, SCMs play a vital role in sustainability initiatives by reducing the carbon footprint of concrete production and facilitating the recycling of industrial by-products, thereby addressing pressing environmental challenges within the construction industry.

The findings emphasize the importance of optimizing the proportions of SCMs in SCC mixtures to strike an effective balance between early strength development and long-term performance. While established SCMs have proven their value, emerging materials such as ultra-fine fly ash and calcium carbide waste offer promising opportunities for further enhancing the sustainability of concrete, especially in regions with limited access to conventional SCMs. Nonetheless, the review highlights significant gaps in the current literature, particularly regarding the long-term performance of emerging SCMs and the urgent need for standardized testing protocols. Future research should focus on addressing these gaps and investigating the synergistic effects of hybrid SCM systems to fully harness the advantages of using SCMs in SCC. By advancing our understanding and application of SCMs, we can enhance the performance and sustainability of concrete, contributing to more resilient and environmentally friendly construction practices.

6. Recommendations

The Following recommendations are made:

1. **Standardization of Testing Protocols:** It is crucial to establish standardized testing protocols for evaluating the performance of SCC with various SCMs. This would ensure consistent results across studies, facilitating better comparisons and more reliable conclusions about the effects of different materials.
2. **Long-Term Performance Studies:** Additional research should focus on the long-term performance of SCC containing emerging SCMs, particularly calcium carbide waste and ultra-fine fly ash. This includes

assessing durability under various environmental conditions and determining their overall sustainability benefits.

3. **Hybrid SCM Systems:** Future investigations should explore the synergistic effects of combining traditional and emerging SCMs in SCC mixtures. This could involve systematic studies to optimize the proportions of different materials, aiming to enhance performance while maintaining sustainability.
4. **Field Studies and Real-World Applications:** To complement *labour*atory findings, field studies should be conducted to evaluate the performance of SCC with SCMs in real-world applications. This would provide valuable insights into the practical implications of using SCMs in various construction scenarios.
5. **Life Cycle Assessment (LCA):** Implementing life cycle assessments for SCC containing SCMs can help quantify the environmental benefits associated with their use. This holistic approach would provide a clearer understanding of the sustainability advantages and inform decision-making in construction practices.
6. **Education and Training:** The construction industry should prioritize educating engineers, architects, and contractors about the benefits and application of SCMs in SCC. Providing training on best practices for using these materials will promote their adoption and contribute to more sustainable construction practices.

By addressing these recommendations, the construction industry can enhance the performance and sustainability of self-compacting concrete, paving the way for more environmentally friendly practices and improved infrastructure outcomes.

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Quantitative Analysis of Incidence of Crime in Unilorin Student Residences: Causes and Prevention Measures

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Abstract

Developing an early warning system for crime prevention has been a topical issue in urban planning discourse. Most past research efforts focused on assessment of crime incidence on campus with sparse effort on crime incidence in student hall of residence. Hence, this study assesses incidence of crime in University of Ilorin students' hall of residence with a view to suggesting measure towards stemming crime. Data was gathered through questionnaires administered to 277 students across five halls of residence using random sampling. The study developed four key indices: the Crime Incidence Index (CII), Causes of Crime Incidence Index (CCII), Effect of Crime Incidence Index (ECII), and Measures for Crime Prevention Index (MCPI). The results showed that "stealing" (CII = 3.49) is the most common crime in the halls, with peer group influence (CCII = 4.39) identified as the leading cause. The high rate of crime has primarily led to the loss of student properties (ECI = 4.32). Among the various security measures implemented by the University, the deployment of security personnel (MCI = 4.71) was found to be the most effective. Although the management has taken significant steps to prevent crime, the issue remains prevalent. The study recommends enhancing current security measures by incorporating modern tools and technology to improve overall effectiveness.

Keywords: Crime Incidence, Hall of Residence, Security Measure.

1. Introduction

Crime remains a significant societal issue, affecting communities worldwide and drawing concern from governments, individuals, and stakeholders alike (World Bank, 2005; Adigun *et al*., 2016). In Nigerian institutions of higher learning, the issue has reached alarming proportions, with increasing reports of criminal activities, particularly within student halls of residence (Eisner, 2014). While the establishment of student halls on campuses has surged globally in recent decades, providing physical and social spaces for students (Mariana *et al*., 2011), this trend has also been adopted by many Nigerian universities. However, despite these advancements, student safety remains a pressing concern, as criminal activities continue to proliferate within these living spaces. The halls of residence, intended to foster a secure and conducive environment for learning and personal growth, have unfortunately become hotspots for various crimes, ranging from petty theft and burglary to more serious offenses such as assault and abduction (Anonkye & Mohammed, 2016). Scholars have linked the rise in crime within student residences to a broader climate of fear that negatively affects academic performance and student well-being (Ujene & Akpanamasi, 2014; Adigun *et al*., 2016). Despite efforts by educational institutions to create safe environments, security measures in place are often inadequate, with criminals easily bypassing them, particularly in halls of residence where students expect to feel most secure.

Previous research has predominantly focused on overall campus crime, overlooking the specific context of student residences, where students are most vulnerable (Adigun *et al*., 2016; Olawale *et al*., 2018; Bakare *et al*., 2023). This gap in the literature is critical because student residences are not just living spaces but integral to the educational experience, impacting students' sense of safety, mental health, and academic success. Addressing crime within student halls of residence is essential for improving overall campus safety and fostering an environment where students can thrive without fear. This study seeks to fill the existing research gap by focusing specifically on crime in the halls of residence at the University of Ilorin.

2. Study Area

The university began as a University College affiliated to the oldest university in Nigeria in 1975 under the leadership of the then principal, Dr T.N. Tamuno. The University College had three foundation Faculties namely: Arts, Science, and Education. The Institution began to develop its programmes in a way that not less than 60% of its effort was directed towards science-oriented programmes. In October 1977, the Institution attained full autonomous status and has since then developed rapidly. The student population of 200 in 1976 has increased to 20,084 by the 2005/2006 session, while the total staff strength of the University stood at approximately 3,040 as at March 1, 2007. The University has two campuses. The Main Campus currently houses the Faculties of Science, Communication and Information Sciences(CIS), Engineering & Technology, Agriculture, Education, Law, Arts, Business and Social Sciences, (following the completion of the new seven-storey Senate Complex), the Unilorin Sugar Research Institute, Postgraduate School, the Main University Library, Computer Services and Information Technology (COMSIT), Works Yard, Conference Centre, Unilorin Resources Development and Management Board (URDMB), Student Canteens, the newly completed 2,000 seat multipurpose Auditorium and the Alumni/ Endowment Office. The Mini-Campus presently houses the College of Health Sciences, a mini Library, Canteens and Shopping Complex, the Institute of Education, some of the Revenue-yielding projects which are under the URDMB such as the Unilorin Computer Centre (Training Wing), Unilorin Bookshop, the Bakery, the Printing Press, and the Guest Houses. Five new Hostels were completed in 2002.

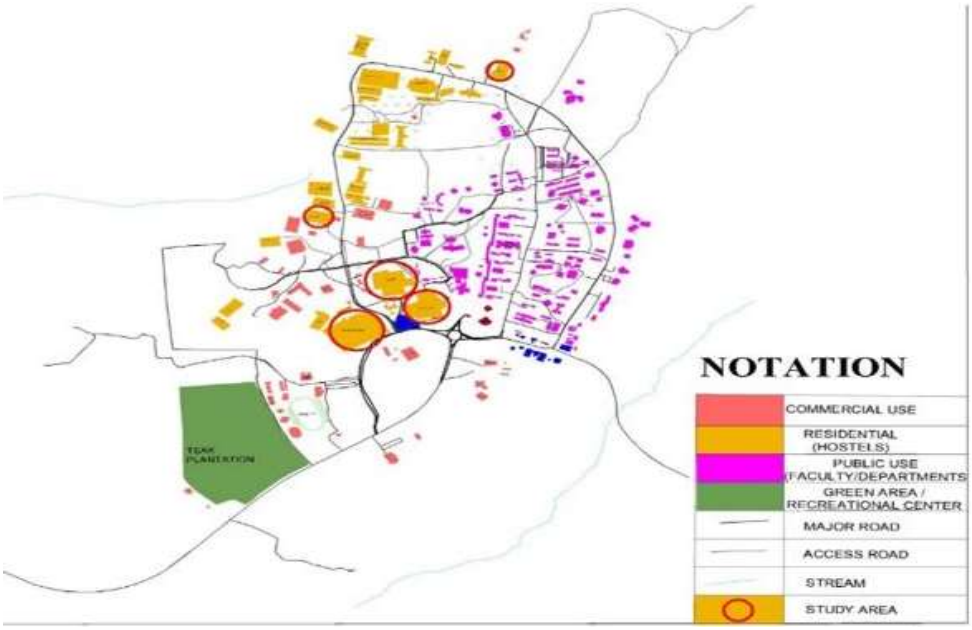

Figure 1: Unilorin Student Hall of Residence
Source: *University of Ilorin, Physical Planning Department, 2023*

3. Materials and Method

The study draws on primary data collected through a questionnaire administered to 277 students from five halls of residence at the University of Ilorin—Village I, Village II (Lagos), Village III (Abuja & Kwara), Village IV (Zamfara), and Village V (Trunil) using a random sampling technique. The sample size of 10% of the total bed spaces (2774) was selected to ensure adequate representation from each hall, with the aim of capturing diverse perspectives on crime incidence across the campus. To ensure the validity and reliability of the questionnaire, it was pre-tested on a small group of students not included in the final study. This helped to refine the questions for clarity, consistency, and relevance. The reliability of the scales was assessed using Cronbach's alpha to ensure internal consistency within the indices developed. The Cronbach's alpha values were all above the acceptable threshold of 0.7, indicating a reliable measurement tool. Four key indices were developed to analyze the data: the Crime Incidence Index (CII), Causes of Crime Incidence Index (CCII), Effect of Crime Incidence Index (ECII), and Measures for Crime Prevention Index (MCPI). The CII measured the perceived level of crime in the student halls of residence, while the CCII, ECII, and MCPI measured the causes, effects, and prevention measures of crime, respectively. The CII was measured on a five-point Likert scale, ranging from "Very Frequent" (5) to "Not Frequent at all" (1). The CCII, ECII, and MCPI were measured on a five-point Likert scale, ranging from "Strongly Agree" (5) to "Strongly Disagree" (1). The indices were calculated by summing the weighted values (SWV) of responses and dividing them by the total number of

respondents. Statistical analysis of the data was conducted using descriptive statistics to summarize the key findings. This approach provided a robust framework for identifying crime patterns, causes, effects, and the effectiveness of prevention measures within the halls of residence. This is mathematically expressed as:

SWV $=(ax5)+(bx4)+(cx3)+(dx2)+(ex1)$;

CII$=\left[\frac{SWV}{No\ of\ respondents}\right]$; $\bar{X}=\sum\left[\frac{SWV/_{NR(f)}}{No\ of\ variables}\right]$; D $=\frac{SWV}{NR(f)}-\bar{X}$; D$^2=\left[\frac{SWV}{NR(f)}-\bar{X}\right]^2$.

$\bar{X}$ = mean D= Deviation; D2 = Standard deviation; SWV = Sum of weight value and NR (f) = No of respondents.

Table 1: Questionnaire Schedule

S/N	Students' Hall of residence	No. of Bed places	No. of Hostel Blocks	Copies of Questionnaire
1.	Village I (Lagos Boys Hostel)	500	5	50
2.	Village II (Lagos Female Hostel)	880	5	88
3.	Village III (Abuja & Kwara Female Hostel)	434	4	43.4
4.	Village IV (Zamfara Female Hostel)	720	7	72
5.	Village V (Trunil Female Hostel)	240	5	24
	Total	**2,774**	**26**	**277.4**

Source: Authors' compilation, 2023.

4. Results and Discussion

4.1 Socio Economic Characteristics of Respondents

The gender distribution indicates a significantly higher proportion of female respondents (81.9%) compared to male respondents (18.1%). This discrepancy aligns with the university's accommodation policy, which allocates more hostels for female students (four hostels) than for males (one hostel). Such an imbalance suggests that crime prevention strategies might need to be tailored differently for male and female halls of residence, considering the unique dynamics and challenges faced by each gender. In terms of age, a substantial majority of respondents (63.18%) fall within the 15–25 years age bracket, typical for undergraduate students. Those aged 26–36 account for 22.74%, while only 6.86% are aged 37–47. This concentration of younger students may reflect a higher level of vulnerability to certain types of crime, such as theft or harassment, as younger individuals may be less experienced in navigating risky situations. The overwhelming majority of respondents (97.42%) are single, with only 2.53% married. This finding reinforces the notion that the halls of residence primarily house younger, unmarried students, which may impact the nature of social interactions and behaviors within the halls. The high number of single students could contribute to a greater sense of community but may lead to increased opportunities for criminal activities, given the often transient nature of their living arrangements. The data reveals that respondents are predominantly Muslim (53.4%) or Christian (46.6%), with the majority identifying as Yoruba (89.2%), followed by Hausa (7.2%) and Igbo (3.6%). This ethnic homogeneity might foster a sense of community and cultural cohesion; however, it could also lead to potential tensions if cultural or religious differences arise, particularly in a diverse university environment. Regarding education levels, the survey captures a wide range of student experiences, with 100 and 200-level students comprising 28.88% and 22.74% of the sample, respectively. This representation indicates that younger students may be particularly susceptible to crime due to inexperience. The financial status of the respondents reveals that nearly half (49.82%) earn less than N5,000.00, while 32.21% earn between N5,001 and N20,000. This economic vulnerability may increase the likelihood of criminal behavior, as students with lower income levels may resort to theft or other illicit activities to make ends meet. Finally, data regarding room occupancy indicates that rooms housing eight students (46.2%) represent the highest proportion, followed by rooms for six (32.1%) and four students (21.7%). The high occupancy in eight-student rooms may create a crowded environment that could facilitate criminal activities, such as theft or harassment, given that larger groups may result in a lack of oversight and accountability.

4.1 Type of Crime in Students Hall of Residence

The calculated Crime Incidence Index (CII) value provides a comprehensive understanding of residents' perceptions regarding crime prevalence within the student halls of residence at the University of Ilorin. By categorizing crime types based on their deviation from the mean CII value (CII = 2.24), it becomes evident that certain crimes are perceived as more prevalent than others. Crimes such as "Stealing" (CII = 3.49), "Squatting of students" (3.26), and "Intimidation" (2.84) are identified as having a high incidence, indicating they occur more frequently in the student halls than the average crime level. Notably, stealing emerged as the most common crime, reflecting significant implications for student safety and security. The observation that a student with varying income levels possess

different quantities of personal belongings—such as electronics, food items, and other valuables suggests that economic disparity among students can contribute to increased theft. Students with limited financial resources may be more inclined to steal items from those who appear to have more, particularly in environments where personal possessions are easily accessible. Additionally, the high incidence of stealing may be exacerbated in crowded living conditions, such as rooms accommodating eight students. In such settings, frequent visits from friends and acquaintances make it challenging to monitor who enters and exits, potentially facilitating opportunities for theft. The social dynamics in shared living spaces may further complicate the identification of offenders, leading to an environment where stealing becomes more common. On the other hand, crime types with a CII value below the hall's average, such as "Squatting of non-students" (2.15), "Burglary" (1.94), and "Drug abuse" (1.86), indicate a lower perceived incidence. The relatively low occurrence of these crimes may be attributed to effective preventive measures implemented by the university management. For instance, strict policies against cultism, including rustication and referral to law enforcement, may deter students from engaging in more serious criminal activities. These preventive actions can also have a ripple effect, as the visible enforcement of rules can foster a greater sense of security and accountability among residents. Furthermore, the lower incidence of violent crimes like "Rape" (1.50) and "Murder" (1.47) suggests that, while the potential for such incidents exists, the university's security measures, community awareness, and possibly cultural norms may play a crucial role in mitigating these more severe threats. However, the perception of crime and its actual occurrence can be influenced by various factors, including the overall campus climate, the responsiveness of security personnel, and the presence of supportive peer networks.

Table 2: Incidence of Crime index in University of Ilorin Students' Hall of Residence

Type of Crime	**TCI**	$\bar{X}$	**D**	**D²**
Stealing	3.49		1.25	1.56
Squatting of student	3.26		1.02	1.04
Intimidation	2.84		0.60	0.36
Theft	2.73		0.49	0.24
Internet fraud	2.47		0.23	0.05
Vandalism	2.44		0.20	0.04
Impersonation	2.44		0.20	0.04
Robbery	2.40		0.16	0.03
Pocket picking	2.40		0.16	0.03
Bribery	2.36		0.12	0.01
Violence	2.32	2.24	0.08	0.01
Squatting of non-students	2.15		-0.09	0.01
Burglary	1.94		-0.30	0.09
Drug abuse	1.86		-0.38	0.14
Assault	1.82		-0.42	0.17
Squatting of rusticated or expelled student	1.76		-0.48	0.23
Arson	1.71		-0.53	0.28
Occultism	1.51		-0.73	0.54
Rape	1.50		-0.74	0.54
Murder	1.47		-0.77	0.59

Source: Authors' compilation, 2023.

4.3 Causes of Crime in Students Hall of Residence

The analysis of the causes of crime incidence in the Students' Hall of Residence reveals several critical factors that significantly influence the propensity for criminal behaviour among residents. With an average Causes of Crime Incidence Index (CCI) of 3.86, it is evident that various interconnected issues contribute to the overall crime landscape within these living environments. Peer group influence, with a CCI of 4.39, stands out as the most significant factor affecting individual behaviour. This finding suggests that social dynamics within the halls—where students are surrounded by their peers—can heavily sway their choices and moral compass, potentially leading to criminal activities. The impact of peer pressure can foster an environment where individuals feel compelled to engage in risky or illegal behaviours to gain acceptance or status among their peers. Following closely is poverty (CCI =4.36), which remains a pervasive issue within society and a recognized catalyst for criminal behavior. Economic deprivation can lead individuals to engage in crime as a means of survival or financial gain. The sense of belonging (CCI =4.22) and social media influence (CCI =4.14) further highlight the complex interplay of social factors

in crime incidence. A strong sense of community and belonging can be protective factors, but when individuals seek validation through negative peer interactions or the promotion of harmful behaviors on social media, the risk of criminal engagement increases.

Other factors, such as family conditions (CCI =4.11) and economic hardship (CCI =3.96), reveal how family dynamics and financial struggles can create environments conducive to crime. Stressors related to unstable family environments or financial insecurity can lead individuals to seek out criminal avenues as coping mechanisms or survival strategies. While factors such as depression and mental disorders (CCI =3.78), domestic violence (CCI =3.74), access to weapons (CCI =3.65), and extortion (CCI =3.36) were rated lower, they still represent significant contributors to crime incidence that warrant attention. Mental health issues can impair judgment and increase impulsivity, leading to criminal behavior. Similarly, domestic violence can create cycles of abuse that perpetuate criminality within communities. The availability of weapons further exacerbates the potential for violent crime, while extortion can foster an environment of fear and coercion that hinders community cohesion.

Table 3: Causes of Crime index in University of Ilorin Students' Hall of Residence

Causes of Crime	**CCI**	$\bar{X}$	**D**	**D²**
Peer group influence	4.39		0.53	0.28
Poverty	4.36		0.50	0.25
Sense belonging	4.22		0.36	0.13
Social Media Influence	4.14		0.28	0.08
Family's Condition	4.11		0.25	0.06
Economic hardsip	3.96		0.10	0.01
Over-population	3.93	3.86	0.07	0.00
Competition	3.89		0.03	0.00
Depression and mental disorder	3.78		-0.08	0.01
Domestic violence	3.74		-0.12	0.01
Drug	3.65		-0.21	0.05
Extortion	3.36		-0.50	0.25
Poor security measure	3.31		-0.55	0.30
Access to weapon	3.28		-0.58	0.34

Source: Authors' compilation, 2023.

4.4 Effects of Crime in Students Hall of Residence

The analysis of the effects of crime incidence in the University of Ilorin Students' Hall of Residence reveals profound and multifaceted consequences on students' well-being and daily lives, with an average Effect of Crime Index (ECI) of 4.03. The dominant effect identified is the loss of properties (ECI=4.32), indicating that a significant number of students have experienced theft or other forms of property loss within their residence halls. This situation compels students to carry essential items, such as laptops and smartphones, with them at all times, which not only adds physical strain but also heightens anxiety about their safety and the security of their belongings. The second-ranked effect, feeling unsafe to walk alone at night ((ECI=4.32), illustrates a pervasive culture of fear that transcends individual experiences of crime. This anxiety limits students' freedom of movement and can disrupt social interactions, as they may avoid certain activities or gatherings due to safety concerns. Coupled with worrying about becoming a victim of crime ((ECI=4.25). The manifestation of post-traumatic stress disorder (PTSD) ((ECI=4.11) further underscores the serious psychological repercussions of crime. The emotional toll on students who have experienced or witnessed crime can lead to long-lasting effects that impair their ability to focus on academics and engage in campus life. Additionally, the effect of crime extends to a worried state regarding knowing the victim of crime ((ECI=4.00), reflecting a deep sense of communal concern and empathy for fellow students. The disruption of the serenity of the environment ((ECI=3.90) indicates that crime does not only have personal repercussions but also impacts the overall atmosphere within the halls. Noise, disturbances, and tension stemming from criminal activity can create a hostile living environment, which contradicts the purpose of student residences as safe spaces for learning and personal growth. Feeling unsafe alone in the room ((ECI=3.86) is another critical consequence that speaks to the pervasive impact of crime on students' mental health. The fear of isolation can exacerbate feelings of vulnerability and anxiety, leading to a negative cycle that affects their overall academic performance and social engagement. Finally, the mention of suicide (3.49) as an identified effect highlights the most extreme consequence of crime-related stress. It indicates that the psychological burden of living in an unsafe environment can lead some individuals to consider drastic measures.

Table 4: Effects of Crime index in University of Ilorin Students' Hall of Residence

Effects of Crime	ECI	$\bar{X}$	D	D^2
Loss of properties	4.32		0.29	0.08
Feeling unsafe walking alone at night	4.32		0.29	0.08
Worrying becoming a victim of crime.	4.25		0.22	0.05
Post-traumatic stress disorder	4.11	4.03	0.08	0.01
Worried of knowing the victim of crime	4.00		-0.03	0.00
Disrupt serenity of environment	3.90		-0.13	0.02
Feeling unsafe alone in the room.	3.86		-0.17	0.03
Suicide	3.49		-0.54	0.29

Source: Authors' compilation, 2023.

4.5 Measure of Stemming Crime in Students Hall of Residence

The analysis of the security measures implemented by the University management in the University of Ilorin Students' Hall of Residence reveals a comprehensive approach to crime prevention, with an average Measure for Crime Prevention Index (MCI) of 4.54. The top-rated measures, security personnel and security doors (both with an MCI of 4.71), highlight the critical role of human and physical security resources in fostering a sense of safety among students. The presence of trained security personnel not only acts as a deterrent to potential offenders but also reassures residents that there is a responsive system in place to address any incidents that may arise. Following closely, surveillance cameras (MCI=4.68) and street lighting (MCI=4.57) further emphasize the importance of environmental design in enhancing security. Surveillance cameras serve as a visible reminder of oversight, potentially discouraging criminal behavior due to the likelihood of being recorded. The presence of adequate street lighting is crucial, as it minimizes dark areas where crime may occur, thereby improving visibility and safety for students, particularly during night-time. The availability of room burglary measures (MCI=4.46) indicates a targeted approach to preventing one of the most common crimes experienced by students—property theft. This suggests that efforts to secure individual living spaces are a priority for the university, reflecting an understanding of students' needs for personal safety and the protection of their belongings. The inclusion of paramilitary organizations (MCI=4.14) in the security framework further illustrates the university's commitment to a multifaceted approach to crime prevention.

Table 4: Measure of Stemming Crime index in University of Ilorin Students' Hall of Residence

Measures of Stemming Crime	MCI	$\bar{X}$	D	D^2
School security personnel	4.71		0.92	0.85
Security Door	4.71		0.92	0.86
Surveillance Camera	4.68	4.54	0.89	0.80
Street Light	4.57		0.78	0.61
Room burglary	4.46		0.67	0.45
Paramilitary Organization	4.14		0.35	0.13

Source: Authors' compilation, 2023.

5. Conclusions and Recommendations

The study highlights that while the University Management has made significant strides in implementing safety and crime prevention measures across the student halls of residence, incidents of crime remain prevalent. This indicates that current efforts, while commendable, may not fully address the complexity of crime types occurring within these environments. It appears that the management's initiatives primarily target crimes that can be mitigated through physical preventive measures, such as locks and surveillance systems. However, certain crime types require a more nuanced approach involving collaboration among victims, security personnel, and the University Management. In light of these observations, the study recommends that the university security personnel be equipped with modern security technologies to enhance their operational effectiveness. This includes deploying surveillance cameras in strategic locations within the student halls to ensure comprehensive monitoring. By leveraging advanced security tools and fostering a culture of vigilance and communication among students and staff, the university can create a safer living environment. Additionally, establishing clear protocols for reporting and responding to incidents can empower students to take an active role in their safety. It is crucial for the university to continually evaluate and adapt its security strategies, ensuring that they address the evolving nature of crime and promote a collaborative approach to maintaining safety within the campus community.

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Barriers to Community Participation in Infrastructure Provision and Maintenance in Residential Estate in Abuja, Nigeria

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Abstract

Community participation is crucial for the success of developmental projects, particularly in infrastructure provision and maintenance. Despite community participation issues being highly context-dependent, it has been given limited attention and not fully harnessed to the benefits of generality of Nigerians. Thus, this study investigated barriers to community participation in infrastructure provision and maintenance in the owner-occupier estates in Kubwa Bwari Area Council, FCT. Abuja. The primary data gathering instrument for this study is structured closed-ended questionnaire. Structured questionnaires were used to elicit information from 125 randomly selected respondents which were analysed using percentile and mean item scores. The findings revealed that the lack of transparency in the estate infrastructure participatory planning having mean score value of 3.71, transparency in infrastructure project execution with mean score value of 3.50 and distrust in community leadership having mean score value of 3.43 were the most significant barriers to community participation in infrastructure provision and maintenance in the study area. These barriers might have contributed to the limited participation of the residents in the areas studied due to the way and manner the community residents' associations (CRAs) were administered. Therefore, there is the need for CRA leadership to be open and accountable to all at every phase of project planning and execution so that improvement of the facilities can be engendered.

Keywords: Community participation, infrastructure provision, maintenance, barriers to participation, residential area, Abuja -Nigeria.

1. Introduction

The need for community input and action in developmental projects gave rise to the host community involvement in infrastructure provision and maintenance that included roads, water supply, drainages, waste disposal and electricity supply. Community involvement could be either through decision making, planning, fund sourcing and project implementation, this act is termed Community participation (Daniel, *et al.,* 2021). Community infrastructure provision participation concept of planning was popularized in response to the much criticized and seemingly unproductive top-down and expert-driven approach to planning in the early 1960 (Fariha, 2022). Fateye *et al.* (2021) asserted that this idea of participation has proven to be particularly valuable in places where government entities are unstable and under pressure to accomplish their duty. Volunteering in the community participation has a significant and long-lasting influence on enhancing community members well- being (Yasmin & Jamal, 2023). A meaningful community participation involves idea generation, contributions to decision-making, and responsibility sharing. Community members need a sense of belonging, desire for material or in-kind benefits, yearning for actively better livelihoods, while fulfilling other social obligations are some of the considerations that drive participation. The need to attain a meaningful community infrastructure participatory process that is successful, and long-lasting, requires community leaders to respect, listen to, and learn from community members as participants (Musonda *et al.,* 2024). Participants mutual respect and cooperative learning are essential for the efficient use of time, trust, and most importantly, efficacy of community resources utilization, as these biases serve as barriers to community participation in CRAs. Can these barriers be found in the Kubwa owner-occupier residential estate? Despite the numerus benefits, this approach to development has not been well harnessed or utilized in Nigeria (Ezeanah, 2020). Based on this premise, this study investigated internal factors responsible for physical infrastructural facilities failure in the owner-occupier residential estate in Kubwa, Bwari area council of Abuja, a typical instance of infrastructural deficiency (Ebehikhalu *et al.,* 2016).

2. Literature Review

2.1 Concept of Infrastructure Provision

Infrastructure plays a pivotal role in the advancement of urban areas, the enhancement of individuals' quality of life, the spread of economic activities, and the overarching socio-economic progression of community residents. The requirements of community residents for social, recreational, cultural, and developmental aspects are fulfilled through the provision of sufficient infrastructure. The infrastructure elements in the contemporary twenty-first century pertain to the intricate, extensive, and dynamic economic frameworks and support systems that depict modern development (Tubridy, 2018). The essential, apparatus, and frameworks necessary for the social, mental, and physical welfare of individuals and families are designated as residential infrastructure (Shetunyenga, 2023). This infrastructure encompasses all production systems, structures, and apparatus whose functionalities are used by households for the improvement of residents' well-being. Consequently, residential infrastructure encompasses comprehensive array of social, physical, and economic amenities, fixture such as roads, electricity, water supply, waste and sanitation. These are integral to the daily livelihoods of population and thereby possess the capability to enhance the overall quality of residents' life.

The population influx into Abuja has a direct influence on the residential infrastructure amenities currently in place (Adigun, 2018). The resident's growth is rarely in line with the amenities that are offered, as there is pressure on the already existing residential infrastructural facilities. The bad roads have an adverse effect on urban residents commuting from home to work, while this result in residents having to live with high cost of transportation (Momoh *et al.,* 2018). The Inadequate waste management within the residential area, blocked drains, coupled with deficiency of a storm water collection could lead to disease outbreaks and flooding, (Adigun, 2018) thus resulting in loss of life and property of residents, hence the benefit of residential infrastructure cannot be overlooked in ensuring well-being of residents. Residential infrastructure constitutes essential facilities that elevate the quality of life, foster health, and ensure the safety of inhabitants. These infrastructures are essential to urban living and the absence could impact negatively on residents' health, housing operating costs, and the quality of urban life (Hardekar & Chakraborty 2018). This challenge of providing residential infrastructure will require an intervention through community participation to supplement government efforts, which have not adequately impacted on resident well-being (Annum & Aijaz, 2023).

2.2 Community Participation

Communities has been seen to be integral to provision and maintenance of infrastructural projects, this means that their participation is necessary to achieve adequate infrastructural availability and adequacy. Although, the word "participation" is most frequently used in developmental discourse, it has been used in a wide range of contexts and has come to mean several things. participation signifies a change from the top-down, global planning approaches that dominated participation earlier development projects to approaches that are more context specifics, localized, and urbane (Amusugut *et al.,* 2023). Moreover, the diverse social, political, and economic structure of the community will need to be considered when designing participation strategies that are tailored for developmental requirements (Mubita *et al*., 2017). Nevertheless, for participation to be genuinely beneficial, it needs to be voluntary and unaffected by external circumstances. Communication and understanding are key factors in determining community engagement since successful community participation depends on residents' willingness to take part in development initiatives (Nirmala, 2017).

2.3 Residential infrastructure

Residential infrastructure, as a component of community development, refers to the physical facilities that enable residents to participate in the political, economic, civic and community roles that are important to the well-being of society (Odunola *et al*., 2022 and Kirti, *et al*., 2022). This comprises of physical fixed assets such as roads, electricity, water supply, and sanitation, as well as information and communication technology (Manggat, *et al*., 2018). The social infrastructure includes services such as education, financial institutions, firefighting, and hospitals, while the physical infrastructure includes network of portable water, roads, and power grids. As such residents can access social facilities through social infrastructure, the physical infrastructure allows them to access physical facilities within the residential community (Shunglu, *et al*. 2022).

2.4 Community Residents Participation

Participation is equated to the concept of influencing empowerment of the populace by providing opportunity to develop indigenous solution to perceived needs, thus breaking the dependency attitude (Aurick, *et al.,* 2017). community participation is the gradual process of purposeful voluntary activities by community members to effect improvements to infrastructure services and community welfare. The success of participation is affected by the

political, social, spatial, and cultural contexts; thus, it is essential to contextualize participation within existing local environment and a carefully informed social and local political knowledge base. Community-participation (CP) has become important in community development over time, were participants influence and control developmental initiatives through collaborative decisions as well as fund sourcing to execute the conceived project under a community resident association (Omotayo, *et al*., 2020). The community Resident's Association (CRA), a cooperatively owned and democratically administered residential organisation, which is a self-governing resident group, established voluntarily to minimize conflicts while promoting social and economic improvement in the residential community (Yussif, 2021).

Annum & Aijaz (2023), evaluated barriers to community participation in Cameroon Mutengene, self-help water project planning. The research affirmed that participatory barriers are generally classified as "external and internal barriers." External barriers are those factors that are not present in the beneficiary community but may hinder effective participation, while internal barriers are hindrance present within the recipient community and may originate from resident associations like community leaders' forums and other interest groups within the community. Furthermore, Rahmat, *et al*. (2023) examines participatory approaches in water projects management initiatives. The study adopted qualitative approach, incorporating case studies from India, Sri Lanka, and Turkey, the study concluded that the primary barriers to participatory water projects were elite capture of participatory procedures, diverse influence and lack of societal trust on community leaders, as well as micro-level disparities all these impedes inclusive participatory process. Shetunyenga, (2023) evaluated barriers to community participation in developmental projects in Ompundja constituency, Oshana region of Namibia, A qualitative research approach was adopted for the study. Findings revealed contrasting views between residents' and organisers of community-based development, as such the study thus, advocated for community residents improve capabilities towards contributing to the development of their community well-being. Furthermore Holcombe, *et al*. (2023) investigated the long-term sustainability of post-construction drainage infrastructure network maintenance, emphasising on government- and World Bank-funded hillside projects in urban areas in Saint Lucia, Eastern Caribbean. The findings demonstrated that early community involvement in a project can lead to improved construction quality and impacts on infrastructure maintenance life cycle. The nature of community participation and the obstacles to successful community involvement in community development initiatives were examined by Usman *et al.* (2018). utilizing Gombe State, Nigeria's. recommended increased level of awareness and enlightenment about communal participation through mass media, study further encouraged the timely involvement of rural people in project formulation, planning and implementation.

2.5 Community Participatory Barriers

Annum & Aijaz (2023) affirmed that infrastructure Participatory projects are mostly confronted by external and internal barriers. The external constraints relate to communication and leadership issues and the prevailing perception of tokenism. Alleviating these challenges requires the enhancement of community voices through collaborative implementation of genuine participatory bases for engagement (Emanuel & Wilkins, 2020). While the internal constraints emerge from socio-economic conditions of participant. A comprehensive Participatory approach requires the collaboration of community's participant, and residents' association stakeholders to enable effective participation (Michael & Alex, 2022). Conventional systems of communal participation often fail to foster trust, resulting in a parasitic relationship between communities and project participant. Tackling this concern demands the empowerment of host communities through inclusive stakeholder strategies. Table 1 summarizes reviewed literature extract of participatory barriers to community infrastructure maintenance and provision.

Table 1: Participatory Barriers Extract

Author	Study Topic	Participatory Barriers
Annum & Aijaz (2023),	Study barriers to community participation in Cameroon Mutengene, self-help water project planning.	"External and internal barriers."
Rahmat, *et al*. (2023)	Investigated participatory approaches in water projects management initiatives, case studies from India, Sri Lanka, and Turkey	Elite capture of participatory procedures, diverse influence and lack of societal trust on community leaders and micro-level disparities
Shetunyenga, (2023)	Examined barriers to community participation in developmental projects in Oshana region of Namibia,	Contrasting views between residents' and organisers of community-based development,

Holcombe, *et al*. (2023)	Study the long-term sustainability of post-construction drainage infrastructure network maintenance in Saint Lucia, Eastern Caribbean.	early community involvement in project leads to improved construction quality and impacts on infrastructure maintenance life cycle.
Usman, *et al.* (2018).	Investigated the nature of community participation and the barriers to effective community participation in community development projects. using Gombe Local Government Area, Gombe State, Nigeria.	Participant active contribution to decision-making process encouraged project formulation, planning and implementation input

Community participation in infrastructure projects encounters substantial external impediments, encompassing a lack of acknowledgment, power imbalances, and insufficient communication. Such impediments can impede effective participation and culminate in project failures. Tackling these issues requires a multidimensional strategy:

i. **Lack of Acknowledgment:** The non acknowledgment of Participating community members involvement often leads to exclusion from decision-making frameworks, (Emanuel & Wilkins, 2020). This deficiency in recognition may obstruct participants from articulating their needs and concerns in a meaningful manner.
ii. **Power Inequalities:** Disparities in authority between community residents and project coordinators can result in superficial participation, which is characterized by minimal community input (Shetunyenga, 2023). It is imperative to ensure equitable power relations for authentic engagement.
iii. **Insufficient Communication:** adequate communication channels are vital for bridging the divide between communities and project participants (Rahmat *et al*., 2023). These can be achieved with the formation of multi-actor platforms can promote information dissemination towards strengthen trust among Participating community.

Although these barriers are significant, they can be improved on through community-led initiatives that empower residents and encourage community collaboration. Nonetheless, it is asserted that in the absence of addressing these systemic inequalities, any Participatory efforts may simply produce superficial participation (Rahmat *et al.* 2023).

3. Methodology

This study is carried out in Abuja, the federal capital territory (FCT) of Nigeria, specifically in Kubwa, Bwari area council. Bwari Area Councils of Abuja was purposively selected for this study out of the six area councils, as it is home to some owner-occupier estates in the FCT. The map of Abuja showing Bwari area council is illustrated in Figure1.

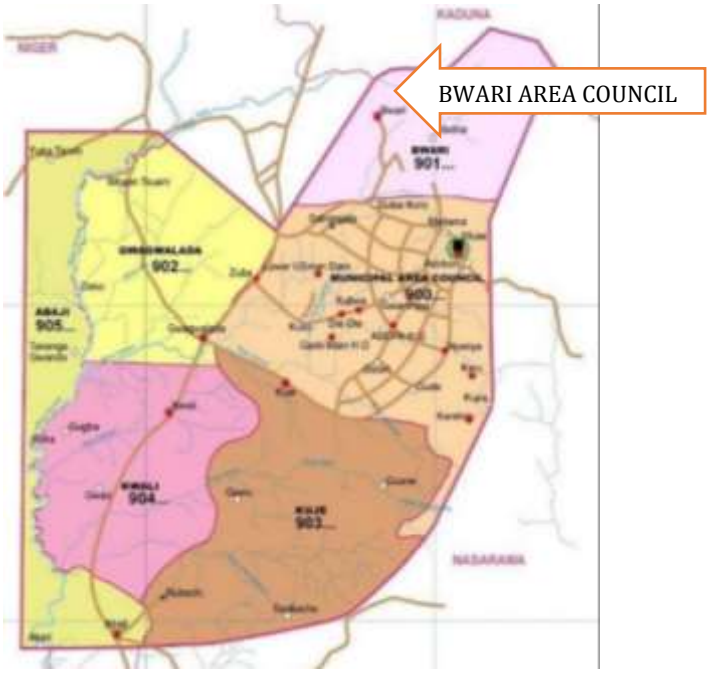

Figure 1: Federal Capital Territory map showing the six Area Councils. Arrowed is Bwari Area Council.
Source: https://www.google.com/search?q=map+of+abuja&sxsrf=ALeKk01-5r702YRS2iV

The main data collection instruments used for this study is close-ended questionnaire structured towards barriers militating against residents' participation in infrastructure provisions and maintenance in the study area. Data were collected using structured questionnaire. The survey research approach was adopted in this study, since it helps determine whether there are significant effects on the variables under study (Yussif, 2021). The study population was one hundred and eighty-five (185) households, out of which one hundred and twenty-five (125) were randomly selected based on Qualtrics (2023) sample size calculator. One hundred and two (102) questionnaires were correctly filled and returned. The data were analysed using statisty (free online statistics app, 2024). The presentation of the results is basically descriptive in form of tables for easy understanding and interpretation. A five-point Likert scale was employed to rate the residents' responses, with designated cut-off points for mean values range from: 1.00-1. 49 = No Extent, 1.50 – 2.49 = Low Extent, 2.50-3.49 = Moderate Extent, 3.50-4.59 = High Extent, and 4.50-5.00 = Very High Extent (Morenikeji, 2006).

4.0 Results and Discussion

4.1 Respondents General Question

This, study pose question to the respondents, if there is existence of CRA in the estate, next is whether respondents attend CRA meetings, and the social media platform used by the estate CRA for information dissemination to the estate community. All of which will enhance the quality of data to be gathered as the respondents will be well informed and in position to provide vailed answers, the result is presented in Table 2.

Table 2: Existence of Community Residents' Association

Respondent	**Frequency**	**Percent**
Yes	87	85
No	6	6
No response	9	9
Total	**102**	**100**
CRA meeting attendance	**Frequency**	**Percent**
Very Regular	23	22
Regular	16	15
Seldomly	63	62
Total	**102**	**100**
social media platform	**Frequency**	**Percent**
WhatsApp	83	81
Telegram	11	11
Instagram	8	8
Total	**102**	**100**

The result shows that 85percent been in the majority study respondents affirmed that there is an existing Community Resident Association in place, while 6percent indicate No, which could mean non-awareness and 9 percent were nonresponsive. The CRA meets quarterly while 62 percent that are majority seldom attends the meeting. Next is respondent with 22 percent who are very regular, and the regular meeting attendee are 15 percent. The social media WhatsApp platform has 81 percent users, with 11 percent of respondents on telegram and 8 percent adopt Instagram as the media platform for effective CRA communication medium, this implies that all the three social media platforms are in use for effective CRA information dissemination in the estate. Three (3) respondents were current executive, members.

4.2 Respondents Demographic Information

The demographic characteristics of the respondents, which include factors such as sex, educational, employment status, residence tenure Status and other relevant data essential to improving the potential quality of data to be collected from the Kubwa owner-occupied estate. This study asserts that community capacity serves as a fundamental factor influencing participation, as it facilitates the decision-making processes associated with the execution of participatory infrastructure initiatives within the estate. The respondent's data are presented in Tables3.

Table 3: Respondents Demographic

Gender Categories	**Frequency**	**Percent**
Gender		
Male	72	71
Female	13	13
No response	17	16
Total	**102**	**100**
Educational qualifications	**Frequency**	**Percent**
OND / NCE	13	13
HND / BSC	71	70
Postgraduate	18	18
Total	**102**	**100**
Employment Status	**Frequency**	**Percent**
Self Employed	12	12.
Civil Servant	72	70
Private Sector	13	13
Retiree	5	5
Total	**102**	**100**
Respondents Income Range	**Frequency**	**Percent**
#100,000 - #149,000	9	9
#150,000 - #199,000	28	27
#200,000 - #249,000	5	5
#250,000 and above	2	2
No response	58	57
Total	**102**	**100**
Residents Tenure Status	**Frequency**	**Percent**
Employee Quarter	11	11
Owner Occupant	73	71
Privately rented	14	14
Squatter	4	4
Total	**102**	**100**

Source: Field data (2024)

The respondents' gender results in table3 indicates that 71 percent were male respondents while female are 13 percent and16 percent were the non-responsive participants. This implies that both gender as respondents are either residents' owner or occupants in the estate, which would enhance efficient data outcome for this study. The respondents' educational status survey revealed that 70 percent, of respondents attained equivalent of first degrees**,** 18 percent also had Postgraduate qualifications, and 13 percent had diploma. This implies that high percentage of respondents are well learned, as such they can critically make objective decision regarding community participation. Hence this is consistent with Adedokun *et al*. (2022) asserts that basic education attainment position respondents to provide valid and reliable information that impacts positively on participation.

The respondents' employment status indicates that civil servant who are the majority account for 70 percent of respondents, followed by Private Sector employees' 13 percent, with the Self-Employed 12 percent and lastly retired civil servants accounts for 5 percent. This indicates that majority of the residents are government workers (Civil Servant) and could influence participatory roles within in the CRAs, as they are supposedly the owner of such resident. The estate is occupied mostly on owner-occupier basis by government workers, who are either in service, retired or lease the residence out; thus, they could make out time between civil service work and CRAs activities to enhance infrastructure maintenance and its provision in the estate.

The respondent's income survey shows that 57 percent, who are the majority non-responsive respondents decline information on income, followed by those within the income range of #150,000 - #199,000 with 27 percent and then #100,000 - #149,000 income range with 9 percent while #200,000 - #249,000 earners, with 5 percent and income earner of #250,000, and above make-up 2 percent of respondents in the estate. The respondent's tenue status survey revealed that 71 percent who are most respondents were the owner occupant, followed by Privately rented 14 percent and then 11 percent make up the employee quarter, while 4 percent of respondents are squatter within the estate.

4.3 Barriers Impacts on Residential Infrastructure Participation

The Infrastructure Participation mean impact of participatory barriers in the study area is analysed with the results presented in Table 4 illustrating the basic characteristics and description analysis of barriers to community participation

Table 4: Ranking the barriers to community participation in infrastructure provision and maintenance

Barriers	Mean	Rank	Remark
Lack of early information	3.07	10	ME
Lack of timely awareness	3.21	6	ME
Limited access to decision-making	3.29	4	ME
Lack of transparency in initiation of infrastructure project	3.21	6	ME
Lack of transparency in the estate infrastructure participatory planning	3.71	1	HE
Lack of transparency in infrastructure project execution	3.5	2	HE
Residents' income	3.21	6	ME
Estate residents' educational attainment	2.86	12	ME
Distrust in community leadership	3.43	3	ME
Residents' tenure status	3.29	4	ME
Household size	3.07	10	ME
Elites' leadership dominance	3.14	9	ME
Class of resident	2.86	12	ME

Source: Author's Field Survey, 2024

Consequently, Table 4 shows the extent each barrier impacts on residential infrastructure provision and maintenance in the owner occupier estate**.** The result shows that lack of transparency in the estate infrastructure participatory planning ranking first (1st) with a means score of 3.71. This aligns to Annum & Aijaz, (2023), affirming of internal barriers to community participation, as it is an exclusive participatory process hinderance emanating from the residential community. Similarly, lack of transparency in infrastructure project execution ranked second (2nd) with a mean score of 3.50, this could be asserted to be a contextual-based barrier related issue. Lastly distrust in community leadership came third (3rd) with score of 3.43 confirming Rahmat, *et al*. (2023), study outcome of societal lack of trust on community leaders in community water projects management initiatives, case studies from India, Sri Lanka and turkey. These three factors were the most significant barriers to residents' participation in infrastructural provision and maintenance. Furthermore, elites' leadership dominance (3.14), household size and lack of early information (3.07), educational attainment and class of residents (2.86) ranked 9th, 10th and 12th respectively. These factors were the least significant barriers to residents' participation in infrastructural provision and maintenance as identified by the respondents. However, majority of the respondents indicated moderate extent on impact of these other barriers so identified.

5. Conclusion and Recommendation

The study investigated barriers to community participation in infrastructure provision and maintenance in owner-occupier residential estate in Kubwa, Abuja. The study found "three most significant barriers that needs to be given utmost attention for a successful resident's participation in community infrastructure provision and maintenance. The identified hinderance in order of significance are the lack of transparency in the estate infrastructure participatory planning, transparency in infrastructure project execution and residents' distrust in community leadership. These identified barriers revealed may have substantially influenced limited participation of the resident community within the studied estate, this can be attributed to the organizational approach and governance of the community residents' associations (CRAs). Therefore, it is essential for the leadership of the CRAs to embrace a policy of transparency and accountability during all phases of project initiation and execution, thus promoting participatory improvement of community infrastructure facilities. With these highlights of barriers to participation in this study, it will be a good guide to community resident association organisers in owner occupier estate especially in the study aera. As the study has provided insight on the significant barriers to infrastructure provision and maintenance. Limitations Like many other mixed-methods studies, the present study had some limitations, most notably the fact that it was limited to one estate in Kubwa. As such, the findings may not be sufficiently generalisable to estates in other area councils of Abuja. Therefore, it is recommended that future studies examine the barriers to community participation in infrastructure development and maintenance on a larger scale.

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Factor Inducing Failure in Controlling Physical Development in Metropolitan Kano

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Abstract

Kano city has reemerged as a major metropolitan of socio-economic hub influenced by urbanization and urban renewal challenges that has impacted on its city growth that requires regulatory management strategies of it built environment. The study examines factors induced failure in controlling physical development of Kano metropolitan built environment. The research uses ten (10) rated Likert items on a five-point scale, 1 being high positive impact to 5, high negative impact., were seventy-five (75) questionnaires targeting at metropolis were distributed to respondents. Sixty- nine (69), accounting for 92% distributed questionnaires were retrieved. The descriptive and inferential statistics techniques were used to analyze data and each coded response was multiplied by number of respondents, which gave the Weighted Value (WV). Result were interpretation using ranges and mean weight scores (MWS) in first, second and third quartile. This revealed five attributes in the first quartile range between (0.7 - 0.80) to be weak urban planning (MWS= 3.88), subdivision of plot (MWS= 3.82), traffic congestion (MWS= 3.68), environmental pollution (MWS= 3.57), Duplication of regulatory agencies (MWS= 3.53) range between (0.7- 0.80). The second quartile range between (0.6 - 0.69) and has Urban Heat Effect (MWS-3.39), Landscape distortion (MWS-3.17) and sprawling informal development (MWS-3.14), the third quartile range between (0.5-0.59) and has land tenure system (MWS-2.87), rural-urban immigrants (MWS-2.61), sprawling and spontaneous informal growth and development with (MWS-2.50). The study concludes by recommending ways to ensure orderly development and recommend areas for regulatory interventions and management strategies to sustain built environment.

Keywords: Built environment, Controlling, Metropolitan, physical development, and Urbanization.

1. Introduction

Over the years, Kano city as one of the biggest Hausa land settlements in Nigeria right from the early stage in pre-colonial time has grown uncontrollable as a result of urbanization and inconsistent transformation as a result of increased demand for the change of land use and building redevelopment (Unah and Ibrahim, 2020). Kano metropolis being the most urbanized urban centre in northern Nigeria with a population of over 4 million people is as confront with induced problem of uncontrolled physical development activities such as weak urban planning, duplication of planning regulation, land tenure system, environmental pollution, high population growth and mismanages its urban open spaces, urban heat effect, sprawling informal suburban development and traffic congestion. The present conditions and levels of infrastructural development in the state, has left the epi center continued to expand in hinterland of large shanty of peri- urban slum population growth that creates risks of physical, economic and social breakdowns are encountered. Amoateng *et al*., (2013) asserted that the built environment of has always experience uncontrolled physical development), as this is responsible for high-rate physical growth, and identified such physical development factors as been locally based. Zakkal *et al.,* (2022) opted that Kano will continue to develop indisputably of becoming a mega city despite the undermine power of urbanization as a factor of controlling the physical development Maigari (2018) noted that it is difficult to provide the social services such as housing, water supply, sanitation, education, and medical facilities in the rapidly growing urban areas. Dankani (2011) posited that Cities are not capable of providing neither intense activity in high density areas, nor intense quiet in low density areas, but however, it necessary to ensure controlling of physical development in absorbing an ever expanding labour force into struggling urban economies. The need of providing an effective regulatory policy constitutes one of the major instruments required for Sustainable urbanization. Since Kano existing conditions of critical problematic practices that lack the effectiveness in controlling physical development and management planning of its metropolitan city Umar *et al.,* (2019). The growth and management of a developing city like Kano has to takes into cognizance decision-making that will account for sustainable economic, ecological, and social impacts that seeks to improve the built environment and effective functions of both

better human quality of life and activities in near cosmopolitan city. Unah, (2021) ascertained that urban growth and sustainable development of the built environment is one of the many critical factors that determine the poor quality of human habitation and by extension, impeding adequate developmental and sustainable growth. This consequence is due to inadequate industrialization, sufficient formal employment or secure wages, that fastest growing city like Kano has resulted in over stretching of controlling physical development of the built environment. Unah and Ibrahim (2021) posited building redevelopment in Kano as being induce compliance amid physical controlled development of changes that violate the building regulations

The need of providing an effective regulatory policy constitutes one of the major instruments required for Sustainable urbanization. Since Kano existing conditions of critical problematic practices that lack the effectiveness in controlling physical development and management planning of its metropolitan city (Umar *et al.,* 2019). The united nation development program (UNDP, 2009) through a series of its Human Development Reports consistently showed that the proportion of Nigerians dwellings poorly ranged from 34.7% (1992) to 47% (1997). However, desperate effort is needed to revitalize the Kano metropolitan built environment as induce failure in controlling physical development of the built environmental appears as a veritable tool (Unah, 2020). Kano Municipal was conceived in the mid-1970s with urban policies that focused on tackling urbanization challenges (Ibrahim 2016), infringed on achieving sustainable urban development policies by integrating the "three pillars of sustainability". The old ancient city wall (unplanned) (fig. 1) being integrated into metropolitan of it outer wall (planned) and it surrounding environs. This was undertaken with the intentions of achieving equal access, sense of place and integration, physical beauty, and exemplary physical development for its citizenry (Ikoku, 2004; Jibril, 2006). Ibrahim and Mai (2020), Innocent (2019) opted that building control and regulation practice has not improved the competence of both the design and construction of the building industry to deliver building projects that are eco-friendly and attaining sustainable environmental objectives, due to the impact of rapid urban growth that has brought significant changes into the urban planning (Ogunsola, 2016, and Unah, 2019). Consequently, Amoateng *et al., (*2013) emphasized that the regulatory practice has often been seen chasing over physical development management in major cities in Africa.

However, while the concentration of people in a place (urban centre) could be continuous and seemingly unstoppable due to urbanization (Obiadi *et al.,* 2017) response to human, and institutional need (Okonkwo and Agbonome, 2012), has contravention the proper development of the built environment (Ibrahim and Unah 2023, Ibrahim 2016). Urban induced environmental transformation has implications for proper physical developments of it built environment (Unah *et al.,* 2024), as a result of urban population growth (Zakka *et al.,*2022) which needs for housing development has distorted the cityscape (Unah, 2019) by illegally built-up of arid land initially used for cultivation (Magari, 2018) has emerged slum development within the city pheriphial (Nasidi, 2022). If urbanization could be summed up as the process of the concentration of people and their socio-economic activities within a place over a period of time (Obiadi *et al.,* 2017*)*. Therefore, it should be fundamentally guided by man's reaction to his environment which passes through successive stages of transformation. It is against this background, this study seeks to unearth the induce factor of failure in controlling the physical development of Kano Metropolitan built environmental challenges confronting this populous Hausa land. The following objectives are necessary to achieve the paper aim study: to identify urban growth impediment sustainability; highlight the key factors responsible for controlling physical development as an implication of induce failure on the built environment and recommend areas for regulatory interventions and management strategies.

2. Literature Review.

The impact of urbanization has brought significant changes into the urban planning Ogunsola (2016), as seen in many parts of the nations. Sustainable development practice and development regulatory system in Nigeria more specifically Kano, the state capital city which was conceived in the mid-1970s with sustainable urban policies that focused on tackling rapid urban growth challenges. The development of Kano city today has been infringed by development practices which were envisioned to achieve sustainable built environment by creating policies which suggested the integration of the old and new city. This was undertaken with the intentions of achieving equal access, sense of place and integration, physical beauty, and exemplary physical environment for its citizenry (Ikoku 2004; Jibril, 2006). The non-adherence to implementation of current development policies and practice have failed to curtail the negative impact of sustainable built environment Ogunsola (2016). Urbanization and cities growth continues to developed rapidly causing increase significant impacts on land and environmental dynamics at the residential and cityscape hub in the cosmopolitan city of Kano. The associated land use/cover changes (Akpu, *et al.,*2017) posit as great effect and challenge on the environmental sustainability. However, Zubair, *et al., (*2015) opined that land use changes have a distinctive pattern on the landscape as an expression of 'man-land' relationship. This is manifested in the pressure that is exerted on the built environment by population increase (Gambo, 2014) and often time is a use by influx of people in search of commercial urban development (Unah, 2019a). In this context,

environmental sustainability as posit by Enoguanbhor *et al.,* (2019) is the condition that allows human society to meet their current needs without compromising the current and future health together with social, economic, and cultural considerations of creating a functional urban environment for current and future generations. Environmental sustainability and sustainable urban development can be improved through Urbanization and proper planning development (Unah, 2020, Ibrahim, 2014). Sustainable development growth if uncoordinated, un-enforced or non-existent land use planning may result in haphazard development and cause excess deterioration of the built and natural environments. Amoateng *et al.,* (2013) noted that the built environment are characterized by paced of unplanned physical growth and development given rise by complex and unregulated pattern of organic growth

In most developed countries capital city (and particularly in Sub-Saharan Africa), rapid urban expansion and growth of informal development activities is on steady raise. This urban renewal has great challenge and impact on residential properties which has paved way for less building being converted to higher density commercial building Unah (2019a). As Kano City continues to grow in terms of population and physical expansion, so does its commercial and industrial activities. Residential areas constitute most part of the city, most of which lacks planning (Sani, 2006; Dankani, 2016).

2.1 Urban Growth Impediment

The history of attempts to plan and regulate urban spaces in Africa since independence has for the most part constituted a litany of failure (Mabogunje, 1990) who posit that despite major shifts in development thinking in this period, the varying menu of proposed policy remedies did little to stem the ultimately nature of urban growth, particularly after the 1970s Goodfellow (2013) Just the distortion of the Abuja Master plan which did not only start as a result of urbanization but also the rules and the mix management of land allocation by the various military administrations under the leadership of different head of state. Same is akin to Kano, as a result of "Man- known Man syndrome" which has adversely polluted the skyline of the city. Atebije and Razak (un-dated) posit that these constraints led to indiscriminate developments, impunity, and abuses which made the city to lose its planned form, shape, size and beauty. The agencies of government have been on their beats in the effort to restore the image originally conceived through re-planning, controls and sanctions. This has left till present day various planning laws with its constant change of regulatory names. As stated earlier, population pressure in Kano metropolis is mainly as a result of lack of another growth centre that will relieves pressure on the existing metropolis and the ancient city and environs. Maiwada (2014) posit that the government and public sector must deliberately invest in this small town's peripheral Kano- region- currently what is akin to the development of Kwankwasiyya estate, Amana estate and Kano economic city respectively. Despites the dual natural of Kano city metropolitan, inconsistence building regulation has affected drastically it built environment, which has continually experienced the phenomenon of urbanization more than any state in the Africa South of the Sahara. This is also responsible for the encroachment to the borderline of caved- out ancient city walls (Unah un-dated).The growth of this metropolitan city and none adhere to the supervisory role of the regulatory authority has been responsible for these old city wall surrounding being absorbed into the new urban fabric (Unah, 2021b) and also infilling of every available open spaces within the existing built up by private individual (Maiwada, 2014).The rapid growth witnessed in the city (Table 2) is more of an urban sprawl fuelled by lack of effective urban planning (Maiwada 2014; Barau, 2017a) result in ineffective poor funding of planning authorities.

Housing redevelopment and building regulations contravention are on the raises in many cities in Nigeria. This usually takes places in most core housing estate ranging from all geo-political zones of the country. Earlier studies focused largely on the documentation of Aduwo *et al.,* (2017), housing transformation Unah (2019) housing redevelopment Ibem (2012), physical developmental control, Jiboye (2011) urbanization challenges and housing delivery Ogundele (2011), Abdulazeez and Umar (2017) building setbacks Ilesanmi (2012) housing neighbourhood quality, Ndalai *et al*., (2017), contravention of planning regulations Ibem *et al.,* (Anosike) challenges in public building. Ogundele, *et al*. (2011) challenges and prospects of physical development control, Aluko (2011) sustainable housing development and functionality of planning laws, Goodfellow (2013) planning and development regulation amid rapid urban growth (Unah and Ibrahim (2021) building redevelopment and assessment of second house owner compliance, Adeponle (2013) integrated city as a tool for sustainable development Ibrahim (2013) assessment of the impact of contraventions of building regulations Unah (2021) urbanization and sustainable growth of urban Kano, Unah (2021) urban growth and sustainable development of the built environment, Ibrahim and Raji (2018), sustainable green building public awareness, Silva (2012) urban planning in Sub-Saharan Africa, Ibrahim and Gyoh (2018) development control practices, Ibrahim and Mai (2020) effect of contraventions of building regulations on the quality of built environment, Maiwada (2000) disappearing open spaces in Kano metropolis, Maiwada (2016) urban planning in the context of rapid growth, Maigari (2018)housing among the low income groups Unah and Ibrahim (2019) urbanization and development control management of sustainable growth,

Unah and Muktar (2020) spontaneous settlement at the peri-urban fringe, Unah and Abubakar-Kamar(2020) urban green spaces in Kano City

3. Factors responsible for Controlling Physical Development in Kano

Large scale building contravention are more in part of Kano environs and are major challenges to sustainable built environment satisfaction in most part of the city metropolis which posed significant challenge to environmental sustainability of the built environment (Unah and Ibraim, 2021; Amao and Ogunlade, 2015). This Factors responsible for failed urbanization controlling the physical development in Kano are as followed:

Weak Urban Planning: Weak urban planning in northern Nigeria is a reflection of the sub-Saharan Africa "Urban planning and Master Plans have lost their meaning in many Africa Cities Zakka *et al.,* (2022), have a master plan, but many of the plans are out dated. This has created an enabling environment for spontaneous informal growth (Unah and Murtkar, 2020) in the peri-urban areas. Informal and uncoordinated growth are the destruction of urban natural resources embeds in the green open space (Maiwada 2014).

Duplication of Planning Regulation: Apparent rivalry exist among that professional regulatory bodies in the state and silent compromises by the operatives in the discharge of their respective duties may lead to a decline in the quality of built environment. Ibrahim and Mai (2020) averred the manifestation of these inter-disciplinary encroachment, and tactical, but gradual sacrifice of environmental standards, just for consideration (cash or kind). Issues of duplication of duty lies silently in physical development contraventions include, effectiveness of building regulations on the quality of built environment. Zoning regulations which do not take the need and requirement of the people into account, problem of building plan approval procedure? Regulatory laws are not enforceable and thereby neglected by all Ibrahim and Mai (2020).

Subdivision and development of land (plots): Illegal development arises mostly in local customary title layouts therefore outside the authority jurisdiction (control) (Ibrahim, 2018). This subdivision lands were acquired from farmers at the illegal areas on the urban periphery. They are, however spontaneous and unplanned form of development. This settlement remained poorly related physically to motor able access to build plots, public facilities such as drainage and building setbacks.

Influx of rural-Urban immigrants-This low-income group migrate to cities originates from smaller peri**–**urban centers, of rural areas, leading to urban expansion of informal low-income housing development on fragmented plot sizes. This has led to masses living in urban slum and unhealthy buildings characterized by environmental conditions, basically unplanned substandard housing, overcrowding, poor drainage network (Maigari, 2018).

Land Tenure System in Kano– This has greatly influenced the physical development pattern in an uncoordinated manner that deals without consultation of the planning authorities (Unah, 2021). These practices have contributed to the distorted and unauthorized physical development where haphazard and uncontrolled physical in Kano and environs is influencing by late planning preparation in Kano metropolis

Environmental pollution-Kano city is facing the challenge of inefficient waste management practices due to the lack of appropriate uncollected municipal indiscriminate waste disposal and the growing number of open dumpsites such; Gandun Albasa by Zoo Road, Mopol Barracks by Hotoro road, Kofar-Ruwa.

Sprawling informal suburban development-The inadequate capacities of institutions in Kano permit poor anticipation of urban population growth which has led to the growth of informal suburban development in cities to absorb the pressure of unprecedented urbanization on the built environment. Dankani (2016) averred this growth as being informal, un-regulated and unplanned development with poor services which depicts poor settlement of low-income environment. An attributed capacities of planning institutions inadequacy to providing plans and services that will shape the growth and development of the suburban settlements. However, urban growth in the sub-Saharan region has always been synonymous with sprawling (Zakka *et al.*, 2022)

Urban Heat Island Effect-This trend of growing informal activities on designated open spaces and disappearing of open green corridors (Maiwada, 2014, 2016), impact of urban heat island. These challenges have seemed Kano cities being characterized by extensive predominance of hard surface. The resultant effect from externalities of it built environment has continue to inhibit the defacing functioning. The challenges of cleaning and greening of cities are

less obvious, because institutional capacities to implement the provision of plans abound and are effective. (Unah *et al.,* 2024) opted revitalization of vegetative enclaves for restoration of the metropolitan urban heat effect.

Traffic Congestion-The unprecedented urban population growth in cities has been effected with increasingly unequivocal mobility in cities that is a critical enabler of economic growth and development (Dankani, 2016).The proliferation of automobile permissive environment is always high due to uncontrolled traffic roadways by informal activities and generation of wastes on the streets by street hawkers and itinerant by cumulating traffic congestion and go-slow as this impact on travel time and transport related air pollution and greenhouse gas emissions.

4. Methodology

4.1 Study Area:

This study involves the planned areas of Kano metropolis (Ibrahim and Mai, 2020) which stand as the commercial and epi-center of Northern Nigeria since the 18th century. It is a mega-city inhabited largely by Hausa-Fulani Muslims which urbanization was influenced by early local civilizations in the Western African sub-region savannah zone (Urquhart, 1977). Kano State comprises of 44 Local Government Areas (LGA) and the metropolitan is composed of Seven LGA‟s, namely: Kano Municipal, Dala, Fagge, Nassarawa, Ungogo, Kumbotso and Tarauni. The built environment is characterized by a combination of formal (planned) setting manifests in the Government Residential Area (GRA), SabonGari (Hausa term for new settlement). Kano and Fagge was recognized as the traditional native areas; SabonGari was labelled as the African non-indigene area; Fagge-Ta-kudu classified as the Arabian natives' area, while Bompai, Nassarawa GRA and the railway areas alongside its environs considered as the European areas (Barau, 2011). mostly inhabited by migrants, especially, from the South Western and South Eastern Nigeria among others and informal setting is found in the walled city, peripheral areas of the city and some areas lately settled by the indigenes-built environment (Ibrahim and Mai, 2020).

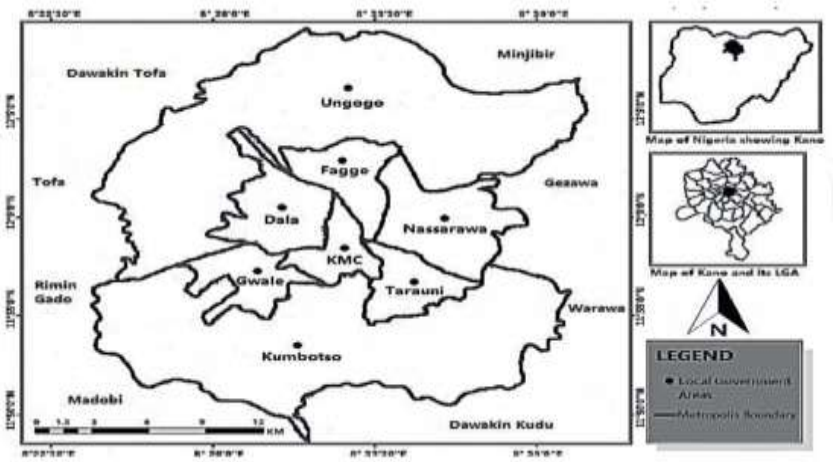

Figure 1. Map of Kano Metropolis and its surrounding LGAs.

4.2 Methods

The research was largely based on field survey employing qualitative techniques approached by developing a set of survey questionnaire using observational schedule checklists derived from literature on and performance attributes as key assessment of factors responsible for uncontrolling physical development criteria on urban growth management in Kano metropolis from residents' perception of the externality-built environment participatory approach (Sagada, 2016). The research uses ten (10) rated Likert items on a five-point scale, 1 being high positive impact to 5, high negative impact., were seventy-five (75) questionnaires targeting at metropolis were distributed to respondents. Sixty- nine (69), accounting for 92% of the number of distributed questionnaires were retrieved. The descriptive and inferential statistics techniques were used to analyze collected data gathered and each coded response was multiplied by number of respondents, which gave the Weighted Value (WV).

Equations is mathematically expressed as

$$RII = \frac{1n1+2n2+3n3+4n4+5n5}{5N} \quad \ldots\ldots(1)$$

Factors with RII of 0.7 and above were considered *"high negative Impact* "in this study. These correspond to ratings in the first quartile range (75% and above). RII values between 0.60 and 0.69 corresponding to the second quartile (50%-74%) are considered "negative Impact" RII values between 0.50 and 0.59 corresponding to the third quartile (Vanduhe, 2012) in this study.

Table 1: Likert Scale

Range	Interpretation	Quartile
0.7 - 0.80	High Negative Impact	First
0.6 - 0.69	Negative Impact	Second
0.5- 0.59	Positive impact	Third

Vanduhe (2012)

5. Discussion

Frequency distribution of variable under study including summation of the Weighted Values (ΣWV) was divided by number of respondents (n) to arrive at each component Mean Weighted Value (MWV). The rating of all the factors for the degree of significance was based on the value of their respective Relative Importance Index (RII). This is used to Rank the level of Interpretation the respondents attached to the variables affecting the built environment. The distribution of Standard deviation across the built environment variables indicates that the result from the study can be generalized from the study population.

Table 2: Factors responsible for Uncontrolling Physical Development in Kano Metropolis

Attributes	MWV	STD	RII	Rank	Interpretation	Quartile
Weak Urban Planning	3.88	.0562	0.78	1st	high negative impact	First
Subdivision of plot	3.82	.0553	0.76	2nd	high negative impact	„
Traffic Congestion	3.68	.0533	0.74	3rd	high negative impact	„
Environmental pollution	3.57	.0517	0.71	4th	high negative impact	„
Duplication of regulatory	3.53	.0511	0. 70	5th	high negative impact	„
agencie	3.39	.0491	0.68	6th	negative impact	second
Urban Heat Effect	3.17	.0459	0.63	7th	negative impact	„
Landscape distortion	3.14	. 0455	0.62	8th	negative impact	„
Sprawling informal dev.	3.06	.0443	0.62	9th	positive impact	Third
Land Tenure System	2.50	.0362	0.50	10th	positive impat	„
Rural-Urban immigrants						

Source: Author Fieldwork, 2023

5.1 Result and Discussion

Table 2 showed the factors responsible for uncontrolling physical development in Kano Metropolis. The study analysis ten (10) key performance indicators as identified from literatures. Result from the survey revealed five attributes in the first quartile to be weak urban planning, ssubdivision of plot, traffic congestion, environmental pollution, Duplication of regulatory agencies were ranked 1st and 2nd 3rd,4th and 5th, with arious mean weight scores (MWS) = 3.88, 3.82, 3.68, 3.57 and 3.53. Their respectively R.I.I range between (0.70-0.80) see Table 1. This are interpreted to have high negative impacts on the built environment. Mai (2008) posited formal housing delivery system seems to be too weak to meet the demands of enforced planning. In order to maintain the built environment satisfaction in most part of the city metropolis which posed significant challenge to environmental sustainability (Zakka *et al.,* 2022), opted that Urban planning and Master Plans implementation that are out dated needs to be review. This has remained the case of Kano and a reflection of many Nigerian states that is responsible for failed urbanization controlled of the physical development. Abubakar and Doan (undated) avers that government policies places much emphasis on physical segregation of the poor from the wealthy elites in city development of infrastructure. Unah (2021, 2019, Unah and Ibrahim ,2019) reported that urban growth and sustainable development of the built environment has weak government polices intervention, that is responsible for the mode of urbanization which has negative impacts on ssubdivision of plot, resulting on building congestion of urban slum houses in metropolitan districts and the disruption of the livelihood of the people in the informal sector. Issues of duplication of duties of regulatory agencies lies silently in physical development contraventions which include, effectiveness of building regulations on the quality of built environment. Ibrahim and Mai (2020) Maigari, (2018) posited that regulatory laws are not enforceable and thereby neglected by all. The second quartile has Urban Heat

Effect, Landscape distortion and sprawling informal development were rank 6th, 7th and 8th with MWS 3.39,3.17 and 3.14 with R.I.I range between (0.6 - 0.69). They are having negative impact on uncontrolling physical development in Kano Metropolis. Maiwada (2014,2016) opted the growing activities on informal designated open spaces has impacted on urban heat island following disappearing of open greeneries corridors The inadequate capacities of institutions in Kano permit poor anticipation of urban sprawling of informal suburban development that encourages population growth. This is responsible for the growth of informal suburban development in cities to absorb the pressure of unprecedented urbanization of development (Unah and Murtkar, 2020) of the peri-built environment. Amoateng *et al., (*2013) asserted that the built environment of has always experience uncontrolled physical development, that is responsible for high-rate physical growth factors that are locally based.

The metropolitan Kano today is without any ample green spaces (Mawada 2014, 2016, Unah 2020, 2021, Unah *et al*., 2024, Unah and Abubakar-Kamar, 2020), Some of these vegetative urban spaces have been misused and built-up as a result of urban expansion. The third quartile has land tenure system, rural-urban immigrants, sprawling and spontaneous informal growth and development with MWS 2.87, 2.61 and 2.50 with respectively and R.I.I range between (0.5- 0.59). Buildings are constructed on larger scale contravention as a result of land tenure system that are more recognised with people customary practices in Kano and environs. Dankani (2011, 2016) assented that this has remains a major challenge of uncontrolled urban growth with implication for planning and infrastructural development. Dankani, (2016) averred this growth as being informal, un-regulated and unplanned development with poor services which depicts poor settlement of low-income environment. An attributed capacities of planning institutions inadequacy to provide plans services and implementation that will shape the growth and development of the suburban settlements.

7. Conclusions and Recommendation

The paper highlighted that the built environment has experience uncontrolled physical development in metropolitan Kano. Undoubtedly, northern Nigeria's largest city has faced the most contemporary problem identified as urban population growth has induced the physical development that has changes the built- up area uncontrollable. The fact that different relevant government planning authorities' inabilities in chasing controlled of physical development of the city's growth and expansion that has contributed to city harhazard development. The finding of this study identified the expansion of the city being influenced by weak urban planning, duplication of planning regulation, subdivision and development of land (plots), influx of rural-urban immigrants, sprawling informal suburban development, urban heat island effect: as socio-economic developments in Kano that are potential driver of the rapid induced failure in controlling physical development growth and management strategies. Based on findings from the study the following regulatory approaches are recommended as strategies for control the physical development toward achieving a sustainable built environment that will impact quality life.

7.1 Strategies for Effective Controlling of Physical Development.

Decision on Commercial Street: Due to demand in building for commercial purposes as a response to pressure for spaces for commercial, religious, educational and other complimentary services, developers illegally changed the uses of their buildings (Unah 2020, 2021, Unah *et al.,* 2024, Unah and Ali, in-press) e.g. Zoo Road, Ibrahim Taiwo road. The impacts of these changes on the streetscape have been tremendous through the attraction of traffic to such environments beyond the designed capacities for the roads. This change in use has resulted in traffic congestions, hawking, noise and other nuisances have also been attracted to these environments.

Informal development and activities on designated open spaces: Uncontrolled urbanization has consequence on informal growth and activities such as 'on-street trades' and hawking on designated streets road junctions and urban green open spaces. These activities generated the flow of un-anticipated vehicular and pedestrian patronages. This requires infrastructure on the streets to improved and accommodate the changes introduced.

Corner Shops and Structures in Green areas and Flood Plains. Kano metropolitan city today is without any ample open greeneries spaces (Mawada 2014, 2016, Unah 2020, 2021, Unah *et al.,* 2024, Unah and Abubakar-Kamar, 2020), Some of these vegetative urban spaces have been misused and built-up as a result of urban expansion, which has impacted negatively on the relationship between the urban dwellers and the natural environment. Example are the perimeter ancient old city walled (Unah un-date). This Private individual that are threat to the wall used them as a veritable cheap raw material for moulding sun dried mud blocks and direct quarrying of sand from the wall for construction of houses.

Structures on Sites for Community Facilities and Services. These are structures located on various sites designated for community facilities, ancestral prayer ground, and perimeter reserve green about the old city wall. They were made to give way to enable restoration of great tourist sight.

Revoked Plots. Revocations of titles to land by designated authority are necessary on plots who's earlier allottees violated aspects of conditions for the right of occupancy or for purposes of overriding public interest. This illegal structures and slums built on transit way corridor and expressways should be identified and removed.

Physical Development on Circulation Areas and Parking Lots within Markets: Erection of structures on parking lots and areas meant for circulation in major markets include the famous Kurmi market, Sabon Gari market, Kantin Kwari market, Dawanau market, and Kwanar with the majority of its populace and in-migrants engaging in a large volume of trading activities in various markets in the city. This has led to over-crowding, congestion and threat to public safety in the markets. These illegal structures mostly steel containers identified and be removed.

Unapproved Change of Land Use by developers: This became rampant and it created inhibitions to the implementation of the Master Plan. Areas earmarked for residences, schools, health facilities and recreational purposes were largely sacrificed there by heightening the non-availability of or inaccessibility to accommodation, basic social facilities and leisure outlets. The effective performance of the schedules of the regulatory bodies has not given the City the level of sanity and cleanliness it deserves. To this effect the regulatory bodies has to embark on demolitions of illegal developments to keep the city clean has been a continuous process with the Development Control Department. surplus population new towns had to be created known as satellite town, i.e such as settlement outside city wall Sharada, Dorayi, Fagge, Kura, D/Kudu, RimiGado, Challawa, Dawanau, Bichi, Minjibir, Gezawa, Mariri (Nabegu and Mustapha, 2014).

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Conceptualization of Architectural Forms Using Critical Thinking and Design Thinking for Generating Design Ideas

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Abstract

This study investigates the impact of critical thinking (CT) and design thinking (DT) instruction on the architectural design process among students at Najran University. An experimental design compared two groups: one receiving targeted CT and DT training and a control group without such instruction. Both groups were tasked with designing a Masjid, and their designs were evaluated based on creativity, functionality, spatial quality, and contextual relevance. The research aligns with two of the UN's Sustainable Development Goals (SDG 4: Quality Education and SDG 9: Industry, Innovation, and Infrastructure). Results indicate that the experimental group, enhanced by model-making and critical thinking exercises, produced designs that were significantly more innovative and contextually responsive. Quantitative analysis revealed that this group scored, on average, 25% higher in creativity metrics compared to the control group. These findings underscore the essential role of CT and DT in fostering creative architectural solutions and suggest their integration into undergraduate architectural curricula to better equip students for complex, real-world challenges. The study further supports the premise that critical thinking serves as a foundational element of the design thinking process.

Keywords: Architectural Form; Critical Thinking; Design Thinking; Generating Design Ideas

1. Introduction

The integration of critical thinking (CT) and design thinking (DT) in architecture is crucial in addressing real-world complexities by combining analytical rigor with creative ideation. Critical thinking encourages architects to systematically analyze site-specific constraints, regulatory frameworks, and cultural contexts to develop solutions that align with structural and social requirements (Casakin & Wodehouse, 2021). This process enables them to scrutinize and question traditional design paradigms, encouraging informed decision-making that responds dynamically to environmental, material, and spatial challenges (Blaikie & Buys, 2023). In parallel, design thinking prioritizes a user-centered, iterative approach—engaging empathy, ideation, and prototyping to create spaces that are functional, aesthetically pleasing, and adaptable to users' evolving needs (Zuo *et al*., 2020). Together, CT and DT provide a balanced framework that equips architects with the tools to address the multifaceted challenges of modern design, from sustainability to user engagement, allowing for innovative yet practical design solutions.

However, there is a significant research gap regarding how effectively architectural education prepares students to balance these two approaches. While design thinking has gained traction in design pedagogy, fostering a holistic understanding of both CT and DT in architectural education remains underexplored (Park & Lee, 2022). This paper addresses this gap by examining how blending CT and DT can enhance problem-solving skills and design outcomes, especially when navigating complex, real-world architectural challenges. By examining the complementary roles of CT and DT, this study seeks to develop an educational framework that could better equip future architects to meet both aesthetic and functional demands, ultimately leading to spaces that are resilient, user-friendly, and sustainable.

2. Theories

In the context of architectural education, Sustainable Development Goal (SDG) 4 and SDG 9 can significantly benefit from integrating critical thinking (CT) and design thinking (DT) into training programs, as these approaches cultivate essential skills for sustainable development.

Sustainable Development Goal 4: Quality Education

Target 4.7 under SDG 4 highlights the need for educational programs that empower students to contribute to sustainable development by building knowledge in areas such as human rights, gender equality, and global citizenship. By fostering CT and DT, architectural education aligns with these objectives, enabling students to critically assess and creatively approach challenges like environmental sustainability, equity in design, and cultural inclusivity. For instance, CT encourages students to question and evaluate traditional architectural practices, while DT introduces a problem-solving mindset that prioritizes empathy, prototyping, and iterative learning. Integrating these skills in architecture helps future architects understand the broader social implications of their work and develop solutions that reflect sustainability and inclusivity (Park & Lee, 2022; Casakin & Wodehouse, 2021).

Sustainable Development Goal 9: Industry, Innovation and Infrastructure

SDG 9 emphasizes the need for resilient infrastructure, sustainable industrialization, and innovation, with targets 9.1 through 9.4 highlighting the importance of critical and design thinking in addressing these goals. For instance, Target 9.1 focuses on developing sustainable infrastructure, while Target 9.4 emphasizes upgrading existing infrastructure to enhance sustainability. Incorporating CT and DT into architectural education equips students to meet these goals by teaching them to rigorously analyze material impacts, energy efficiency, and the durability of designs (Blaikie & Buys, 2023). These competencies encourage architects to innovate in materials and construction methods, promoting designs that align with sustainable industrialization and climate action. Thus, by grounding architectural education in CT and DT, students gain the skills necessary to drive sustainable infrastructure development, supporting economic growth and environmental sustainability (Zuo *et al*., 2020; Anderson *et al*., 2021).

Figure 1 The UN 17 Sustainability Developmental Goals SDGs (World Sustainability Collective 2024)

Figure 2 Selected SDGs (World Sustainability Collective 2024)

These approaches demonstrate how CT and DT in architectural education are essential for meeting the sustainability targets set by SDG 4 and SDG 9, empowering students to design future-oriented solutions for a rapidly changing world.

3. Problem Statement

Despite the emphasis on creativity in architectural education, there remains a significant gap in integrating critical thinking (CT) and design thinking (DT) as structured methodologies. These approaches, while essential for addressing the complex, evolving demands of modern architectural practice, are often applied inconsistently in design curricula (Anderson *et al*., 2021; Casakin & Wodehouse, 2021). This research identifies a need for a cohesive

framework in architectural education that blends CT's analytical rigor with DT's user-centred, iterative problem-solving approach. Without structured exposure to both methods, students may lack the necessary skills to create innovative yet practical designs that are resilient, sustainable, and responsive to user needs.

The primary objective of this research is to evaluate the effectiveness of combining CT and DT in architectural education, aiming to establish a balanced pedagogical model that enhances students' ability to address real-world design challenges. To achieve this, the study will test the hypothesis that an integrated CT and DT framework in design education leads to improved problem-solving skills, greater design innovation, and enhanced ability to respond to user and environmental needs. By investigating this approach, the study seeks to bridge the current gap in design pedagogy, equipping future architects with a comprehensive skill set for contemporary practice (Zuo *et al*., 2020; Blaikie & Buys, 2023).

4. Methodology

This study employed an experimental design to assess the impact of integrating critical thinking (CT) and model-making instruction on architecture students at Najran University. The research involved 6 undergraduate students, randomly assigned to either an experimental group (3 participants) or a control group (3 participants). The experimental group received targeted training in critical thinking and model-making techniques over a period of one week, while the control group participated in standard architectural design coursework without any specific instruction in these areas. Participants were selected based on their enrolment in the architecture program, ensuring a uniform baseline of design knowledge.

Both groups were tasked with designing a Masjid, following the same design brief and given an equal timeframe of three weeks to complete their projects. To monitor the design process, weekly check-ins were conducted to assess progress and provide feedback. This structure allowed for consistent evaluation of both groups during the development of their designs. The resulting designs were evaluated using a rubric that assessed creativity, functionality, spatial quality, and contextual relevance. Creativity was gauged through originality and innovation in design, while functionality was assessed based on usability and adherence to the design brief. Spatial quality evaluated the effective use of space, and contextual relevance considered how well the designs responded to cultural and environmental factors (Blaikie & Buys, 2023; Casakin & Wodehouse, 2021).

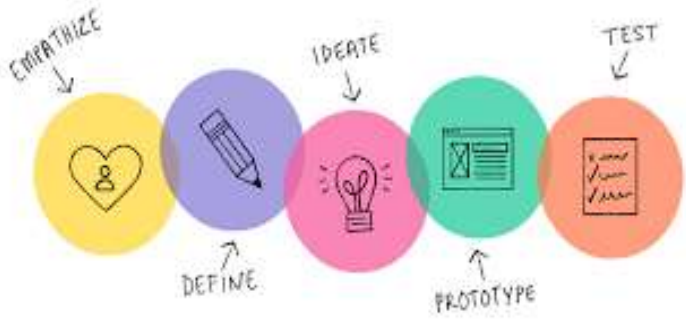

Figure 3: The design thinking process (Lieberman, 2020)

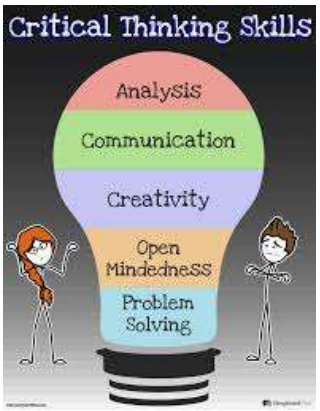

Figure 4. Developing Critical Thinking Skills (Ayube, 2024)

Data analysis involved both quantitative and qualitative methods. For the quantitative aspect, a paired t-test was conducted to compare the design scores of the experimental and control groups across the evaluation criteria. Qualitative feedback from design mentors and peer assessments were analyzed thematically to gain insights into the perceived benefits of CT and DT integration in the design process (Anderson *et al*., 2021; Zuo *et al*., 2020). This comprehensive approach allowed for a robust analysis of the impact of CT and DT on design outcomes, contributing valuable findings to the field of architectural education.

5. Results

5.1 Control Group (Without Critical Thinking and Model-Making Instruction)

The control group's designs primarily relied on basic geometric shapes, exhibiting limited architectural complexity. Their average evaluation scores across the criteria were as follows: creativity (4.2/10), functionality (5.0/10),

spatial quality (4.5/10), and contextual relevance (3.8/10). These scores indicate a basic understanding of spatial arrangements but reflect a lack of innovative design thinking. The models showcased standard rectangular forms with minimal variation, leading to flat layouts that did not effectively integrate different mosque functions. Additionally, there was little consideration for the cultural or environmental context, resulting in designs that did not respond to local traditions or site-specific conditions (Blaikie & Buys, 2023).

Figure 5a

Figure 5b

Figure 5c

Figure 5: Design Result of the Control Group (Source: Author)

5.2 Experimental Group (With Critical Thinking and Model-Making Instruction)

In contrast, the experimental group produced designs characterized by innovative, non-traditional forms, resulting in higher average evaluation scores: creativity (8.5/10), functionality (7.5/10), spatial quality (8.0/10), and contextual relevance (7.2/10). The designs exhibited greater architectural complexity, with angular and dynamic forms that demonstrated critical thinking in the conceptualization of the Masjid. The models as illustrated in figure 6a-6c below suggested thoughtful exploration of internal and external interactions, indicating a deeper engagement with contextual adaptation in response to environmental and cultural factors.

Figure 6a

Figure 6b

Figure 6c

Figure 6: Design Result of the Experimental Group (Source: Author)

Statistical analysis revealed a significant difference between the groups. A paired t-test showed that the experimental group's scores were significantly higher than those of the control group across all evaluation criteria ($p < 0.01$), confirming that the integration of critical thinking and model-making instruction positively impacted design outcomes. This improvement aligns with the broader objectives of the research, highlighting the necessity of structured CT and DT methodologies in architectural education to foster innovation and creativity among students (Anderson *et al*., 2021; Zuo *et al*., 2020).

6. Discussion & Conclusion

This study demonstrates that integrating critical thinking (CT) and design thinking (DT) into architectural education significantly enhances creativity, spatial awareness, and contextual responsiveness among students. The experimental group, which received explicit instruction in CT and DT, produced innovative designs characterized by architectural complexity and thoughtful integration of contextual elements. In contrast, the control group relied on conventional design methods, resulting in less imaginative outputs that failed to engage deeply with the architectural challenges presented. The findings underscore the necessity of incorporating CT and DT into undergraduate architecture programs. By fostering these methodologies, educators can encourage students to

question traditional design assumptions and develop practical, user-centered solutions that address real-world challenges. The positive outcomes observed in the experimental group align with contemporary educational paradigms that advocate for holistic learning approaches, promoting not just technical skills but also critical and creative capacities.

Moreover, embedding CT and DT into architectural curricula can significantly contribute to broader educational goals, such as achieving Sustainable Development Goals (SDGs) related to quality education (SDG 4) and innovation (SDG 9). By preparing students to think critically and design innovatively, architectural education can play a crucial role in shaping a sustainable future, where architectural solutions are responsive to societal needs and environmental contexts. In conclusion, the integration of CT and DT is not merely an enhancement of the curriculum but a vital strategy for producing future architects equipped to tackle the complexities of contemporary design challenges.

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The Role of Sustainable Interior Design in Advancing Saudi Arabia's Vision 2030: Barriers, Strategies, and Case Study Insights

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Abstract

This study investigates the integration of sustainable design practices in Saudi Arabia's construction sector, employing a dual methodology of literature review and case study analysis. As the Kingdom works toward the goals of Vision 2030, sustainable construction practices—such as the use of eco-friendly materials, energy-efficient designs, and advanced building technologies—are highlighted as critical for reducing the industry's environmental impact. However, significant challenges remain, including regulatory constraints, limited awareness, and cultural attitudes toward sustainability. Through an examination of existing literature and specific case studies, this research proposes strategies for overcoming these challenges, such as promoting sustainability education and strengthening policy frameworks that encourage innovation. The findings aim to provide actionable insights for industry stakeholders, supporting practical applications that align with global sustainability standards and foster a collaborative approach to sustainable development in Saudi Arabia's construction sector.

Keywords: Construction; Cultural Sustainability; Ecological Footprint; Energy Efficiency; Innovative Materials; Saudi Vision 2030; Sustainable Construction; Sustainable Development.

1. Introduction

Since the inception of Saudi Arabia's development process, sustainable development has been a critical focus, reflected in the Kingdom's long-term strategic direction. This focus has been progressively implemented through successive five-year development plans, starting in 1970. These plans have prioritized building the capabilities of citizens, meeting their needs, and improving their standard of living, as citizens are the central beneficiaries of sustainable development. The development strategy extends across social and economic sectors in all provinces, guided by Islamic principles, economic freedom, and a balanced integration of economic, social, and environmental dimensions. Over the years, Saudi Arabia's development plans have led to significant social and economic progress. This is evident in the country's continued high economic growth, a favorable environment for private sector expansion, and enhanced global competitiveness. Additionally, the Kingdom has developed an advanced socio-economic infrastructure and continually improved health, education, and environmental services for its citizens (Sustainable Development Goals 1st Voluntary National Review, 2018)..

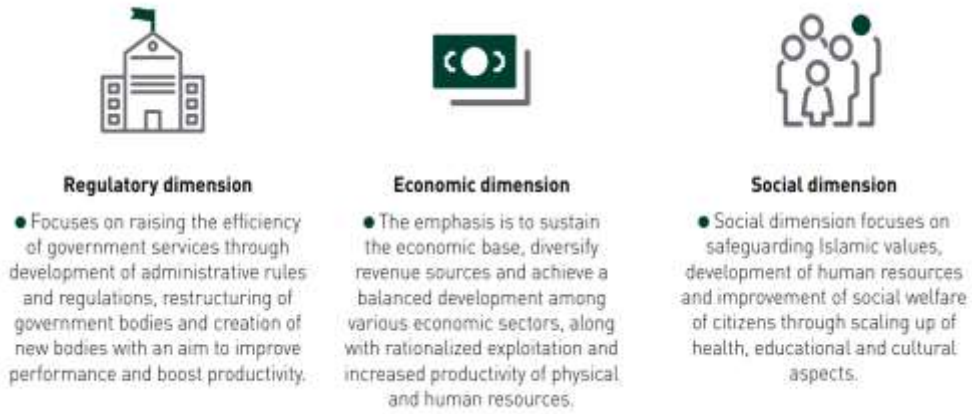

Figure 1: Pillars of Saudi Vision 2030 (SDG, 2018)

Sustainable design has become a global priority, addressing the environmental challenges posed by traditional architectural practices. At its core, sustainable design emphasizes energy efficiency, environmental responsibility, and cultural responsiveness. A significant aspect is the integration of energy-efficient systems and renewable energy sources, which help reduce carbon emissions and reliance on non-renewable resources. This approach includes the use of low-impact materials, such as recycled or sustainably sourced products, and energy-efficient processes that minimize the environmental footprint (Al-Sarihi, 2018; Papanek, 2016). Furthermore, waste reduction is another key element, achieved through practices like recycling, biodegradability, and material reuse (United Nations Environment Programme, 2017).

Globally, the focus on environmental responsibility has driven a shift toward circular economies, where materials are used more efficiently and waste is minimized. Sustainable designs also aim to protect biodiversity by minimizing the impact of construction on natural habitats. For instance, bio-based materials and renewable resources are increasingly used to replace traditional, resource-heavy materials such as concrete and steel (Papanek, 2016). These approaches help reduce pollution and conserve natural ecosystems, ensuring that future generations can continue to benefit from environmental resources (Sustainable Development Goals 1st Voluntary National Review, 2018).

Cultural responsiveness in sustainable design is especially relevant in regions like Saudi Arabia, where traditional building techniques and materials are incorporated into modern construction. This not only honors local heritage but also ensures that designs are better suited to the environmental conditions of the region. For example, in desert climates, vernacular architecture that incorporates natural cooling techniques can significantly reduce energy consumption (Al-Sarihi, 2018). This integration of sustainable practices with cultural traditions demonstrates that sustainable design is not a one-size-fits-all solution but one that must be tailored to regional and cultural contexts (Papanek, 2016).

In the context of Saudi Arabia's Vision 2030, sustainable interior design plays a crucial role in aligning the Kingdom's infrastructure with its goals for environmental stewardship, economic diversification, and social development. By adopting sustainable design principles, Saudi Arabia can create energy-efficient, culturally resonant interiors that reduce environmental impact while promoting the well-being of its citizens. This vision supports the broader goals of global sustainability by ensuring that growth in the built environment does not come at the cost of ecological degradation or cultural disconnection (Sustainable Development Goals 1st Voluntary National Review, 2018; Papanek, 2016).

2. Methodology

This research employs a dual-method approach, combining a Critical Literature Review with a Case Study analysis to provide both theoretical and practical insights into sustainable interior design within the context of Saudi Arabia's Vision 2030. In the literature review, current academic and industry sources are examined with a focus on themes of energy efficiency, eco-friendly materials, and culturally responsive design (Foster *et al*., 2020; UNEP, 2019). This review not only positions Saudi Arabia's Vision 2030 within a global framework of sustainable design principles but also identifies specific gaps, especially regarding the environmental and social objectives of Vision 2030 (Alyami & Rezgui, 2012). Findings from the literature review are then integrated with case study insights to enhance methodological rigor by highlighting critical intersections and discrepancies between theory and practice. The case study is selected based on criteria that ensure alignment with Vision 2030 sustainability goals, including the project's use of locally sourced materials, cultural relevance, and energy efficiency strategies (Alghamdi *et al*., 2019). To ensure analytical depth, an analytical framework encompassing cultural, environmental, and economic dimensions is used to assess each case study's contributions to sustainable development. This integrated approach ensures that findings from both literature and case studies provide a holistic understanding of sustainable design's potential for supporting Saudi Arabia's long-term goals.

3. Results

3.1 Literature Review Findings

Energy Efficiency

Energy efficiency in sustainable interior design encompasses a range of strategies that minimize energy consumption and emissions, directly contributing to Saudi Arabia's Vision 2030 goals. A primary approach is passive solar design, which utilizes natural light and heat to reduce reliance on artificial climate control. This is especially pertinent in Saudi Arabia's arid environment, where optimized window placement and thermal mass can significantly cut cooling demands (Alyami & Rezgui, 2012). Such methods align with global sustainability standards, integrating environmental needs with Saudi Arabia's ambition for reduced energy dependence and economic growth.

Additionally, advancements in Heating, Ventilation, and Air Conditioning (HVAC) systems play a critical role. Modern systems such as Variable Refrigerant Flow (VRF) offer precise climate control, adjusting automatically based on occupancy and climate. Such systems enhance energy efficiency by reducing operational loads, which is crucial in commercial and residential settings in Saudi Arabia (UNEP, 2019). The Green Riyadh Project, a major Vision 2030 initiative, reflects these principles by promoting urban greening to reduce temperatures, absorb CO_2, and lessen energy loads across Riyadh (RTF, 2023). Furthermore, the Saudi Energy Efficiency Program has implemented policies to advance building energy codes, advocate for efficient technologies, and educate the public on energy conservation, demonstrating Saudi Arabia's commitment to creating an energy-conscious society (Saudi Energy Efficiency Center, 2021).

Material Selection and Eco-Friendly Practices

Material selection in sustainable interior design prioritizes eco-friendly options that align with Saudi Arabia's Vision 2030 goals, balancing environmental impact and cultural integrity. Eco-friendly materials are those that minimize resource use, waste, and pollution throughout their lifecycle. In Saudi Arabia, utilizing locally sourced and recycled materials reduces transport-related emissions while supporting local industries. Revival of traditional building materials such as mud bricks and stones illustrates this trend, as these materials not only lower carbon footprints but also enhance durability in local climatic conditions (Alghamdi *et al*., 2019). By integrating these materials, Saudi Arabia merges traditional building practices with modern sustainability goals.

Modern eco-materials, including bamboo, reclaimed wood, and recycled metals, also offer viable solutions, meeting global sustainability standards while incorporating aesthetic and practical advantages. These materials promote resource efficiency, offer thermal benefits, and support LEED (Leadership in Energy and Environmental Design) certification requirements, which Saudi building codes increasingly encourage (Saudi Green Building Council, 2021). In doing so, Saudi Arabia follows global practices that value sustainable materials, reinforcing Vision 2030's commitment to sustainable urban development.

Cultural Responsiveness

Culturally responsive design is essential for sustainable practices that align with Saudi social norms and environmental needs. In the Saudi context, integrating traditional design features—such as mashrabiyas, wooden screens that allow for airflow while providing privacy—bridges sustainability and cultural relevance. These elements support passive cooling strategies and improve comfort, reducing the need for energy-intensive air conditioning (Papanek, 2016). Such practices demonstrate that sustainability and cultural heritage can work in tandem to create functional, energy-efficient spaces.

Figure 2: Mashribiyya Screens (Esfahani, 2020)

Saudi Arabia's Vision 2030 promotes cultural heritage within architectural projects as part of its sustainable development plan. This approach emphasizes local resources and heritage design, creating spaces that foster a sense of belonging and respect for tradition (Alzahrani *et al*., 2020). Moreover, integrating cultural aspects in design encourages public acceptance and engagement, which are vital to the success of sustainable initiatives in urban areas. Globally, there is growing advocacy for culturally sensitive design as a pathway to sustainability, and Saudi Arabia's focus on heritage architecture positions it as a leader in this space (RTF, 2023). These findings highlight a multi-dimensional approach to sustainable interior design, emphasizing energy efficiency, eco-friendly materials, and cultural responsiveness. Together, they reinforce Saudi Arabia's Vision 2030 by advancing sustainable urban

growth, preserving cultural identity, and promoting environmental stewardship. Through these integrated design elements, Saudi Arabia can position itself as a leader in sustainable practices, contributing to climate action while honoring its cultural legacy.

3.2 Case Study Insights in UAE's Luxury Hotels: Lessons for Saudi Arabia's Vision 2030

The intersection of luxury and sustainability in the UAE's luxury hotel sector reveals significant insights that are crucial for Saudi Arabia as it works toward achieving its Vision 2030. Luxury hotels in the UAE face the challenge of reconciling opulence with eco-consciousness, a tension rooted in the perception that luxury inherently implies excess. Findings from Sadeghi Esfahani (2020) underscore this conflict, indicating that stakeholders often prioritize extravagant design over sustainable practices. This perception complicates efforts to integrate sustainability into luxury offerings, emphasizing the need for a cultural shift within the hospitality industry to align luxury experiences with environmental responsibility. The recognition that sustainability can coexist with high-end design is essential for creating a sustainable future in both the UAE and Saudi Arabia.

Figure 3: Sustainable Interior Design Practices in UAE I (Esfahani, 2020)

Moreover, the financial barriers associated with implementing sustainable practices further hinder the adoption of eco-friendly solutions in luxury hotels. The literature indicates that initial costs for sustainable materials and technologies are significantly higher than conventional alternatives, deterring hotel owners from embracing green innovations. Research by Reid, Johnston, and Patiar (2017) highlights that the focus on short-term financial viability often overshadows long-term benefits associated with sustainable practices, such as energy savings and reduced operational costs. This disconnect between financial considerations and environmental stewardship underscores the necessity for a paradigm shift among hotel investors and developers. By addressing these financial challenges and promoting the long-term value of sustainability, the luxury hotel sector can better integrate eco-friendly practices.

Figure 4: Sustainable Interior Design Practices in UAE II (Esfahani, 2020)

While resistance to sustainable practices persists, there is evidence of a growing awareness among manufacturers of luxury goods regarding the importance of sustainability. Sadeghi Esfahani (2020) notes that many luxury brands are now striving to produce sustainable products without compromising aesthetic appeal. This trend reflects a broader shift in consumer expectations, as travelers increasingly demand eco-friendly options and transparency regarding the sustainability practices of hospitality providers. This evolving landscape presents an opportunity for Saudi Arabia to cultivate a luxury hotel market that prioritizes sustainability, aligning with the country's broader objectives to reduce its environmental footprint and enhance its global competitiveness.

Aspect	Findings from UAE Luxury Hotels	Implications for Saudi Vision 2030
Luxury vs. Sustainability	Luxury hotels in the UAE often struggle to balance opulence with eco-conscious design. High-end aesthetics are commonly prioritized over sustainable practices, creating a perception that luxury implies excess (Sadeghi Esfahani, 2020).	Encourages a cultural shift within Saudi hospitality to redefine luxury as compatible with environmental responsibility, fostering a sustainable high-end market aligned with Vision 2030 goals.
Financial Barriers	Initial costs for sustainable materials and technologies are high, deterring adoption of eco-friendly solutions. Short-term financial priorities often overshadow potential long-term savings (Reid et al., 2017).	Promotes policy incentives or funding mechanisms in Saudi Arabia to address upfront financial barriers, enabling luxury hotels to embrace sustainable investments that offer long-term cost and energy savings.
Growing Sustainability Awareness	A shift is occurring among luxury brands in the UAE, with many manufacturers seeking to create sustainable products without sacrificing style, responding to increasing consumer demand for eco-friendly options (Esfahani, 2020).	Highlights an opportunity for Saudi Arabia to attract eco-conscious travelers by positioning sustainable luxury hotels as part of Vision 2030, boosting the nation's sustainable tourism and hospitality credentials.
Cultural Adaptation	Resistance to sustainable practices remains, yet there is growing awareness among stakeholders about the importance of sustainability (Reid, Johnston, & Patiar, 2017).	Suggests a need for Saudi Arabia to emphasize the cultural compatibility of sustainability in luxury, reinforcing that luxury and environmental stewardship can enhance cultural pride and identity in tourism development.

Figure 5: Summary of Case Study Insights (Author)

The lessons learned from the UAE's luxury hotel sector are invaluable for Saudi Arabia as it strives to realize the ambitions of Vision 2030. By acknowledging the cultural and financial barriers to sustainability in luxury design, Saudi Arabia can develop targeted strategies to promote eco-conscious practices within its burgeoning hospitality industry. Emphasizing sustainability not only enhances the appeal of luxury hotels but also contributes to the national goal of fostering a more sustainable future. The successful integration of sustainable practices into the luxury hotel sector can serve as a model for other industries, positioning Saudi Arabia as a leader in sustainable development in the region.

4. Conclusions

The analysis of sustainable practices within the luxury hotel sector in the UAE provides actionable insights for Saudi Arabia's Vision 2030 goals, emphasizing the integration of eco-friendly principles in luxury design and development. Key insights highlight the importance of policy support and strategic design principles that foster an industry-wide cultural shift, where luxury is no longer seen as contradictory to sustainability but rather complementary. To realize this transformation, policy frameworks could prioritize incentives for sustainable investments, such as tax reductions or grants for the use of sustainable materials and technologies. These policies can help offset initial

financial barriers, thereby encouraging hotel operators to adopt eco-friendly practices without compromising luxury.

Design principles, including energy-efficient HVAC systems, locally sourced materials, and passive cooling techniques, provide both economic and environmental benefits, creating spaces that are not only luxurious but also aligned with sustainability goals. In the long term, these measures offer extensive benefits: economically, they lower operational costs and attract environmentally conscious travelers; environmentally, they reduce resource depletion and carbon emissions; and culturally, they allow Saudi Arabia to create a unique luxury identity that resonates with national heritage. Additionally, by normalizing sustainable luxury, Saudi Arabia can build a brand that appeals to a growing demographic of eco-aware travelers, enhancing its competitive positioning in the tourism sector. In embracing sustainable luxury as a core component of Vision 2030, Saudi Arabia can create a tourism sector that exemplifies economic growth, environmental responsibility, and cultural preservation. This commitment to sustainability will not only enhance the appeal of Saudi Arabia's luxury offerings but also position the nation as a regional leader in sustainable tourism, setting a standard for balancing opulence with ecological integrity. Through this approach, Saudi Arabia strengthens its path toward a more resilient, environmentally conscious future, achieving long-term sustainability while contributing to global efforts to combat climate change.

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Effect of Infrastructure Proximity on residential Property Values in Minna, Niger State.

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Abstract

Housing as the fundamental need of man is desired by almost every household for numerous reasons including shelter, economic investment, social status and continuity amongst other growing and competing needs. The socio-economic characteristic of human makes the demand for residential property offering the highest utility more valuable. Improved neighbourhood condition and quality contributes substantially towards determining the market value of residential properties and owing to this fact, most prospective investors and tenants tend to seek for areas having adequate supply of basic infrastructure and amenities. Despite the rising need to secure housing in locations with good infrastructural development, there seem to be insufficient information on the impact of proximity on rental values in residential neighbourhoods. This study aims at assessing the effect of infrastructure proximity on property values with a view to establishing the relationship between distance from housing facilities and rental values. In order to achieve this, a systematic analysis of literatures from academic journals published from 2013-2023 was reviewed. Findings indicated that water facilities is the most significant in determining rental values followed by the availability of electricity. Distance to central business district (CBD) influenced most property values significantly, thereby making proximity to good road network to have the most effect with increasing distance per kilometre. It was recommended that real estate developer should make provision for water and electricity to optimize return and the government should provide good road network to enhance access to other supporting infrastructures such as hospital, schools, shopping centre and parks.

Keywords: Housing, Infrastructure, Location, Proximity and Rental values.

1. Introduction

Residential land use as one out of the many uses put to land, represents the single largest consumption of land accounting for about half of the total land area in urban centres (Anand *et al.,* 2010). The benefit of shelter to man as touching the provision of safety from adverse weather condition and attacks makes it the second most pressing in the hierarchy of needs after food (Ajibola *et al*. 2013). Housing as a concept exceeding the provision of shelter, comprises of complementary facilities and auxiliary services enhancing the wellbeing of humans (Randeniya *et al.,* 2017).

Housing choice at any given moment by a household is aimed at the maximization of utility (Usman *et al.,* 2015). Man's desire to take up residential units is influenced by his socio-economic nature, considering the fact that the demand and choice of residential property is dependent on the availability of infrastructure offering optimum benefit at affordable costs (Jimoh and Ige, 2017). The market value of a property is dictated by the attribute of the residential property and entire features of the environment (Adegoke, 2014).

A mix of complex factors including the composition (socio-economic characteristics) and context (facilities) of a place drives the value of residential properties (Coffee *et al*., 2018). In real estate investment decision, the location and features of a place serves as magnetic poles that influences property values (Otty *et al.,* 2023). House location with respect to distance from central business district (CBD), accessibility to transport facilities and basic neighbourhood services have huge impact on housing prices (Yan *et al.,* 2012).

The mantra "location, location, location" in real estate domain gives the suggestion that housing price is subject to the extrinsic and intrinsic features existing within a locality in terms of accessibility and environmental quality (Hongbo and Corinne, 2012). Information gathered on properties seem to lack quantitative information on spatial dimension of the environment (Hsu *et al*., 2012). Incorporating locational information into models by way of multiple regression analysis like hedonic pricing analysis takes into account the regional, local or neighbour specific attributes such as distance to CDB (Löchl and Azhausen, 2010).

Discussing the link between nearness of real estate users to neighbourhood services is important in identifying the trend in neighbourhood condition and how they collectively promote or detract property values. The aim of this

paper is assessing the effect of infrastructure proximity on residential property values with a view to determining the relationship between distance to housing facilities and rental values in Minna. The objective of the paper is to identity the significance of housing infrastructure in residential property value and to also establish the impact of infrastructure proximity on residential property value.

1.1 Problem

The geographic fixity of real estate as a unique commodity makes its utility, function and value to be influenced by infrastructure and other environmental goods (Famuyiwa and Babawale, 2014). As societies expand due to urban growth, it is envisaged that infrastructural supply will rise in response to the growing needs of dwellers (Udoka, 2013), however the escalating process of urbanization which ushered dynamic changes in the structure of cities have appeared not to be at par with the supply of infrastructural facilities and amenities in neighbourhood (Oluseyi *et al*., 2017). As a result of the low supply of neighbourhood infrastructure, great difficulties are encountered in terms of accessibility to services by real estate users.

In spite the importance of location and environmental features in a neighbourhood, the implicit value of housing facilities and services are not usually taken into cognizance (Yusof and Isamil, 2012), especially the factors affecting the complex process of housing selection which is left unknown in most cases (Usman *et al.,* 2015). Against this backdrop real estate agents, developers and property owners have become unaware of pertinent issues affecting investment decision (Randeniya *et al*., 2017).

There is a need to identify the amenities and services available in a given location, considering the fact that returns anticipated from an investment is a function of the location (Adeogun *et al.,* 2023). Examining housing performance cannot be carried out in isolation of ancillary services associated with its uses (Average and Dube, 2018). Therefore, this paper is focused on determining the influence of housing facilities on property values with a view to ascertain the relationship between proximity to housing services and rental values.

1.2 Aim and Objectives

The aim of this paper is to assess the impact of infrastructure proximity on residential property values with a view to determining the relationship between distance and rental values. To achieve this aim the objectives of this paper is to;

1. Identify the significant housing amenity influencing rental value?
2. Determine the impact of proximity to infrastructure on residential property values?

1.3 Scope

This paper covers academic journals focusing on residential properties and infrastructure. Variables including intrinsic and extrinsic housing services such as water, electricity, drainage, access road, security, schools, hospitals and shopping centres was considered with respect to availability and distance from residential property. Publications within the period of 2013-2023 was selected for review.

2. Literature Review

2.1 Concept of Value

The creation of value is an outcome of effective demand, utility and scarcity of an item (Ajibola *et al*., 2013). For an object to have value it must possess certain economic and legal characteristics (Ibrahim, *et al*., 2022). The meaning ascribed to value depends on the form or type of value referred including open market value, rental value, forced sell or liquidated value and value-in-use. Value in economic and real estate perspective is viewed as the power of an item to command the exchange of other items (Dabara *et al*., 2012).

Market value exist in two main forms namely capital or rental values (Adegoke *et al*., 2017), property owners and real estate professionals are interested in the rental and capital value of properties which is treated distinctly as a form of return from an investment (Bello *et al*, 2020). The market value of a property is dictated by the characteristics of the residential property and the overall attribute of an environment (Adegoke, 2014).

2.2 Factors Influencing Residential Property Values

The value of residential property when offered for sale or purchase cannot be viewed in isolation without making consideration of the quality of surrounding environment which combines implicitly towards determining housing prices (Randeniya *et al*., 2017). Choices made regarding housing accommodation is based on the availability of facilities, existing bundle of services and housing goods (Opaluwa and Arigbola, 2015). Real estate customers are keen about the features of a property and care about the environmental facilities, traffic condition and external factors (Hsu *et al*., 2012).

The value of residential property is influenced by the impact of adjourning environmental amenities including proximal facilities and services such as transport, school, parks, medical centres, shops and employment (Coffee *et al*., 2018). The process of selecting a property comprises ranking essential features within and across a range of property before picking an ideal property (Omran and Al-Marwani, 2015). The difference in position and natural resource endowment makes some land parcel within some locations attract higher values (Deshmukh *et al*., 2016).

2.3 Residential Property Value and Neighbourhood Infrastructure

The development of infrastructure is crucial in providing an enabling environment for real estate investment to thrive. Residential area gets more appealing with enhanced and improved infrastructure (Adeogun *et al*., 2023. Location with increased access to modern infrastructure will have uplift in value which will be reflected in higher rents (Mulley *et al*., 2015). Rental value as perceived by the early contributors of rent theory is considered as differential formed by distance and transport cost (Udoekanem *et al*., 2014)

The concerted effect of positive and negative externalities relating to the proximity of locational amenities is reflected in residential property values (Dzlauddin and Idris, 2018). Areas supplied with adequate urban infrastructure attracts a more productive and profitable land uses (Ajibola *et al*., 2013). The characteristics of the built environment including public services, urban amenities and educational institution is essential in the determination of housing prices (Guan and Pieser, 2018).

2.4 Challenges of Infrastructure Delivery Nigeria

The issues facing infrastructure in terms of adequacy vary from place to place but very rampant is the challenge of availability, functionality, and distance to places of residence and maintenance problem (Jimoh and Ige, 2017). The increasing growth in urban population as triggered by the influx of rural settlers to urban centers in quest for opportunities have created pressure on the few infrastructural facilities available in urban areas (Ankeli *et al.,* 2016). As a result, ultimately leading to public outcry on the fluctuating rental values of residential properties in recent times

The passive commitment of the public sector to infrastructural development and investment in Nigeria, have on the long-run amounted to a sharp fall in the growth of infrastructure and its impact on the economy (Ayoola *et al.,* 2016), and compounding the problem further is the general attitude of people towards the maintenance of infrastructure which is poor due to the inadequate attention paid towards running maintenance cost as opposed to the keen interest for developing capital in its initial provision (Udoka, 2013).

3. Research Methodology

The approach adopted by this paper is systematic literature review. Secondary data was collected from online publication accessed through Google scholar. Eligibility and selection criteria for the academic journals gathered for the purpose of this paper was based on a ten-year time period spanning from 2013-2023 with relevance to the research objectives. A total of 74 journals was downloaded, 13 was screened out due to duplication, 21 was excluded based on inadequacy to the objective, 25 not within the preferred timeframe was taken out and remaining 15 journals was selected and reviewed. Result of this paper was arrived at through thematic analysis of journals.

4. Result and Discussion

4.1 Determining the significant housing amenity influencing rental values

Adeogun *et al.* (2023) from their findings revealed that a significant relationship exists between property return and housing facilities including water supply, quality of access road and security across the entire study area in Jos, Nigeria. The study of Olatunji *et al*., (2022) agreed with Adeogun *et al.* (2023) as regarding access to portable water having the most significant relationship with rental values, however other variables which includes refuse disposal facility and adequate drainage channels with a correlation coefficient of .050 and .184 respectively were more significant compared to roads which seemed not to be considered in the study area.

Dabara *et al.* (2016) observed that drainage, electricity and access road have the most influence on property value as they affect rental value by 67%, 45% and 35% respectively. The findings of this study concluded that water has a lower influence on property value while waste dump facility had no influence. Famuyiwa and Babawale (2014) in slight conformity with the discovery of Dabara *et al*. (2016) revealed that electricity is the most important variable across 19 variables considered. As stable power supply was found to contribute about 16.5% to the rental value of properties, followed by good road surface, availability of street light, availability of pedestrian walkway, adequate drainage, improved neighbourhood security and waste disposal system which contributed 14.9%, 12.6%, 12.1%, 8.7%, 3.3% and 2.5% respectively.

Ajayi *et al* (2015) affirmed that water facilities have the most influence on rental values based on the regression analysis which showed that water based infrastructure have a p-value of 0.000 implying that a direct variation in rental value was influenced be availability of water. Ihuah *et al*. (2014) indicated road network as the most significant infrastructure with relative importance index (RII) of 0.945. Electricity supply (0.9184), portable water supply (0.9180), drainage system (0.9162), waste system (0.9100) and recreational facilities (0,900) came 2nd, 3rd, 4th, 5th and 6th respectively based on RII. A study by Ajibola *et al* (2013) indicated that water, electricity and roads ranked 1st, 2nd, and 3rd as the most crucial facilities.

4.2 Assessing the impact of proximity to infrastructure on residential properties values

Aziz *et al.* (2023) in their work indicated that a strong positive correlation exists between the prices of property and their proximity to roads. The value of properties close to the road ranged between 250,000 to 350,000 PKR per 26 sq. meters while properties away had lower prices of about 150,000 to 250,000 PKR per 26 sq. meters. The importance of road networks as an infrastructure is significant (Ihuah *et al*., 2014).

Dzlauddin and Idris (2018) observed that a significant positive effect on property values was created with proximity to shopping centre, park and forest which contributed 0.01%, 0.006% and 0.007% with one meter closeness respectively. On the contrary, a significant negative impact on property values were discovered with closeness to hospital, primary school, high-performing school and high performing secondary school which decreased property values by 0,01%, 0,009%, 0.005% and 0.01% respectively.

Li (2018) discovered that a positive but nonlinear land value uplift effect occurred with proximity to metro stations within 0.3 and 1.2 kilometre but as distance increase at about 2 kilometres from the road network value decreases. It was established that property values tend to decline by 0.46% with 1 kilometre distance from CBD which is the focal point of business, commercial activities and employment opportunities.

Tsai *et al* (2017) realized that housing price increases with 2.2% on the average with one kilometre proximity to the CBD. It was revealed that property prices are expected to increase by 4% with one kilometre decrease from ferry terminals. The prices of housing close to train station decreases with closeness to it. The outcome of this finding contradicts the submission of Dzlauddin and Idris (2018) which opined that proximity to CBD have negative influence on value.

Jimoh and Ige (2017) showed in their study that property value in low density area is significantly influenced by road network (O.45) and waste disposal, while those in high density area is influenced by electricity (0.45), hospital (0.025) and schools (.000). As opposed to the result of this work, Dzlauddin and Idris (2018) argued that closeness to hospital and schools have significant negative effect on housing prices.

Rendeniya *et al*., (2017) revealed from findings that minimum distance to the CBD with 0.130 person coefficient has weak positive correlation with housing price. The minimum distance to the nearest railway station (0.188), park (0.114) and hospital (0.157) has weak positive relationship with housing price while minimum distance to the main road (-0.091) and shopping centre (-0,007) has weak negative relationship. Other variables including minimum distance to the bus stop, nearest school, market and workplace have no relationship with housing price.

Mulley *et al.,* (2016) result showed that, with all things held constant, housing prices increases with 0.14% for every hundred meters closer to the bus rapid transit (BRT) station. Nearness to train station had a negative impact on housing prices, as 0.15% reduction in housing prices occurred with every hundred meter.

Wu *et al*., (2015) discovered that proximity to the central business district have the greatest influence on the prices of housing followed by the distance to park, distance to school, distance to arterial road and subway. Results from the 71 parks evaluated revealed that property value across 412.14 km^2 tend to increase with proximity to park which contributed about 0.041% to housing price while a declining rate of $3,356/km is found in housing price distance away from the closest park.

4.3 Summary of Findings

Availability of water infrastructure in residential property have proven to be the most significant in determining rental values of properties as revealed in the works of Adeogun *et al.* (2023); Ajayi *et al* (2015) and Ajibola *et al* (2013). The contribution of electricity to property value comes in as the second most important infrastructure as found in the studies of Dabara *et al.* (2016) and Ihuah *et al*. (2014). Other infrastructure provided in residential property including security, burglary proof, access road, drainage and waste system have varying significance across various findings reviewed.

The effect of proximity of residential property to infrastructure is considered with regards to nearness to central business district (CBD) which is the hub for business, commercial activities an employment opportunity. Property value tend to have increased with closeness to CBD in the studies of Tsai *et al* (2017), Rendeniya *et al*., (2017) and Wu *et al*., (2015). Road network showed a significant contribution to property values, as an increase or decrease from it affected values significantly as revealed by Aziz *et al.* (2023); Jimoh and Ige (2017) and Li (2018).

The influence of infrastructure including shopping centre, hospital, schools, parks and transport terminals fluctuated based on varying location. However, the significance of accessibility to road networks and CBD remained consistent in the studies reviewed. In a nutshell, the provision of water facility in residential neighbourhood has the most significance in determining the rental values, while the proximity to road networks has the greatest influence on property values based on distance.

5. Conclusion and Recommendation

A strong correlation exists between the development of infrastructure and property values (Average and Dube, 2018). Property situated in locations having access to newly developed infrastructures will command higher rental value thus reflecting an uplift in value (Mulley *et al*., 2015). The delivery of improved and enhanced infrastructure is of paramount importance in creating an enabling environment for real estate investment as it will make residential areas become more attractive (Adeogun *et al*., 2023).

The provision of water and electricity is very significant in value appreciation of residential properties. Tenants and would-be investors are attracted in taking up residential properties with access to portable water and stable electricity supply. Access to good road network in significant in the determination of rental values as proximity to it have positive impact on property values, From the findings of the literatures reviewed, this paper recommends that;

1. Property investors and developers should take the provision of water facilities seriously in order to realize attractive returns in the form of rental or capital values.
2. The government should enhance the accessibility to supporting infrastructure through the provision of good road networks which influences property values positively.
3. The opinion of experts in property management such as Estate Surveyors and Valuers should be obtained for informed decision-making based on feasibility and viability of public asset investment.

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This paper is an original work of the authors and was done based on scientific approach of academic reporting. The ideas generated from the works of other authors was referenced.

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Trend Analysis of Cholera Cases in Bida Metropolis, Niger State, Nigeria (2000-2020): A Retrospective Study

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Abstract

Cholera remains a significant public health concern in Nigeria, with Bida metropolis experiencing recurrent outbreaks. This study evaluates the trend of cholera cases in Bida Metropolis, Niger State, from 2000 to 2020, using retrospective data from two hospitals. The study is limited to retrospective cholera cases reported at Umaru Sanda Ndayako General Hospital and the Federal Medical Centre Bida. Data on cases, deaths and vaccination coverage were collected through primary and secondary sources. Data collected were analysed using trend analysis, standardised coefficient of Skewness (Z1) and Kurtosis (Z2) statistic. The results showed that a significant increase in trend in cholera cases was observed from 2000-2020 with an average annual incidence which revealed that year 2007 ranked the highest with 231 cases of cholera, followed by the 2014 with 198 cases and the least was observed in the 2013 with 26 cases. The study concludes that a significant increase in cholera cases was observed, with peaks in 2007 and 2014. Statistical trend analysis was applied to assess seasonality and distribution patterns. The study highlights the critical need for improved environmental sanitation and public health interventions, particularly during the dry season. It recommends strict enforcement of waste disposal regulations to mitigate future outbreaks.

Keywords: Bida metropolis, Cholera, Diarrheal disease, Public health, Trend analysis.

1. Introduction

Cholera, a diarrheal disease caused by Vibrio cholera remains a significant public health concern globally, particularly in developing countries like Nigeria (Osunla and Okoh, 2018).Cholera remains a global threat to public health and an indicator of inequity and lack of social development (WHO, 2016). Unhygienic practices like indiscriminate dumping of refuse and open defecation are prevalent in many areas in Nigeria and thus the likelihood of meeting tainted water through drinking, cooking, using utensils or eating vegetables washed with contaminated water is high. Most of the time, the infection is moderate or symptomless, but it can also occasionally be severe and life-threatening (Bashar and Soundappan, 2022). According to WHO (2015), Lagos in Nigeria recorded the first-ever cases of cholera with a figure of 22,931 and 2,945 deaths. Subsequently, four northern states in the late 1970s witnessed about 260 deaths from the pandemic, mainly affecting Maiduguri, Jere, Gwoza, Biu, and Dikwa local government councils. According to Abdulsalam (2014), between 1991 and June 2017, Nigeria saw a significant increase in cholera-related fatalities, with the pandemics of 1991 and 2010 recording the highest numbers of cases and fatalities to date. According to Kalaiselvan (2010), eighty-three per cent of deaths in children under age five are caused by infectious, neonatal and cholera. The overall child mortality declined significantly in the 1990s into the 2000s, but environmental risk factors still kill at least 3 million children under age 5 every year. Such young children make up approximately 10% of the world's population and comprise more than 40% % of the populace suffering from health problems related to the environment (WHO, 2016).

It is estimated that about 2.86 million (1.3 m - 4.0 m) cholera cases occur annually in endemic countries with 95,000 (21,000 - 143,000) deaths per year (WHO, 2016). Cholera is endemic in several developing countries in Asia, Africa, and Latin America (Yanda *et al*., 2018). Limited access to clean water, poor sanitation practices, and the disruption of public health systems continue to have a considerable negative impact on morbidity and mortality in nations with dense populations (Yanda *et al*., 2018). Cholera is a significant public health challenge in developing countries, including Nigeria. Recurrent outbreaks in Bida Metropolis necessitate an understanding of cholera trends to inform preventive strategies. This study assesses cholera incidence in Bida from 2000 to 2020, addressing a gap in localized epidemiological data.

2. Methodology

2.1 The Study Area

The study area is Bida in Niger State, Nigeria. The study area resides in the heart of Northern Nigeria (Figure 1). It is in the Niger Valley within latitudes 09^0 09' 9" North of the equator and longitudes 05^0 56' 64" East of the Greenwich meridian. Bida has an area coverage of 1,698 km2 (Ishaya and Musa, 2023).

Figure 1: Satellite Image of Bida Metropolis and Environs of Niger State, Nigeria. (Source: Niger State Geographic Information System, 2022)

2.2 Sources of Data and Research Design

Hospital records of cholera cases in Bida Metropolis between the periodsof year 2000 to 2020 were collected from Umaru Sanda Ndayako General Hospital and the Federal Medical Centre Bida, Niger State. The records utilized were confirmed cholera cases after clinical symptoms and histopathological and bacteriological investigations. Twenty years of data were utilized due to availability from the sample hospitals.

2.3 Data Sampling and Analysis

The study utilized retrospective hospital data from Umaru Sanda Ndayako General Hospital and the Federal Medical Centre Bida, covering the years 2000 to 2020. Skewness and Kurtosis were applied to determine the distribution of cholera cases over time. Data validation was conducted by cross-checking with national health records, and ethical approval was obtained from the hospital review board. While Skewness measured the asymmetry of the probability distribution of a real-valued random variable about its mean, Kurtosis measured how data disperse between a distribution's center and tails, with larger values indicating a data distribution may have "heavy" tails that are thickly concentrated with observations or that are long with extreme observations.

The standardized coefficient of Skewness (Z_1) was calculated thus:

$$Z_1 = \left[\left(\sum_{i=1}^{N}(x_i-\bar{x})^{3/N}\right)\Big/\left(\sum_{i=1}^{N}(x_i-\bar{x})^{2/N}\right)^{3/2}\right]\Big/\left(6/N\right)^{1/2} \quad \text{..... eq. 1}$$

The standardized coefficient of Kurtosis (Z_2) was determined as

$$Z_2 = \left[\left(\sum_{i=1}^{N}(x_i-\bar{x})^{4/N}\right)\Big/\left(\sum_{i=1}^{N}(x_i-\bar{x})^{2/N}\right)^{2}\right]-3\Big/\left(24/N\right)^{1/2} \quad \text{..... eq. 2}$$

Where,

$\bar{x}$ is the long-term mean of $\mathbf{X}_1$ values,

$\boldsymbol{N}$ is the number of years in the sample.

When the calculated value of Z_1 or Z_2 is greater than 1.96, it depicts a significant deviation from the normal curve indicated at the 95% level of confidence.

3. Results

3.1 Trend of Cholera Cases between 2000 – 2020 in the Research Area

The trend of study cholera cases from year 2000 to 2020 is shown in Figure 2. The results showed an increased trend in cholera cases which was observed from 2000-2020 with an average annual incidence which revealed that year 2007 ranked the highest with 231 cases of cholera, followed by the 2014 with 198 cases and the least was observed in the 2013 with 26 cases as revealed in Figure 2.

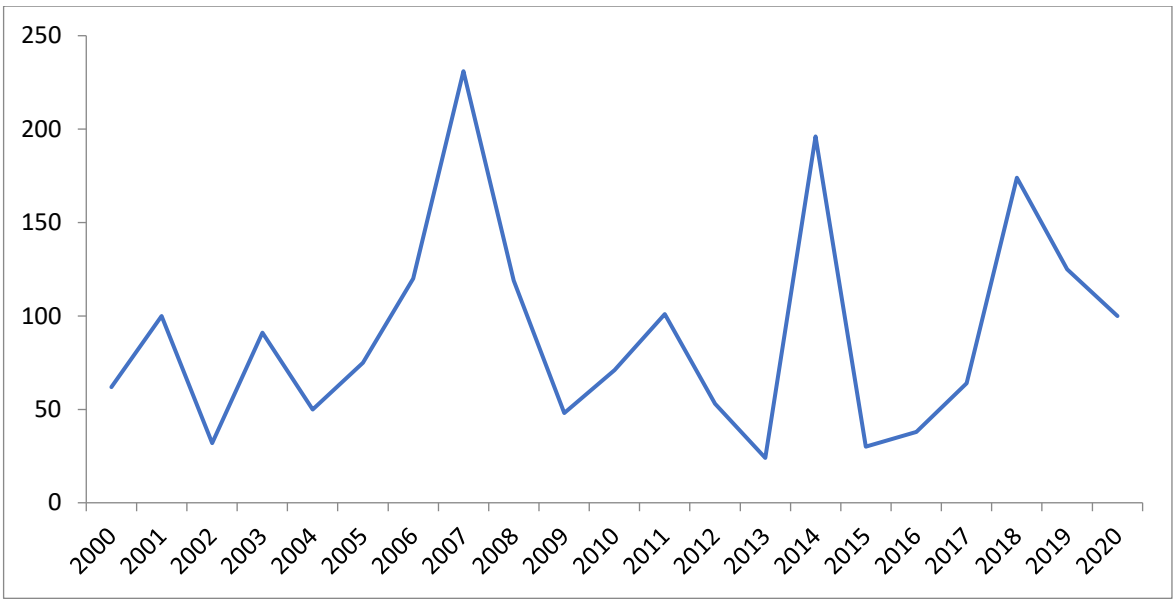

Figure 2: Annual Incidence of Cholera Cases in Bida Metropolis
Source: Authors (2022)

The results revealed that cholera cases peaked during the rainy season (March – November) with March ranking the highest with 82 cases followed by November with 66 cases and least was observed in August with 5 cases as shown in Figure 3.

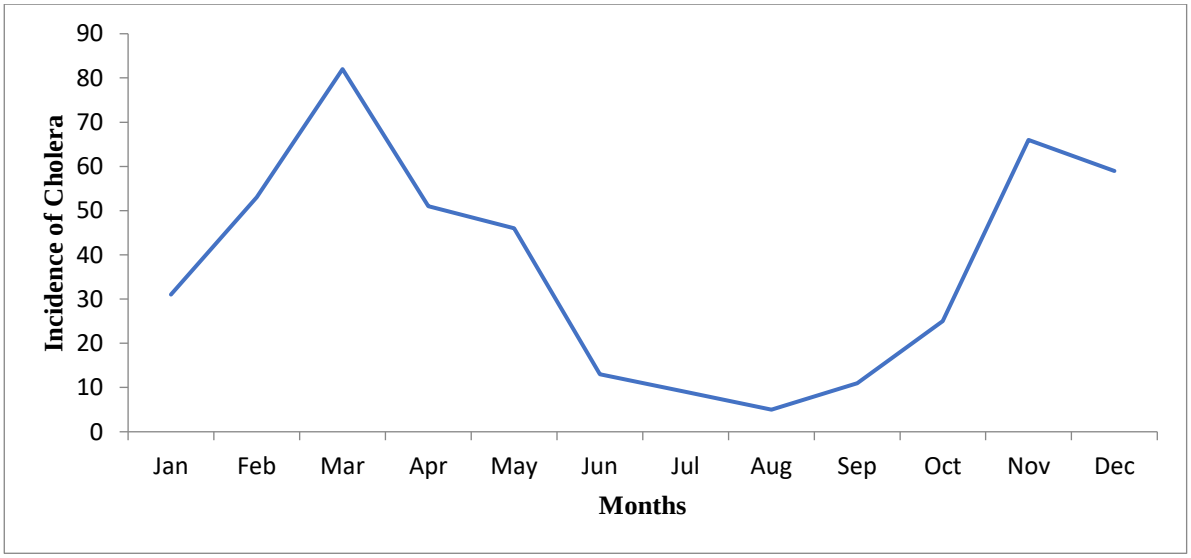

Figure 3: Monthly Incidence of Cholera in Bida Metropolis
Source: Authors (2022)

3.2 Distribution Pattern of Cholera Cases in the Study Area from 2000 - 2020

The distribution pattern of cholera cases in the study area were analyses using Skewness and Kurtosis statistical measures presented in Table 1.

Table 1: Distribution Pattern Cholera Cases

Distribution	Calculate value
Skewness	1.11
Kurtosis	1.83

Source: Authors (2022)

The Skewness result of approximately 1.11was calculated (see Table 1). It indicates that the distribution of cholera cases from 2000 to 2020 is positively skewed. This suggests that over these two decades, there have been more years with relatively low or moderate numbers of cholera cases, but a few years experienced significantly higher numbers (e.g. 2007 and 2014). This pattern of distribution is critical for understanding the epidemiology of cholera during this period. The kurtosis of the cholera cases data is approximately 1.83 as presented in Table 1. This value indicates that the distribution is moderately peaked compared to a normal distribution.This 1.83 suggests that the distribution of cholera cases over the years is platykurtic, meaning it is flatter and less peaked compared to a normal distribution. This indicates that the distribution has fewer extreme values or outliers. In practical terms, this implies that the cholera incidence data tends to be more evenly distributed, with fewer dramatic spikes or drops in case numbers. The flatter shape of the distribution means that large fluctuations in cholera cases are less common.This lower kurtosis value also highlights that the distribution of cholera cases is relatively stable and less prone to extreme variability. Also that, the incidence of cholera tends to be more consistent over time.

3.3 Discussion

The findings in this study revealed that there was a significant increase in cholera cases observed from 2000–2020 with an average annual incidence of 231 cases of cholera. This implies that cholera incidence is on the increase despite some fluctuation in some years. This might be attributed to incidents of consumption of contaminated water and food. The upward trend in cholera cases in Bida aligns with findings from similar studies in Northern Nigeria, where poor sanitation and contaminated water sources are leading contributors. This result is similar to the work of Fagbamila *et al*., (2023), who reported that the 1995–1996 cholera outbreak in Kano State revealed that poor hygiene, a lack of proper sanitation, and contaminated water were major sources of infection. Contamination of wells and other types of water, overflowing latrines, and frequent modifications of water sources for human behaviour and consumption may also result in cholera outbreaks (Osunla and Okoh, 2014). Similarly, Gidado *et al*., (2018) reported that Bashuri in Jigawa State had experienced a major cholera outbreak in September 2010 with high mortality rates and that the major sources for getting water for consumption for most people dwelling in that locality were uncovered wells dispersed across the streets in unclean areas. However, the seasonality of outbreaks, peaking during the dry season, suggests that water scarcity may exacerbate the spread of the disease. Public health efforts should focus on improving water infrastructure and educating residents on sanitation practices, particularly during high-risk months.

The asymmetry in the distribution cholera incidences in the study area also suggests that the average number of cholera cases (mean) is higher than the median, due to these higher values pulling the mean up. This has important implications for public health policy. If most years see only moderate numbers of cases, but a few years see very high numbers, it may indicate a need for better preparedness and targeted interventions during those critical years.The Skewed and Kurtosis distributionsprovide the importance of historical context when analyzing cholera data. The years with higher cases might correspond with specific events or conditions that made populations more vulnerable to cholera outbreaks. In the study area, during the dry season, there were high record cases of cholera outbreaks. This might be due to the increase in the bacterial load. This implies that cholera incidence is on the increase during the dry season despite fluctuation in some months. This further indicated that throughout the dry season, there is a shortage of good drinking water which allows people to take untreated water. Idoga *et al* (2019) also reported the seasonal distribution of cholera infection, time of outbreaks, and geographical distribution is however predictable for the cholera outbreak. This was similar to the reports of Adewale *et al*., (2016) who reported that V. cholerae in boreholes, wells, streams, and tap water from the 2007–2013 cholera outbreaks in Kano State,north central Nigeria.

4. Conclusion

The study found that cholera cases increased in Bida between 2000 and 2020, which was attributable to causes such as polluted water, poor hygiene, and inadequate sanitation. The imbalance in incidence indicates the necessity for

focused public health measures at sensitive periods. The study emphasises the significance of historical context when calculating cholera risks, particularly during the dry season. In conclusion, This study reveals a persistent rise in cholera cases in Bida over the last two decades, with pronounced seasonal patterns. Targeted interventions, particularly in improving water access and enforcing waste management policies, are essential to mitigate future outbreaks. The study recommended that the public must be educated by the government on the importance of proper environmental sanitation. Since indiscriminate trash disposal contributes to the cholera outbreak in the research region, tough regulations should be in place against it.

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Drivers and Barriers of Urban Densification in Kano Metropolis, Nigeria

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Abstract

Kano metropolis is one of the fastest growing cities in Nigeria. The urban structure has evolved from a concentric zone to a sectorial and now a multi nuclei-like urban area. This rapid urban growth has become a major challenge for urban environmental sustainability. This growth has over time contributed to a number of environmental, social, and economic problems like traffic congestion, land use conflicts, destruction of the natural environment, conversion of agricultural and forest land uses to other forms of urban land use. Urban densification has become an acceptable way to respond to urban change as it ensures sustainability, efficiency and increases the liveability of cities. This research investigated the drivers and barriers to urban densification in Kano Metropolis, with a view to proposing a framework for a sustainable Urban Kano. Delphi survey was employed to gather information from experts using the snowballing sampling technique. The results show the scope of urban densification in Kano metropolis to be people-oriented and not policy driven. The necessary policies, regulations and intervention for developers and the people to invest in urban densification development are not in place or adequately enforced. The study recommends that effective planning; development and policy implementation defining the role of all the stakeholders in urban planning will provide a shift towards a better urban Kano. Urban densification will provide a number of advantages that will make Kano more sustainable, by promoting efficient land use, enhancing public transportation, and development of public infrastructure and social amenities contributing to the overall well-being of the urban population and the environment.

Keywords: Barriers, Drivers, Urban densification, urban growth

1. Introduction

United Nations (2018) report described urbanization as a shift in a population from one that is dispersed across small rural settlements in which agriculture is the dominant economic activity towards one where the population is concentrated in larger, dense urban settlements characterized by industrial and service activities that are distinguished as a condition at a point in time and a process occurring over time. The United Nations Economic and Social Report of 2018, recognizes urbanization as one of the significant global trends of the 21st Century with a majority of the world's population expected to live in urban areas by 2050. The desire to make the built environment habitable to man has brought about an increase in consumption of natural resources like land, water, energy, materials etc. hence, growing cities are faced with the task of providing sufficient adequate housing as they try to contain expansion of settlement areas to prevent urban sprawl (Artmann et.al. 2019; Angelo & Wachsmuth 2020). Over the years, creation of higher densities through compact development in cities was accepted by urban planners and other environmental professionals as a means to reduce urban sprawl, induce positive sustainability effects that protect the un-built land, biodiversity and help reduce CO2 (Carbon dioxide) emissions from mobility and energy through compact development, especially when it is restricted through land use regulations. To this end, urban densification has become an acceptable way to respond to urban change due to population growth, rapid urbanization and as a means of city transformation for both economic and social benefits (Duranton and Puga 2020; Cavicchia and Cucca 2020). Oluwakemi *et al*. (2021), define urban densification as the process of increasing the population density in urban areas by building higher and more compact structures. The use of urban densification as an urbanization strategy entails making the most of all small amounts of living spaces, intensification of the built environment to build compact cities as opposed to large ones thus presenting itself as a means to reduce or stop urban sprawl, promote urban sustainability for land use planning policy and as part of a strategy for achieving goal 11 of the Sustainable Development Goals of the United Nations in many countries (Opoku, 2016; Neuman, 2005).

A driver according to the Cambridge dictionary, refers to something that make other things progress, develop or grow stronger; thus, drivers of urban densification refer to strategies for increasing the efficiency of utilizing natural resources (land)while also introducing a more efficient use of the city core. In like manner, barriers are things that impede the development, growth and progress of urban densification. Teller (2021) classifies the drivers and barriers of urban densification into two categories: macro (demography, economics, and transportation infrastructures) and micro (housing level and parcel or site level). The government through certain policies and regulations, investors and other land users constitute a transversal factor that is affected by and influencing these changes in urban spaces. To this end, this paper investigated the drivers and barriers of urban densification in Kano metropolis, Nigeria.

2. Materials and Methods

2.1 Study Area

Kano metropolis is the administrative centre of Kano State and the third largest city in Nigeria located between latitude 11° 55′ 23.93" N and 12° 3′ 53.10" N and between longitude 8⁰ 27′ 42.26" E and 8° 36′ 41.62" E. It consists of eight Local Government areas (Dala, Fagge, Nassarawa, Tarauni, Gwale, Kano Municipal, Kumbotso and Ungogo) and is the largest commercial and industrial centre of Northern Nigeria and second to Lagos in the country (Abdu *et al*., 2014). The metropolis is experiencing population increase and rapid urban growth from 295,432 in 1963, 760,000 in 1973, 1.6 million in 1991, and 2.84 million in 2006 with a growth rate of 5.5% per annum (Mustapha and Abdu, 2013). The 2018 UN World Urbanization Prospects report shows that Kano metropolis in addition to adjacent suburban areas; has an estimated population of 4,348,481 depicting an increase of 129,272 from the previous year representing a 3.06% annual growth rate. The urbanization process is mainly an attribute of population increase that brings about rapid urban growth that makes it highly vulnerable to environmental changes (Idris et.al, 2021)

The objective of the study is to determine the main drivers and barriers of urban densification in Kano metropolis using expert consensus which was achieved through a two-round Delphi survey. This study therefore requires an exploration of diverse opinion of experts in order to have an enriching detail and a deeper understanding of urban densification through an examination of a structured knowledge. The Delphi method being a systematic approach was used to reach expert consensus from the various professionals that are involved in urban and regional planning in Kano metropolis. The method is basically divided into three stages- the preliminary stage, the exploratory stage and the final stage (Figure 1).

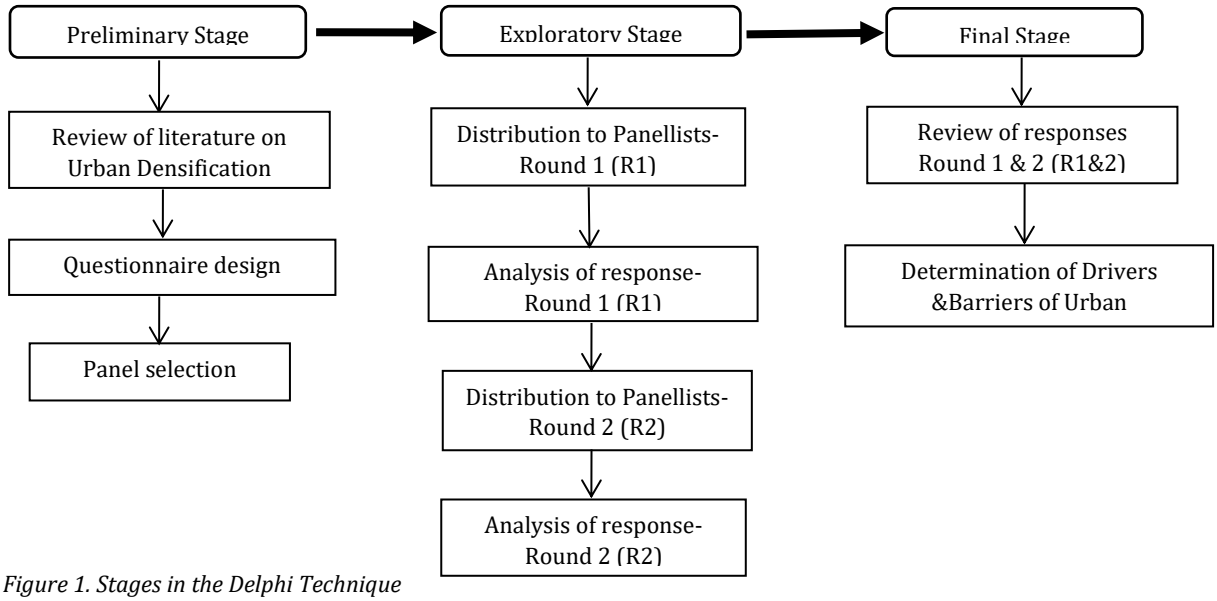

Figure 1. Stages in the Delphi Technique

2.2 Methods

The preliminary stage is the preparatory stage with three basic steps- literature review, survey design and panel selection. The literature review is key for a better understanding of the subject matter and as pre-requisite for survey design and moderation. The survey design- (an important phase of the Delphi technique) entails drafting of the survey questions that is expected to explore the participants' views on urban densification. These research

questions were based on statements about various aspects of urban densification and are concise, clear and also cover all the perspectives involved in the process of urban and regional planning. These questions were first developed by the researchers, reviewed by an expert with over 30 years' experience in urban and regional planning which finally came up with 14 statements each for both the drivers and barriers of urban densification. Next is the selection of experts in the area of interest and the size or number to be used with their profile that depends solely on the subject and aim of the study and their consent approval- (April 2024); participant anonymity and confidentiality of responses were ensured with individual responses only known to the moderator. As reiterated by Stewart *et al*., (2017) the selection of an appropriate and willing panel is very crucial in ensuring a robust and valid research. For this research, Snowball sampling technique was employed (exponential non-discriminating method); where an expert suggests two or more professionals to be involved in the research. As regards, the size of the panel, Torrecilla-Salinas *et al*. (2019) and ZarthaSossa *et al*. (2019), reveals that there is no clear framework to be used and most of the sizes reported are between 10 and 20. Hence, the most important consideration about Panel size is that the number of members should be large enough for every discipline to be represented and be easy to manage without losing any data, advisably an odd number should be adopted in order to have a good consensus. Urban densification is a multidisciplinary concept adopted for urban development and applied by professionals in urban and regional planning, Architecture, Estate survey, Building Engineering, Quantity survey and Civil engineering; as such 21 experts were selected from these professions who have being practicing for over 5 years across the academic, private and public practice.

The exploratory stage covers the period for physical contact, distribution of questionnaire electronically and analysis; for this research, questionnaire was distributed in two rounds with the second round depicting the response of the respondents from the first round. A total of six weeks was used to conduct the two round surveys. In each round, respondents were asked to rate items on 5-point Likert scale (strongly disagree-1, disagree-2, somewhat agree-3, agree-4 and strongly agree-5). Round 1 (R1) collected demographic information of the panellists as well as their opinion on the statements provided on drivers of and barriers to urban densification while Round 2 (R2) of the survey contained all Round 1 items, the grouped mean along with response of each of the respondents as feedback for their review. Round 1 and 2 results were then analyzed and reviewed in the final stage.

The final stage entails an analysis of round 1 and 2 responses, establishing agreement level and determining the key drivers and barriers of urban densification in Kano metropolis, Nigeria.

3. Results

3.1 Panel Participation

A total of 24 experts were invited to participate in the survey. Responses were received from all 24 participants in the first round out of which 3 were discarded for not meeting the required number of experience and 2 responses on barriers were rejected for being incomplete. From the survey, 23.81% of the participants were academics while 79.19% were experts from various fields. Also 42.86% of the expert participants had over 20 years of experience in Urban and Regional Planning, 33.33% had 15<20 years of experience, 14.29% had 10<15 years' experience while 9.52% had 5<10 years of experience in Urban and Regional Planning. Base on field of expertise, the participants comprised of 8 Urban and Regional Planners, 4 Architects, 2 Civil Engineers, 1 Estate surveyor, 1 Quantity Surveyor, 1 Building Engineer, 1 Geographer and 3 GIS experts.

3.2 Data Analysis

The study followed the methodology adopted in studies by Lee, Altschuld, & Hung (2009); Williams (2003) & Zawacki-Richter (2009). Data obtained from the panel of experts were subjected to statistical analysis in the SPSS environment to determine the reliability of the data, the measure of central tendency (Mean) and dispersion (Standard Deviation). Here, the mean value as well as the standard deviation was used to determine the level of consensus or agreement. Criteria used to determine the consensus is stated in Table 1.

Table 1. Consensus Criteria for the Delphi panel

Consensus	**Parameters**	
	(M: Mean and	**SD: Standard Deviation)**
Agreement (A)	M≥3.5,	SD <1.24
Disagreement (DA)	M≥3.0≤3.4,	SD ≥1.25<1.5
Neutral (N)	M>0≤2.9.	SD≥1.5

Adapted from Dr. S. Chuenjitwongsa (2017)

The data obtained was subjected to a reliability test using the Cronbach's alpha equation:

$$\alpha = \frac{k}{k-1}\left(\frac{1-\Sigma\alpha^2 y}{\alpha^2 x}\right) \quad \text{.....Eq (1)}$$

Where;
α = Cronbach's Alpha k = Number of items in your scale
$\Sigma\alpha^2 y$ = Summated variance of each item$\alpha^2 x$ = Variance of total scores

For the Drivers, reliability coefficient obtained was 0.818 (Good) for Round 1 and 0.65 (Moderate) for Round 2; for the Barriers, it was 0.587 (Moderate) for Round 1 and 0.857 (Good) for Round 2. Hence, the data fall within the moderate range and an acceptable level of reliability. Data analysis during Round 1 showed a broad agreement on 7 drivers and 6 barriers of Urban Densification in Kano metropolis. While Round 2 showed a unanimous consensus on 5 of those items for the drivers and barriers respectively as shown in Table 2 below.

Table 2. Analysis of the results obtained during the Delphi rounds

Drivers						**Barriers**					
Item	**R1**		**R2**		**Consensus**	**Items**	**R1**		**R2**		**Consensus**
	M	**SD**	**M**	**SD**			**M**	**SD**	**M**	**SD**	
D1	3.1	1.5	3.24	1.57	N	B1	3.89	1.32	4.14	1.27	DA
D2	9	7	3.90	0.94	A	B2	3.84	1.24	3.95	1.24	A
D3	3.9	0.9	3.52	1.50	N	B3	4.00	0.88	4.00	0.94	A
D4	5	7	2.19	1.07	N	B4	3.47	1.30	3.33	1.35	DA
D5	3.4	1.5	3.33	1.52	N	B5	3.37	1.06	3.29	1.14	DA
D6	8	0	2.67	1.56	N	B6	3.47	1.38	3.62	1.35	DA
D7	2.3	0.9	3.62	1.24	DA	B7	4.00	1.33	4.05	1.16	A
D8	3	6	4.14	1.10	A	B8	3.79	1.13	3.86	1.15	A
D9	3.4	1.4	2.90	1.44	N	B9	3.68	1.15	3.67	1.15	A
D10	8	3	4.00	1.22	A	B10	3.68	1.20	3.76	1.17	A
D11	2.6	1.5	4.19	0.87	A	B11	3.79	1.22	3.86	1.15	A
D12	7	2	4.00	0.94	A	B12	3.32	1.49	3.14	1.45	DA
D13	3.6	1.2	4.43	0.67	A	B13	3.42	1.26	3.19	1.32	DA
D14	2	8	3.71	0.95	A	B14	3.42	1.21	3.33	1.27	DA
	3.9	1.2									
	5	0									
	2.9	1.4									
	5	6									
	4.1	1.0									
	0	9									
	4.1	0.8									
	9	7									
	3.9	1.0									
	5	7									
	4.3	0.7									
	3	3									
	3.6	0.9									
	7	1									

Martha JM, Field Report (2024)
Note: M= mean, SD=Standard deviation, R1=Round 1, R2= Round 2, A= Agreement, DA= Disagreement, N= Neutral, D=Drivers, B=Barriers

4. Discussion

This study critically looked at the morphology of Kano Metropolis to decipher indicators that may either influence or hinder Urban Densification being the trend of urban development for a sustainable built environment (Wang & Kang, 2011). Findings show a unanimous agreement on 5 drivers and barriers of urban densification in Kano Metropolis, Nigeria. Increase in population is the main driver of urban densification with a mean of 4.33, 4.43, SD of 0.73, 0.67 and 47.6%, 52.4% of the experts strongly agreeing to this in R1 and R2 respectively. The culture of living within ancestral lands is also a major driver of urban densification as concurred by the experts with a mean of 4.19, SD of 0.87 and a percentage agreement of 47.6% for both R1 and R2 respectively. On the part of the government, experts agreed that recent policy changes in the state like the establishment of KNUPDA (formerly KASEPA) has greatly influenced urban densification in the metropolis; this fact is backed with a consensus from the mean value of 3.95,3.90; SD 0.97,0.90 and a percentage agreement of 38.1% and 52.4% for R1 and R2 respectively. The study area is famous as a business hub and commercial centre of Northern Nigeria hence increase in activity within the Central Business District has a positive impact on urban densification as shown with a mean of 3.95, 4.0; SD of 1.07, 0.94 and a percentage agreement of 42.86% , 47.6% respectively for R1 and R2. Continuous increase in demand for housing and commercial spaces to cater for the increase in population is also a major driver as agreed by the experts with means of 3.95, 4.10; SD of 0.97, 0.94 and a 42.9%, 47.6% percentage agreement for R1 and R2 respectively.

The main barriers of urban densification in Kano metropolis from the analysis are centred on the lack of government enforcement of urban planning regulations, lack of coordination between the policy makers and Practitioners and lack of access to fund for private developers to go into sustainable land development. Findings show that lack of proper coordination between policy makers and Practitioners is top on the list with a mean of 4.0, 4.0; SD of 0.88, 0.94 and a percentage agreement of 36.8% and 38.1% respectively. This is followed by lack of implementation of urban planning regulations with a mean of 3.84, 3.95; SD 1.24, 1.24 and a percentage agreement of 36.8% and 42.0% respectively for R1 and R2. Lack of visible target for urban growth and development is another major hindrance to urban densification with a unanimous agreement ascertained by mean value of 3.79, 3.86; SD 1.13, 1.15 and percentage agreement of 47.37%, 38.1% respectively for R and R2. The experts also see unplanned development within the metropolis that is caused by continuous rise in the value of land within the city centre as another barrier. This is agreed by the experts as depicted in the mean value of 3.79, 3.86; SD 1.22, 1.15 and percentage of 42.1%, 38.1% obtained from the data analyzed for R1 and R2 respectively. The fifth major barrier is difficulty in accessing fund from financial institutions for urban development as depicted by the experts with a percentage agreement of 36.8%, 38.1%, mean 3.68, 3.76 and SD 1.2, 1.17.

5. Conclusion

Understanding the drivers and barriers of urban densification in Kano metropolis is a major step towards reducing environmental problems associated with its continuous urban growth. This study shows how demographic change and economic growth has impacted on the densification of the study area. These findings substantiate that on the dynamics of urban morphology and environmental change in Kano, Nigeria by Aliyu et.al. (2015) that showed the transformation in structures, land use, buildings and open spaces; depicting an increase that is largely attributed to its demography and economy. It also shows a similarity in the categorization of drivers and barriers of urban densification by Teller (2021). For sustainable development of the built environment, there is need for the government to enforce policies, enact regulations, ensure synergy between the relevant institutions of government and Practitioners in urban planning and development and create more access to fund for land development in order to encourage private developers. These actions will change the course of urban densification in Kano metropolis from being people- driven (soft, small scale) to policy- driven (hard, large scale).

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Assessment of Strategies for enhancing hazard recognition amongst Construction Contractors in Abuja

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Abstract

Workplace accidents comprise the failure of contractors to identify a hazardous condition that occurs before or after starting an activity. The study therefore assesses "Strategies to enhance hazard recognition amongst construction contractors in Abuja, with the ultimate goal of improving safety and reducing workplace accidents by exploring the effectiveness of training programs, safety management systems, technology adoption, awareness campaigns, regulatory enforcement, and worker engagement. Key findings highlight the need for continuous training, employee Involvement and preventive actions to enhance hazard recognition with RII of 0.98, 0.94 and 0.90 respectively. Recommendations include adequate training, developing feedback mechanisms, and adopting safety as one criteria for tendering. By adopting a multi-faceted approach, this paper argues that improved hazard recognition will lead to safer construction sites, reduced workplace incidents, and enhanced contractor performance in Abuja.

Keywords: Assessment, Strategies, Contractors, Construction, Hazard Recognition

1. Introduction

For any industry to be successful, it has to be safe, reliable and sustainable in its operations. The industry has to identify the hazards and assess the associated risks and to bring the risks to tolerable level (Purohit *et al*., 2018). However, in complex and changing environments, construction contractors are often unable to identify all possible hazards that can occur in the jobsite (Shrestha *et al*., 2022). Therefore, construction contractors experience various forms of uncertainties as work progresses on construction project sites (Shittu *et al*., 2022).

Hazard recognition mostly depends on contractors' ability to spot hazards (Li *et al*., 2019). Unfortunately, the construction industry is characterized with low safety awareness and inadequate knowledge about safety leading to accidents (Adhikari, 2015; Jeelani *et al*., 2017). Consequently, safety training is needed to equip contractors with the skills needed to recognize and manage hazards (Jeelani *et al*., 2017). Abubakar *et al*., (2020) also noted that the root causes of workplace accidents comprise the failure of contractors to identify a hazardous condition that occurs before starting an activity or that developed after starting an activity; resolving to continue with a work after the worker detects an existing dangerous condition; or deciding to act in an unsafe manner irrespective of initial conditions of the work environment.

According to Shittu *et al*. (2022), the unique characteristics of a construction site such as rotation and interaction of teams, changing weather and environmental conditions, higher proportion of unskilled labourers, high labour turnover, and presence of hazardous materials makes safety management and training for hazard recognition difficult (Shittu *et al*., 2022). Therefore, identification of drivers and barriers that influence hazard recognition in the work environment is necessary to reduce safety incidents as well as to develop strategies that can improve worker's hazard recognition performance (Shrestha *et al*., 2022).

Despite the implementation of various safety regulations and practices in the construction industry, workplace accidents and injuries continue to occur at alarming rates. One significant contributing factor to these incidents is the effectiveness of hazard recognition capabilities among construction contractors. While hazard recognition is a critical aspect of ensuring workplace safety, there remains a lack of comprehensive understanding among drivers regarding the effective implementation of hazard recognition capabilities by construction contractors. This research seeks to evaluate the hazard recognition capabilities of construction contractors in Abuja, with the ultimate goal of improving safety and reducing workplace accidents. By addressing this research gap, this study aims to recommend strategies and interventions to enhance hazard recognition and safety practices in the construction industry in Abuja."

1. Literature review

Construction has been severally referred to as the most dangerous industry globally due to its alarming rate of accidents and fatality (Abubakar, 2019). Many construction safety manuals and textbooks consider hazard recognition and safety risk perception the first step for safety management in the construction workplace (Richard *et al*., 2015). In the safety management process, hazard recognition is typically referred to as the first phase (Perlman *et al*, 2014). Yet, most of the hazards in construction sites still remain undetermined by the construction contractors (Debnath *et al*, 2015). Most construction safety management methods rely on the hazard recognition skills of construction contractors (Albert *et al*., 2014). A research study conducted in the U.K. construction sites identified 6.7% of the method statements in U.K. construction sites identified all the relevant hazards, and 93.3% remain unrecognized (Abubakar, 2019). Many research studies have sought to identify potential hazards in the construction workplace and improve job site safety culture. If hazards remain unrecognized in construction job sites, the probability of an accident at the workplace increases, making the construction job site more hazardous and workers more vulnerable to injuries, illness, and fatalities (Albert *et al*., 2014; Namian *et al*., 2016).

In a research study conducted by Perlman *et al*. (2014). Supervisors working in the construction site were unable to identify all the hazards in their regular job site despite having years of experience. Safety training in construction job sites can aid in the hazard recognition performance of the construction workers. Namian *et al*. (2016) found that workers from construction projects who were provided high-engagement training were able to detect a more significant proportion of hazards.

The activities of unsafe workers are not the consequence of intentional safety violations but instead of poor hazard recognition and risk assessment ability on their own (Tixier *et al*., 2014). Both hazard recognition and safety risk perception rely on workers' cognitive abilities, and any element that weakens employees' cognitive capacities, such as fatigue, might influence their safety performance (Namian *et al*., 2021).

1.1 Strategies to Enhance Hazard Recognition and Safety Practices in the Construction Industry.

The state of health and safety program implementation in the Nigerian construction projects is a concern when compared to other developed and developing countries across the globe. It requires urgent interventions to limit harm to construction workers (Maano *et al*., 2017). The importance of workers' health and safety in any organization cannot be overemphasized. Jimoh *et al*. (2017) emphasized that work can only go on smoothly when workers are healthy and in a good state of mind. This denotes that task completion on a construction site depends on workers' health and safety for effective execution. Belayutham and Ibrahim (2019), while studying some strategies for improving worker's hazard recognition practices in construction projects, listed the following strategies: government funding on Occupational Health and Safety (OHS) training; safety is one of the criteria in tendering; safety as one of the Key Performance Indicators (KPI); platform to share experience and promoting best practices; linking OHS and insurance; tougher renewing licenses; strict enforcement on Occupational Health and Safety (OHS) regulations; more focus and tougher health and safety training programme; forming "safety responsible group; measuring tool for Occupational Health and Safety (OHS) practice; less prescriptive on the Occupational Health and Safety (OHS) regulations; creating more safety-conscious culture; tougher penalties; outreach efforts - coordinated action among worker unions and related associations and more communication efforts.

Mambwe *et al*. (2021) established seven success factors in the use of management strategy in entrenching organisational safety culture that improves performance of occupational health and safety and the authors concluded that training, employee involvement, preventive actions, Occupational Health and Safety policy, reporting of accidents and near-misses, risk management and culture for continuous improvement are strategies for improving worker's hazard recognition practices in construction project. The authors emphasised further that management should integrate firm's decision making with Occupational Health and Safety as it reduces or completely eliminates the risks and addresses safety culture and motivational issues. Ali *et al*. (2019) noted that for Occupational Health and Safety performance management to improve, safe behaviours through reporting of accidents and near-misses, preventive and proactive measures, strategic management through policy formulation, planning Occupational Health and Safety and implement effective management systems through safe work culture, inspections, monitoring, checking and review plans are essential aspects in the workplace.

2. Methodology

A survey research design employing the quantitative research approach was adopted for the study. The population of this study comprises safety health professionals of construction firms in Abuja, FCT listed in the Nigeria Directory Online website (www.directory.org.ng). A total of 244 questionnaires were administered, a total of 207 (85.0%) were returned, and only 200 (82%) were found valid for the analysis. The use of descriptive statistical techniques and inferential analysis (Kruskal-Wallis H) was employed for the analysis of the data. Findings from the data analyses carried out in the study led to the conclusions made in this section.

3. Analysis and Discussion

Table 1 below reveals twenty (20) strategies to enhance hazard recognition and safety practices in the construction industry. With RII values ranging between 0.98 and 0.65. The most effective strategies to enhance hazard recognition and safety practices in the construction industry identified by the respondents were training, employee involvement, and preventive actions (RII = 0.98, 0.94, and 0.90 ranked 1st, 2nd, and 3rd), while outreach efforts coordinated action among worker unions and related associations and more communication efforts More focus and a tougher health and safety training programme; forming a "safety responsible group; measuring tools for occupational health and safety (OHS) practice; and reporting accidents and near-misses (RII = 0.68, 0.68, 0.65, and 0.62 ranked 17th, 17th, 19th, and 20th) were the least identified strategies to enhance hazard recognition and safety practices in the construction industry. On average, all the identified strategies and to enhance hazard recognition and safety practices in the construction industry were effective (average RII = 0.79). The findings from this study are in tandem with submissions from Ali *et al*. (2019), who noted that for occupational health and safety performance management to improve safe behaviours through reporting of accidents and near-misses, preventive and proactive measures, strategic management through policy formulation, planning occupational health and safety, and implementing effective management systems through a safe work culture, inspections, monitoring, checking, and review plans are essential aspects in the workplace.

Table 1: Results of Strategies to enhance hazard recognition and safety practices in the construction industry

Code	Strategies to enhance hazard recognition and safety practices in the construction industry	RII	Rank	Decision
1	Training	0.98	1st	Very Effective
2	Employee involvement	0.94	2nd	Very Effective
3	Preventive actions	0.90	3rd	Very Effective
4	Risk management and culture for continuous improvement	0.88	4th	Effective
5	Strategic management through policy formulation	0.86	5th	Effective
6	Preventive and proactive measures	0.85	6th	Effective
7	Government funding on Occupational Health and Safety (OHS) training	0.83	7th	Effective
8	Safety is one of the criteria in tendering	0.82	8th	Effective
9	Safety as one of the Key Performance Indicators (KPI)	0.80	9th	Effective
10	Platform to share experience and promoting best practices	0.80	9th	Effective
11	Linking OHS and insurance	0.80	9th	Effective
12	Tougher renewing licenses	0.79	12th	Effective
13	Strict enforcement on Occupational Health and Safety (OHS) regulations	0.77	13th	Effective
14	Less prescriptive on the Occupational Health and Safety (OHS) regulations	0.74	14th	Effective
15	Creating more safety-conscious culture	0.74	14th	Effective
16	Tougher penalties	0.70	16th	Effective
17	Outreach efforts - coordinated action among worker unions and related associations and more communication efforts	0.68	17th	Fairly Effective
18	More focus and tougher health and safety training programme	0.68	17th	Fairly Effective
19	Forming "safety responsible group; Measuring tool for Occupational Health and Safety (OHS) practice	0.65	19th	Fairly Effective
20	Reporting of accidents and near-misses,	0.62	20th	Fairly Effective
	Average RII	***0.79***		Effective

Source: Researcher's data Analysis 2023

4. Conclusion

The result reveals that all the strategies to enhance of hazard recognition amongst construction contractors are very important. This is in tandem with the reports of FEMA (2022), which shows that construction contractors play a crucial role in hazard recognition and mitigation to ensure the safety of workers and the success of construction projects.

The study also discovered "Training, Employee involvement and Preventive actions" as the most significant strategies to enhance hazard recognition amongst construction contractors and Reporting of accidents and near-

misses as the least effective strategy, the study recommend that construction contractors should ensure that they earn health certification before taking on large projects to minimize the rate of hazard on their projects.

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The Role of Art in Shaping Economic and Environmental Resilience in the Built Environment

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Abstract

This paper reviews the historical and contemporary role of art in nation-building, emphasizing its impact on the resilience of the built environment in Nigeria. It explores traditional African architectural practices and highlights the significance of integrating professional artistry into modern city planning to foster both cultural and economic sustainability." Conclusively, the paper is of the view, Nigeria possesses educational programmers and the strengthening of the arts both the institutional and its practice.

Keywords: The Arts, Economy, Environment, Nation Building, Resilience.

1. Introduction

Art is a powerful means to communicate complex ideas, inspire action, question received wisdom, and connect communities. In the 21st century, there is perhaps no more important set of challenges than understanding the impacts of disasters and environmental changes on our communities and societies, particularly in the developing world. Art plays a crucial role in enhancing urban resilience and shaping the built environment through community cohesion, where the bonds that hold a community together , fostering a sence of unity, cooperation, and collective identity (Borrup,2015), Emotional resilience: Art provides an outlet for emotional expression and stress relief (Kaplan, 2000), Cultural preservation: Art preserves cultural heritage, promoting identity, and continuity (Taylor, 2015), Placemaking: Art transforms public spaces into vibrant, inclusive areas (Project for Public Space, 2018}, Sustainable design: Art integrates green infrastructure, promoting environmental sustainability (American Planning Association, 2019), Urban Renewal: Art driven revitalization projects stimulate economic growth (National Endowment for the Arts, 2017). Traditional architecture in Nigerian setting has to do with the indigenous building styles and techniques that have been passed down through generations, reflecting the country's cultural, social, and environmental context such as Nigeria's Yoruba, Hausa, and the Igbo styles, exemplifies art's influence on resilience:

- Cultural Identity: Traditional architecture reflects community values and history (Oliver, 1987).
- Community Engagement: Public spaces in traditional architecture foster social connections (Prussin, 1986).
- Environmental Adaptability: Traditional architecture incorporates local materials and climate –responsive design (Ucko, 1966).

Yoruba Architecture (Southwest Nigeria): Is characterized by intricate wood carvings, ornate doors, and courtyards. Examples: Ooni of Ife's palace, Ile-Ife; Ancient city of Oyo.

Hausa Architecture (Northern Nigeria): Features mud-walled structures with thatched roofs, intricate wall decorations, and Islamic influences. Examples: Kano city walls, Kano; Sultan's palace, Sokoto.

Igbo Architecture (Southeast Nigeria): Are well known for their wooden houses with pitched roofs, carved doors and communal living spaces. Examples: Igbo Ukwu village, Anambra State; Mbari houses, Imo State. The Yoruba from the southwestern Nigeria, the Hausa from northern Nigeria, and the Igbo from the southeastern Nigeria uses Local materials (wood, mud, thatched), Climate-responsive design (ventilation, shading), Cultural and symbolic expressions (carving, decorations), Community oriented layouts (courtyards, communal spaces), and Sustainable building techniques. However, traditional practices face with modern challenges through urbanization and cultural erosion (UN-Habitat, 2016)., Climate change and environmental degradation (IPCC,2020)., Social inequality and community disengagement (World Bank, 2019). To address these challenges, modern adaptation of traditional architecture can integrate green technologies and sustainable materials, incorporate community-led design and participatory planning and preserving cultural heritage while promoting social cohesion.

Before the advent of the Arabs and Europeans to Nigeria, the sophistication of the Nigerian kingdom was very visible in their peculiar architecture. In a multicultural society like Nigeria, most of the kingdoms had a beautiful and unique architecture built by our skilled men that reflected the climate, culture, and beliefs of the people. Most of the buildings are usually made of mud and thatched roofs, which shows a careful thought in this style of building, the choice of materials is readily available and fits our tropical climate. Some of the popular and noticeable architecture are the Hausa, Igbo and Yoruba, the three popular tribes:

1.1 The Hausa Architecture

Traditional Hausa architecture is in form of a housing unit large enough to house the man, his wives and the children, this housing structure forms part of an extensive walled city with a gate built into a tall of storey building. It can be categorised into three: calligraphy, surface design and ornamental. Some of such designs are still common and mostly found in the emir palaces in various northern cities. In the traditional Hausa architecture, the high and dry lands attracted the use of mud with linear decoratives motives, mouldings and painted and decorated with local materials, such as kaolin(clay), limestone(chalk) and other materials as well as periwinkle seeds, animals waste, and from various leaves, roots, wood and seeds. Charcoal and soot were also other sources of getting natural pigments for the decoration of the built environment.

1.2 The Igbo Architecture

The traditional Igbo house structure was predominantly round-wall mud houses (ulo aja oto) with thatched roofs (aju or atani). The roofing- a pitched roofing, was the commonest design found across the pre-colonial Igbo communities. By building such, the skeletal framework of the roof is first weaved using bamboo poles or sliced bamboo poles. The bamboo is placed in slopes and then crossed with palm fronds. To give a formidable roofing structure that can avert incidence such as wind, at various points rafters are knotted or tied. The last is thatching, the skeletal structure is covered with grasses and fronds (raffia mat). Most of these houses had no concrete beams due to the materials available at that time, most used woods and bamboos as a support system or beams.

1.3 The Yoruba Architecture

They had a large courtyard with a housing style typically called 'Orowa'. These houses were usually a continuous building making up of extended families. The building of houses was mostly communal effort using readily available materials such as thick mud walls, bamboo rafters or other termite-resistant timber sheets instead of thatch, and a sand plaster to mud walls. In locations where timbers were in abundance, such as the rain forest regions, beautifully carved poles and statuettes were used for house posts, lintels and door panels. Among the Yoruba, city centres were built for various outdoors activities to enhance healthy communal living.

Folarin (1993:203) observes that the courtyard, with its over hung roof often supported by beautifully carved wooden columns served as a stage for theatrical performance, dance, troubadours, concerts, poetic and chanted recitals, also for birth, marriage, funeral and memorial ceremonies.

However, the advent of industrial revolution in Europe of the late 19th century witnessed mass-production of industrial goods. This led to the quest for marketing the goods which necessited the fooding of Africa with cheap building materials. These materials include corrugated roofing sheets, nails, harmer, sawing tools, cement and colourful decorative materials, which outwitted weather conditions that had hitherto determined the type of houses, built in a particular geographic location and the type of decoration used for the interior and exterior parts of the buildings.

Gradually, concrete pillars replaced wooden house posts which subsequently undermined the activities of wood carvers. However, Yoruba in their insatiable quest for aesthetic expression turned to other set of artists who emerged on the scene when the Brazilian slave returnees brought with them a new form of architectural embellishments (the Afro-Brazilian architecture) which was inspired by the churches and houses that the worked on, repaired or saw in city centres in Brazil to enable them create a unique built environment.

But then, old habit die hard says English maxim, hence door panels and frames are still beautifully carved with great symbolic representations, for example the carved doors, known locally as mgbo ezi, were made from slabs of the sacred termite-resistant oji tree- African oak, widely known as iroko. The wooden panels were approximately 1-1.5 meters high and spanned nearly a meter in width. Several individual panels were held with locally made metalworks as some sort of gate at the entry to the home of a tittle igbo chief, one who has accended the ranks of the ozo institution.

1.4 Art and Built Environment In Contemporary Era

The Intersection of art and urban Development in Nigeria's rapidly urbanizing cities, art plays a vital role in enhancing the built environment, fostering community engagement, and promoting social cohesion. Some of the Contemporary Examples includes:

i. Street Art in Urban Regeneration: The Sabo-yaba street Art project in Lagos transformed a neglected neighbourhood into a vibrant arts district (Sabo-yaba, 2020).
ii. Public Installations and placemaking: The Jabi Lake Park in Abuja, featuring public art installations, revitalized a neglected a lakefront into a popular recreational space (Jabi Lake Park, 2020).
iii. Urban interventions and Community Engagement: The African Artist's Foundation's (AAF) public art initiatives in Lagos and Abuja foster community reflection and social connection (AAF, 2020).
iv. Green Infrastructure and Public Art: The Lekki Conservation Centre's Sculpture Garden in Lagos integrates art and ecology, promoting environmental awareness (Lekki Conservation Centre, 2020).
v. Digital Art and Urban Facades: The LED light installations on the Eko Atlantic City Skyscraper in Lagos redefine urban aesthetic and Community engagement (Eko Atlantic City, 2020).
vi. Kaduna Urban Regeneration Project (Kaduna, 2018): Integrated public art, green spaces, and community engagement.

Some of the Successful Urban Planning Efforts were:

1. Lagos State Government's Ministry of Tourism, Arts, and Culture: Initiatives include Public Art Installations, Cultural Festivals and Urban Renewal Projects.
2. African Artists' Foundation (AAF): Promotes Public Art, Community Engagement, and Artistic Collaborations.
3. Nigerian Institute of Architects (NIA): Advocates for inclusive, sustainable Urban design incorporating artistic traditions.
4. Lagos Urban Development Initiative (LUDI): Focuses on community –led Urban Planning, incorporating art and culture.

Artistic Traditions are as follows:

i. Yoruba Architecture: Incorporating traditional designs, materials and symbolism.
ii. Hausa Mural Painting: Preserving cultural heritage through public art.
iii. Igbo Uli Art: Integrating traditional designs, patterns, and motifs.

2. Roles Art Plays in Nation Building

Art plays a vital role through the following:

1. Cultural Preservation: Conserves national heritage, promoting cultural continuity (UNESCO, 2018), Preserves traditional art forms, techniques and materials (National Endowment for the Arts, 2020).
2. National Identity: Shares values, beliefs, and characteristics that define a nation and its people through cultural heritage, share values, symbolism, Geography and Historyevents (Smith, 2010).
3. Social Cohesion: Encourages community engagement, inclusivity, and social change (World Bank, 2019), Promotes cultural diversity, tolerance, and understanding (UN Human Rights Council, 2019).
4. Economic Development: Drives tourism, creative industries, and urban regeneration (OECD, 2014), Supports artistic Innovation, entrepreneurship, and job creation (NEA, 2020).
5. Education: Develops critical thinking, creativity and cultural awareness (UNESCO, 2018), Enhances cultural literacy, appreciation, and participation (National Art Education Association, 2020).

Here are some historical examples linked to modern societies:

- Ancient Greece's cultural Achievement: Democracy, theatre, philosophy, and Arts (Boardman, 2002).
- Renaissance Humanism: Revival of classical learning, art, and culture (Burckhardt, 1860).
- African Diasporic Culture: Resilience, adaptation, and cultural preservation (Thompson, 1983).

Modern Applications

1. Cultural Diversity and Inclusion: Learning from ancient Greece's democratic ideals (UNESCO, 2018).
2. Arts and Culture in Education: Emulating Renaissance humanism's emphasis on classical learning (National Endowment for the Arts, 2020).
3. Community Resilience: Drawing from African diasporic cultures adaptability and cultural preservation (World Bank, 2019)

Lesson for Modern Societies

1. Value Cultural Diversity: Foster Inclusive societies by embracing diversity (UN Human Rights Council, 2019).
2. Invest in Art Education: Develop critical thinking, creativity, and cultural awareness (National Art Education Association, 2020).
3. Empower Community Resilience: Support community-led initiatives and cultural preservation (International Council of Museums, 2020).

Public Art Installation in Nigeria can be powerful tool to strengthen community identity in modern cities and drive economic activity through tourism and urban beautification. By showcasing Nigerian art and culture, these installations can foster sense of community pride and ownership, while also promoting cultural awareness and appreciation.

Community Identity

Public art installation can reflect local culture and history, celebrating indigenous traditions, folklore, and historical narratives. This can help to reinforce cultural identity and foster a sense of belonging among community members. For example, the National Arts Theatre in Lagos, the Fela Kuti Statue, and Freedom Park are all Iconic installations that showcase Nigeria's rich cultural heritage (Barnett, A.2015).

Economic Activity

These installations can also drive economic activity by attracting tourists and stimulating local economies. Art can create jobs, generate tax revenues, and stimulate local economies through tourism. In fact, a study found that Nigerian arts and culture, major festivals, and government policies can influence business growth (OECD, 2014).

Urban Beautification

Public art installations can transform urban landscapes into vibrant and beautiful spaces, making cities more attractive to visitors and residents alike. This can lead to increased investment, economic growth, and improved quality of life (ULI, 2019).

Challenges and Opportunities of Public Art Installations

However, public art installations in Nigeria also face challenges such as lack of government support, vandalism, and accessibility issues. To overcome these challenges, collaboration between artists, government, and community is essential. Integrating technology, increasing awareness and appreciation for public art, and promoting local talents and cultural heritage can also help to drive growth and development in the scene (NGA, 2019).

Overall, public art installations have the potential to strengthen community identity, drive economic activity, and beautify urban spaces in Nigeria. By supporting and promoting these installations, we can celebrate Nigerian culture and creativity, while also contributing to the country's economic growth and development (IJAC, 2017).

3. Significance of The Role of Professional Artist in The Built Environment

Significance of professional artists in the built environment global and African perspectives includes examples like:

3.1 Global

1. Chicago's Millennium Park (USA): Artist Anish Kapoor's "Cloud Gate" Sculpture collaborates with architect Frank Gehry's Jay Pritzker Pavillion.
2. Barcelona's La Rambla (Spain): Artist Joan Miro's mosaic installations enhance the public space designed by architect Oriol Bohigas.
3. Singapore's Garden by the Bay (Singapore): Artist Marc Quinn's sculptures complement the garden's design by architect Grant Associates.
4. Vancouver's Public Art Program (Canada): Artist Ken Lum's installations integrate with architect Bing Thom's urban design.

5.2 African

1. Cape Town's Street Art Initiative (South Africa): Artist collaborate with city planners to revitalize public spaces.
2. Lagos Eko Atlantic City (Nigeria): Artist Victor Ehikhamenor's installations enhance the city's architecture.
3. Addis Ababa's Light Rail Transit (Ethiopia): Artist Elias Sime's public art integrates with the transit system's design.
4. Johannesburg's Nelson Mandela Bridge (South Africa): Artist Marcus Holmes' lighting design complements the bridge's architecture.

5.3 Benefits of Artist Collaboration:

Some of the benefits why artist's collaborate include: Enhanced cultural significance, Increased community engagement, Improved urban aesthetics, Economic benefits through tourism, and Resilient and sustainable environments.

6. Roles of Art in The Built Environment

The peculiar roles that art plays in the community cannot be over emphasized. There is element of art in the built and natural environment. Actually, the early man sharpened his artistic sensibility by copying from nature and his surrounding generally. It can be seen in the planning of our surroundings and in nature itself. The arrangement of flowers, the natural beauty of the foliage, the setting of the houses and design of the building reflect art and creativity. In this regard, Ojo (2006:4) notes that "nature has always been a source of inspiration for creative activities", and artists have explored nature to making life worth living in the built environment. In addition, works of art have been used to create pleasing environments for centuries. Painting, murals, mosaic, are used to decorate our interiors, while sculptures: fountains and ceramics: flower planters, urns and vases are used to enhance the beauty of our gardens, foyers and exteriors of buildings (Fichner- Rathus, 2001:6). Lawal (1982:8) opines that art has continued to enriched the quality of living not only through the creation of basic necessities of life such as shelter, utensils and clothing but also in making them more pleasant in appearance and use. But what becomes of the environment if its inhabitants show apathy towards the aesthetic quality of their surroundings? The only way out is to educate them as regard the concept of art and aesthetics with respect to human development (especially regarding environmental health and sanitation), and thereby make them appreciate the truth that creative art teaching is one of the high ways to individual and national development in the built environment.

7. Conclusion

The concept of nation building can reside only in a healthy and sound mind. To fully leverage art as a global economic revolution and resilience of the built environment tin an emerging world, government, institutions, the private sector, and general populace must unite in supporting the effective utilization of various art forms, including visual arts, performing arts, literary arts and new media arts. These encompass music, dance, theatre, drama, painting, print and book publications, illustrations, fashion, sculpture, and photography, all of which serve as powerful tools for fostering national development. But little contributions of every individual add up to collective efforts of town planners, architects, builders, decorators and other artists and artisans. These collaboratives efforts could promote healthy living. In traditional past, the affluence of a man is exemplified in his ability to give artistic value to his residence and the environments according to his financial capability. This invariably adds value to the community. The researcher believes that with more art-friendly government policies and fundings, along with public support, nations would become more integrated, socially and culturally connected, and economically sustainable. But in the same vain, it is therefore imperative for our architects to be encouraged and motivated by their creative instincts to incorporate our cultural values in designing domestic architecture and the planning of our cities to give art her place to thrive in order to add value to our national life, as more and more architects all over the world are turning to vernacular architecture for inspiration. A true and acceptable architecture must be originated from one's own culture even though it may assimilate materials from other cultures.

Figure 1: The Emir's palace of Katsina (2022)
Source: Sardaunan Katsina

Figure 2: Hausa house in Zinder Niger
Source: Wikiwand

Figure 3: Igboland pre-colonial house
Source: Facebook

Figure 4 Yoruba architecture
Source: Facebook

Figure5: Afro-Brazilian design (Palace 0f Balogun Kuku)
Source: Facebook

Figure 6: Igbo Carved Doors
Source: Vocal Africa

Figure 7: Status of Sango, Lagos (1964)
Source: Ben Enwonwu Foundation

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Effect of Kenaf Fiber Content on the Performance of Rice Husk Ash Blended Portland Cement Foamed Concrete

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Abstract

The research examined how the inclusion of kenaf fibre impacts the performance of foamed concrete made from a blend of rice husk ash and Portland cement. The utilization of supplementary cementitious materials (SCM) to partially replace cement has proven to be a practical approach in transforming the production of Portland cement into a more environmentally friendly and energy-efficient process over the years. Rice husk ash has been one of the SCMs with pozzolanic properties and has the characteristics of enhancing concrete's strength and durability properties. This study reports the results of the experimental investigation to assess the impacts of varying content of kenaf fibre on the performance of foamed concrete produced with a blend of rice husk ash (10 % wt.) and Portland cement (90% wt.) as binder materials. Foamed concrete (FC) mixtures were tested for wet density in the fresh state, dry density, compressive strength, split tensile and flexural strength in the hardened state. Test results show that the increasing kenaf fibre content lowers the foamed concrete mixture's density. The findings of this study show that FC with kenaf fibre addition did not have any significant difference in compressive strength. 0.5% fibre addition shows a 35.09% increase in split tensile strength as against the control concrete; also, the 0.5% fibre concrete shows a 23.48% increase in flexural strength as against the control concrete specimen. The study concluded that FC used for this study has the potential for structural applications up to 0.5% kenaf fibre addition. RHA can be used to reduce overburden on cement and provide insight into the production of energy-efficient and environmentally friendly concrete mixtures. Kenaf fibre up to 1% can be used for foamed concrete for non-structural purposes.

Keywords: Compressive Strength, Density, Foamed Concrete, Kenaf Fiber, Rice Husk Ash,

1. Introduction

Global warming is a phenomenon that is driving the world towards making drastic changes to mitigate its effects. Experimenting with and producing alternative fuels and recycling waste materials by producing new materials are measures to reduce greenhouse emissions. The construction industry is one of the most significant contributors to global warming. The construction industry is searching for alternatives to satisfy the increasing need for cement necessary for concrete production. The global cement consumption in 2023 was estimated to be 4.1 billion metric tons, which shows that it is the most utilized and significant material in construction. The cement industry emits nearly a ton of CO2 for every ton of cement produced (Shoubi, *et al*., 2013; Dahiru, 2010). Researchers are focusing on reducing reliance on cement, using waste materials like fly ash, silica fume, and rice husk ash as cement alternatives. Another approach involves designing and constructing energy-efficient buildings using lightweight materials and integrating waste into construction materials (Al-Jabri, *et al*., 2005). Additionally, the depletion of natural resources also threatens the environment.

The concrete industry consumes approximately 8 billion tons of natural aggregates annually (Geetha and Selvakumar, 2019). Natural aggregates form the major component of concrete and occupy 70% to 80% of the total volume of concrete mixtures (Verian, *et al*., 2013). As a significant consumer of limited natural resources and the most essential player in infrastructural development, the concrete industry must incorporate environment-friendly technologies (Mehta, 1999). This positive impact is by lessening aggregate and cement consumption usage and reducing the CO2 emissions and overburden on natural resources. Therefore, researchers worldwide strive to produce better, greener, stronger concrete using mineral admixtures and supplementary cementing materials (Siddique and Khan, 2011). The materials used as a substitute for cement not only improve the properties of concrete but also conserve energy and positively impact the environment. This technology can be achieved by utilizing lightweight concrete, whereby the quantity of material, such as coarse aggregate, is wholly or partially replaced. Lightweight concrete maintains its large voids and does not form laitance layers or cement films when placed on the surfaces (Ramamurthy, *et al*., 2009).

Foamed concrete, a lightweight material, consists of cementitious mortar surrounded by disconnected bubbles, comprising more than 50% of the volume. These bubbles result from either the introduction of air into the mortar mixture or the formation of gas within it (Tikalsky, *et al*., 2004). Foamed concrete offers high flow ability, low self-weight, minimal aggregates, controlled low strength, and excellent thermal insulation properties, with densities ranging from 2000 to 300 kg/m3 (Ramamurthy, *et al*., 2009). Its ability to achieve a wide range of densities (300-2000 kg/m3) makes foamed concrete suitable for various construction requirements, and it is now widely used in the industry (Jones and McCarthy, 2005; Tarasov, *et al*., 2010). Foamed concrete also enhances sustainability by eliminating the need for coarse aggregates in its manufacturing process.

Moreover, it allows the partial or complete replacement of fine aggregate and cement with secondary materials such as fly ash and rice husk ash, thus utilizing agricultural and industrial wastes for potential construction materials (Agboola *et al*., 2023; Jones and McCarthy, 2006; Agboola *et al*., 2022a; Ahmmad, *et al*., 2017). The recycling or utilization of solid wastes generated from most agro-based and manufacturing industries is very rewarding. The anxiety about enormous waste production, resource preservation, and material cost has focused on the reuse of solid waste (Islam, *et al*., 2015). Furthermore, incorporating secondary materials like pozzolanic material in foamed concrete and its potential for reuse at the end of its service life increases its sustainability potential (Jones, *et al*., 2012). However, given the typical use of foamed concrete as a large-volume fill material, monitoring its impact on sustainable construction is vital, as potentially high Portland cement contents can lead to high CO2 (Jones, *et al*., 2012). To condense this problem, sustainable materials need to be introduced in concrete production, such as rice husk ash, as a replacement cement, which could reduce energy consumption in cement production and cut down construction costs (Mounika, *et al*., 2022). Besides, rice husk ash has almost the same content as concrete with calcium oxide, silicon oxide, aluminium, and iron oxide (Khassaf, *et al*., 2014). This study will provide more information to provide a practical approach for future development, thereby producing foam concrete using rice husk ash. However, there are challenges posed by foam concrete, such as cracks, shear, porosity, strength, and torsion, which are significant issues posed by foamed concrete and affect its strength properties (Deifalla, *et al*., 2020). According to Ramamurthy *et al*. (2009), foam concrete is perceived to be weak and non-durable with high shrinkage characteristics. Also, the properties of its components, such as cement paste and voids, have a measurable effect on the properties and stability of the combined materials (Nambiar and Ramamurthy, 2007).

In addition, lightweight concrete with fibres is becoming more popular in various applications (Hassanpour, *et al*., 2012). Deformation and cracking in foamed concrete, as reported by (Wu, *et al*., 2020; Mydin, *et al*., 2012; Hilal, *et al*., 2016; Jaini, *et al*., 2016), can be minimized using Kenaf fibre to enhance the properties of foamed concrete. An effort was made to improve the strength of foamed concrete in the hardened state by including steel fibres (Abd, *et al*., 2018) and polypropylene fibres (Bing, *et al*., 2012). Studies on the properties of foamed concrete reinforced with different fibres and its behaviour still need to be completed. Investigating the reinforcement of foamed concrete using Kenaf fibre is crucial to determine its potential to enhance the properties of the concrete. Kenaf, scientifically known as Hibiscus cannabinus, belongs to the Malvaceae family and is typically found in tropical and subtropical regions. It is an annual herbaceous plant with a woody base that can grow to a height of 1.5 to 3.5 meters. The stems of the plant range from 1 cm to 2 cm in diameter and may branch occasionally. The leaves of the kenaf plant vary in shape, with the lower leaves being deeply lobed with 3-7 lobes, while the upper leaves are weakly lobed (Millogo, *et al*., 2015).

Many studies have dealt with the mechanical and performance characteristics of foamed concrete reinforced with fibres (Chalioris, *et al*., 2020; Bernardo, *et al*., 2020), but more attention needs to be paid to how the mechanical characteristics of the incorporated fibres influence the physical and mechanical properties of the foam concrete. Therefore, concerted efforts are needed to improve the weaknesses of foam concrete associated with its strength, stability, crack resistance, quality, and resistance to shear using kenaf fibres, with rice husk ash incorporated in the mix. In addition, Nigeria is not an exception in developing countries; foamed concrete is a new construction material. The need for more data on the characterization of local materials for their production, structural properties and performance of structural elements is responsible for its non-application in construction. However, there is a need for a concerted effort to improve the weaknesses of foam concrete associated with strength, stability, crack and quality using rice husk ash incorporated in the mix and kenaf fibre as reinforcement to assess its performance, which no other research or researcher have used for this purpose of producing foam concrete.

2. Materials and Methods

2.1 Materials

Portland Cement, with a strength grade of 42.5R, whose production was per BS 12 (1996), was used as the main binder. Rice husk from which rice husk ash was produced was obtained from a rice mill at Mudalawal market in the Bauchi metropolis. Kenaf Fiber was obtained from Ballanga, Gombe state. The fibres were subjected to a bacterial retting operation. The kenaf fibre was thoroughly cleaned to remove soil particles from the surface and then dried

at room temperature. The fibres were treated because of their hydrophilic properties. In a mercerization process, sodium hydroxide was used to modify the fibres' surface. The reagent (NaoH) was purchased from a chemical dealer in Bauchi, Bauchi state, Nigeria. These fibres were cut to an adequate size of 50mm for use in producing foamed concrete. The 50mm long fibre exhibited no deformation with no crack observed in concrete (Ruben rt al., 2016). River sand from the Yelwa River in the Bauchi metropolis was used for this work. Fine aggregate passes through a 300-micron sieve size but is retained on a 150-micron sieve aperture per BS 882 (1992). The finer aggregate sizes were used as coarser aggregate might tend to settle in a lightweight mix and lead to the collapse of the foam during mixing. A protein-based foaming agent was utilized, and potable tap water was employed in mixing. It is essential to use potable tap water when working with a protein-based foaming agent as organic contamination can negatively impact the quality of the foam and the resulting foamed concrete.

2.2 Mix Proportions

A mix proportion that will produce the target plastic density of 1600kg/m3 (±50kg/m3) was developed, the density being the design criterion in foamed concrete. To date, there is no standard method to carry out the foam concrete mix design. Therefore, the study carried out trial mixes to achieve the desired density and workability with the available local materials. The mix constituent proportion for the kenaf fibre foamed concrete is presented in Table 1, and the percentage of fibre content used in the mix is presented in Table 2.

Table 1: Mix Constituents Proportion for the Foam Concrete Mixes

Mix Constituents Proportion for the Foam Concrete Mixes in kg/m³							
%RHA*	Binder(kg/m³)		Sand (kg/m³)	Water for Base Mix (kg/m³)	Foam Concentration		
	Cement	RHA*			Mixing (kg/m³)	water	Foam (g/m³)
0%	450.00	50.00	850.00	250.00	12.42		220.80

Table 2: Kenaf Fiber Content

Kenaf Fiber Content (%/Kg)				
	% Kenaf Fiber Addition			
Sample	0%	0.25%	0.50%	1%
Cubes	0	0.003	0.006	0.012
Cylinder	0	0.0048	0.0096	0.0192
Beam	0	0.015	0.03	0.06

2.3 Methods

2.3.1 Strength Activity Index of Cement

The strength activity indices of cement-rice husk ash were assessed per ASTM C311 (2007). The control mortars were prepared as per the specifications outlined in ASTM C311. Subsequently, cubes were fashioned for compressive strength testing. For the mixture involving rice husk ash as a partial cement replacement, the test mixture was prepared using a consistent water and sand volume, with 20% of the cement replaced by volume with rice husk ash. The compressive strength test was carried out per the procedures outlined in ASTM C109 (2016). A 1:3 cement sand mix, with a water-cement ratio of 0.5, was employed to create 50 x 50 x 50mm prism specimens to determine the compressive strength of the cement mortar, which was cured for 7 and 28 days.

2.3.2 Wet Density Test

The wet density of foamed concrete was measured according to BS EN 12350-6 (2000) by weighing a fresh sample in a known weight and volume container for each batch before it was poured into a mould. The density was then determined by dividing the weight difference of the container when filled with concrete and when empty by the volume of the container.

2.3.3 Dry Density Test

The concrete samples were left to cure in normal environmental conditions and were subsequently weighed using a weighing balance to measure their mass per the standards outlined in BS EN 12390-7 (2009). The density of the concrete specimens was then determined using Equation 1.

$$D = \frac{M}{V} \quad \text{..... (1)}$$

Where D is the density of the concrete specimen in kg/m^3
M = mass of the specimen in kg
V = volume of the specimen in m^3

2.3.4 Compressive Strength Test

The compressive strength of the foamed concrete was tested using 100 x 100 x 100 mm cubes at intervals of 7, 14, 28, 56, and 90 days, following BS EN 12390-3 (2009) standards. The specimens were cured using the membrane (Sealed) method and were subjected to a loading rate of 120KN/min. Three specimens were tested at each age, and the average strength of the specimens was calculated by dividing it by the area of the specimens.

2.3.5 Split Tensile Strength Test

The split tensile strength in foamed concrete was determined according to BS EN 12390-6 (2009). Cylindrical specimens measuring 100 x 200 mm were used for the test. The splitting strength for foamed concrete was tested at a loading rate of 120KN/min until failure. The splitting tensile strength (Ts) can be calculated using Equation 2 as follows:

$$Ts = \frac{2F}{\pi \times L \times d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where F represents the maximum load (in KN), L is the length of the specimen (in mm), and d is the diameter of the specimen (in mm). The split tensile strength is reported to the nearest 0.05 MPa.

2.3.6 Flexural Strength Test

The flexural strength or modulus of rupture of foamed concrete was determined by using a simple unreinforced beam subjected to a point loading. The beam specimens, which were 100 x 100 x 500 mm in size, were produced, prepared and tested according to BS EN 12390-5 (2009). The flexural strength (Mr) is calculated using Equation 3,

$$Mr = \frac{PL}{bd^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In this equation, b represents the measured width in millimetres of the specimen, d represents the measured depth in millimetres of the specimen, L represents the length in millimetres of the span on which the specimen was supported, and P represents the maximum load in kilograms applied to the specimen.

2.3.7 Water absorption test

Following the specified curing period, the foamed concrete samples (cubes) underwent oven drying at 105°C for 72 hours. After cooling to room temperature, their initial weights (W_1) were measured. Subsequently, the samples were immersed in a curing medium for 30 minutes, then cloth-dried and re-weighed to obtain the final weights (W_2). These values were recorded and used to calculate the absorption rate of the concrete specimens in line with BS 1881-122 (2011). The absorption capacity was computed using Equation 4,

$$W_A = \frac{(W2 - W1)}{W2} \; x \; 100\% \; \ldots (4)$$

2.3.8 Sorptivity test

The sorptivity was determined by measuring the capillary rise absorption on a uniform material. Water was used as the test fluid. The cube, after casting, was cured in ambient conditions, and the test was carried out for 28, 56, and 90 days. After drying the specimen in the oven at a temperature of 100 ± 10°C and placing it in water with a level not exceeding 5 mm above the base of the specimen, the flow from the peripheral surface was prevented by sealing it with non-absorbing sealant using an Abro Sealant or (Silicon Sealant) as a coating. The quantity of water absorbed in periods of 10 minutes, 15 minutes, and 20 minutes was measured by weighing the specimen on a digital balance. The surface water on the specimen was wiped off with a dampened tissue, and each weighing operation was completed within 30 seconds. Sorptivity (S) is a material property that characterizes a porous material's tendency to absorb and transmit water through capillary action. The cumulative water absorption per unit area of the inflow surface increases as the square root of elapsed time (t). The results were calculated using Equation 5,

$$S = \frac{I}{t1/2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where S = sorptivity in mm
T = elapsed time in minutes
I = Δw/Ad
Δw = change in weight = $W_2 - W_1$
W_1 = oven-dry weight of cubes in grams
W_2 = weight of cube after successive minutes' capillary suction in grams
A = surface area of the specimen through which water penetrated

d = density of water

3. Result and Discussion

3.1 Strength Activity Index

The strength activity index of cement mortar is presented in Table 3. The result shows an increasing strength trend at 7 days and 28 days, respectively, for both control mortar and mortar produced with rice husk ash as partial cement replacement. The result also shows that, at both 7- and 28-day curing age, the strength activity index of 20% rice husk ash cement mortar meets the minimum requirement specified by ASTM C311 (2007), which states that the strength activity index of pozzolana must meet 75% of the control strength at 7 and 28 days. This indicates that rice husk ash is a good pozzolana and can replace cement in foamed concrete production.

Table 3: Strength Activity of Cement

	Compressive Strength (N/mm^2)		Strength Activity Index	
% RHA	**7 days**	**28 days**	**7 days**	**28 days**
0% Control	23.5	32.8	100	100
20%	18.5	27.2	78.7	82.9

3.2 Wet Density

Table 4 shows the wet density of kenaf fibre foamed concrete produced with rice husk ash as partial cement replacement. The plastic density varied between 1590 and 1635 kg/m^3, and there was a slight variation within the values recorded for foamed concrete produced and the target density of 1600 kg/m^3. The plastic density of the various concrete mixes decreased as the fibre fraction volume increased. This is anticipated as the density of kenaf fibre is (1200 kg/m^3) low relative to the density of the designed foamed concrete. The bio kenaf fibre reduces the density of foamed concrete as the fibre increases in the mix due to the hydrophilic nature of the fibre material, which tends to absolve water from the surrounding concrete mix. It also shows that the mixture containing 1.0% KF has the lowest plastic density, which has a reduced density of 2.8% compared to the control blend with no fibre.

Table 4: Average Wet Density in (kg/m^3) of Fiber Reinforced Foamed Concrete

% Addition of kenaf fibre	**Actual Plastic Density (kg/m^3)**
0	1635
0.25	1615
0.5	1610
1.0	1590

3.3 Dry Density of Kenaf Fiber Reinforced Foamed Concrete

The effects of kenaf fibre on the dry density of foamed concrete are shown in Figure 1. It can be seen that an increase in the content of kenaf fibre in the mix resulted in a decrease in the dry density of foamed concrete at all curing ages. At the 7-day curing age, there was a decrease in density as the percentage of kenaf fibre increased, and this trend was noticed at all curing ages up to 90 days. The result of the densities of foamed concrete at 28 days is 1640 kg/m^3, 1645 kg/m^3, 1645 kg/m^3, and 1640 kg/m^3, respectively, for 0, 0.25, 0.5, and 1% kenaf fibre addition, with 10% rice husk ash as cement replacement. At 90 days are 1640 kg/m^3, 1645 kg/m^3, 1645 kg/m^3, and 1640 kg/m^3, respectively, for 0, 0.25, 0.5, and 1% kenaf fibre

The behaviour of foamed concrete density variation can be explained by the fact that kenaf fibre rice and husk ash have lower specific gravity values than cement. Lower specific gravity of a material has been found to result in lower density (Ncube and Roopchund, 2024). Thus, increasing the kenaf fibre volume will make the resulting foamed concrete lighter. This can also be observed from the nature of kenaf fibre, which is a hydrophilic material; as the fibre content increases, the demand for water from the surrounding concrete mix increases. The water demand for fibre was reduced due to the treatment of fibre with sodium hydroxide (NaOH), but it still absorbs some percentage of water, as can be seen from the result of low density. The high absorption of the kenaf fibre effect can be noticed immediately after concrete is cast in place. Also, the dry density of foamed concrete at each percentage addition of kenaf fibre increased with increased curing age but with a non-linear trend.

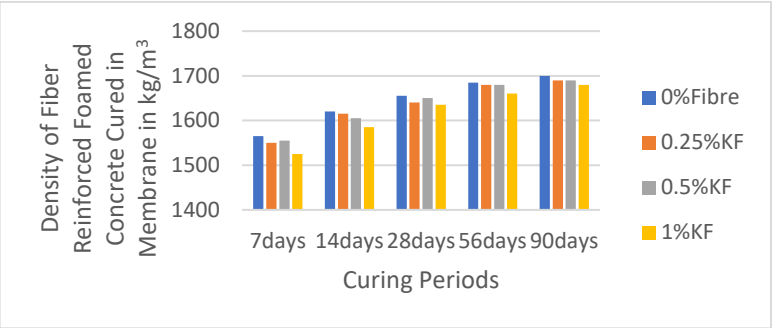

Figure 1: Density of Foamed Concrete Reinforced with Kenaf Fiber

3.4 Compressive Strength of Foamed Concrete Specimen

Figure 2 shows the compressive strength of foamed concrete with fibre content cured in the membrane. The strength of cubes with 0, 0.25, 0.5%, and 1 % KF at seven days are 8.82, 8.76, 8.81 and 8.63 N/mm^2, respectively, at 28 days; the strength gain at different percentages of kenaf fibre as reinforcement in the concrete mix, are 15.22, 15.15, 15.22 and 14.94 N/mm^2 respectively. At 28 days, the control concrete shows the same strength index with 0.5% kenaf fibre addition in concrete and shows higher strength as compared to all other fibre addition, as it shows an increase of 0.46% as compared to 0.25% kenaf fibre addition and 1.84% increase in strength as compared to 1% kenaf fibre addition as reinforcement. The RHA fibrous mixtures with lower compressive strength may be attributed to lower pozzolanic action, particularly at lower curing ages, the destruction of voids due to the inclusion of KF, and the presence of weak interfacial bonds between fibre and particles of pozzolanic cement (Azzmi and Yatim, 2018; Khoshnava, *et al*., 2017). At 90 days, strength gain includes 16.83, 16.81, 16.81 and 16.65 N/mm^2, respectively. At 28 days of curing age, the average normal strength of foamed concrete at 0% and 0.5% KF was found to be 89.5%, and that of 0.25% KF is 89% of the required strength for structural lightweight concrete, which is 17 MPa, according to Neville, (2011) and higher than the 15 MPa requirement for structural lightweight concrete according to ACI 213R (2003). On the other hand, a foamed concrete mix containing 1% KF content achieved 87.9% of the Nevile (2011) strength classification for structural lightweight concrete. The results suggest that the remaining mixes are all suitable for lightweight concrete for semi-structural or structural purposes since their densities did not exceed 2000 kg/m^3 and their 28-day compressive strengths are around 17 MPa (Nevile, 2011; Kosmatka, *et al*., 2002). 0.25% and 0.5% are the optimal level of kenaf fibre addition obtained for foamed concrete. These results also confirm that the compressive strength of lightweight foamed concrete mainly depends on the binder/acceptable aggregate ratio, water/binder ratio, type and amount of foam, curing regime, and the particle size distribution of the sand and RHA.

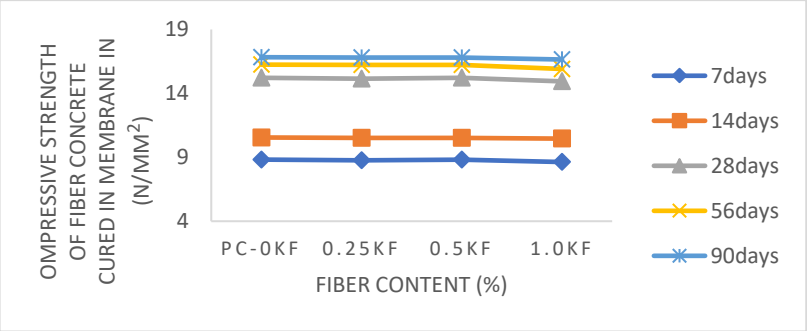

Figure 2: Compressive strength of foamed concrete with fibre

3.5 Split Tensile Strength of Concrete

Figure 3 shows that the split tensile strength of foamed concrete at different curing periods increases with an increase in the curing period. The split tensile strength of the cylindrical specimens at 7 days of curing with 0%, 0.25%, 0.5%, and 1 % kenaf fibre addition are 1.46, 1.77, 2.23 and 1.88 N/mm^2, respectively. At the 28-day curing period, the tensile strength for 0%, 0.25%, 0.5% and 1% kenaf fibre addition is 1.66, 1.85, 2.45 and 1.92 N/mm^2, respectively. While at the 90-day curing period, the tensile strength for 0%, 0.25%, 0.5% and 1% kenaf fibre addition is 2.55, 2.62, 2.85 and 2.62 N/mm^2, respectively. From the findings of this research, at seven days, 0.5% kenaf fibre shows an increase in strength beyond all other addition levels, and 0.5% kenaf fibre addition shows an increase of 52.74% as against control concrete. At 28 days, 0.5% kenaf fibre shows an increase in strength beyond all other addition levels; it also shows an increase of 32.24% as against control concrete; the matrix between rice husk ash

and kenaf fibre increased the tensile strength of foamed concrete significantly. The increase in strength might be due to an increase in the contact area between fibre and the paste-matrix due to the increased volume of hydrated materials, and also might be attributed to rice husk ash increased pozzolanic action, which also increases the healing time of concrete, which tends to improve concrete properties generally. This value from this study is higher compared to 1.8 N/mm² for the same density that was earlier obtained by Jones (2001).

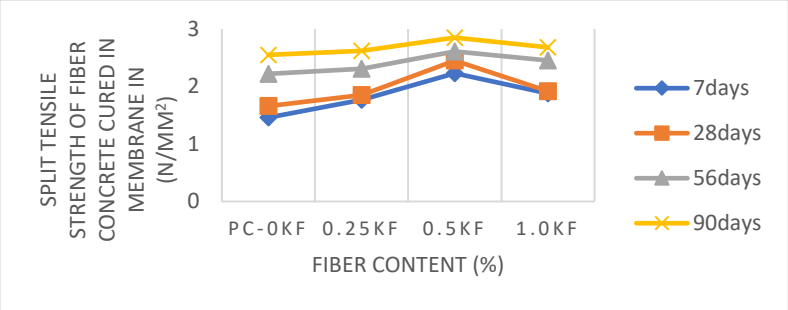

Figure 3: Split Tensile Strengths of foamed concrete Produced with Kenaf Fiber

3.6 Modulus of Rupture of Specimen Cured

Figure 4 indicates that the modulus of rupture increases with an increase in the curing period. Foamed concrete was reinforced with kenaf fibre from 0% to 1% addition. The modulus of rupture of specimens with 0%, 0.25%, 0.5% and 1 % kenaf fibre in foamed concrete at seven days curing periods are 2.44, 2.74, 2.83 and 2.65 N/mm², respectively, 0.5% kenaf fibre as reinforcement in foamed concrete shows improved strength as compared to control concrete and other fibre addition. The strength index achieved at the 28-day curing period is 2.51, 3.16, 3.28 and 2.95 N/mm², respectively. Thus, the modulus of rupture of specimens at 7 days with 0.5% shows an increase in strength of 13.78% compared to control concrete. At 28 days with 0.5%, it shows an increase in strength of 23.48% compared to control concrete. The strength index achieved at the 90-day curing period is 2.77, 3.43, 3.86 and 3.25 N/mm², respectively. The findings of this study revealed that the modulus of rupture of the specimens increases with an increase in the curing period and shows a significant increase in strength with the introduction of kenaf fibre. All kenaf fibre additions are stronger than the control foamed concrete sample. The moduli of rupture obtained in this study were higher compared to the value of 1.00N/mm² obtained by Brady *et al*. (2001) for foamed concrete of the same density.

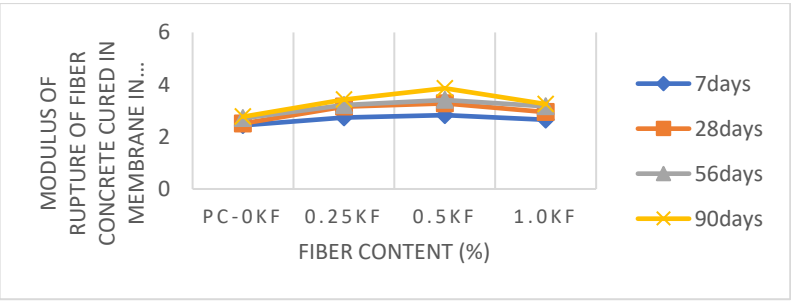

Figure 4: Modulus of Rupture of foamed concrete for specimens

3.7 Water Absorption Test of Kenaf Fiber Foamed Concrete

Figure 5 presents the water absorption test of foamed concrete at 28-, 56- and 90-day hydration periods. At 28 days, 1% of the kenaf fibre in concrete absorbed more agents than the control concrete and other percentages of fibre inclusion, while control concrete absorbed less than all kenaf fibre addition. Control concrete samples absorbed 4.08% agent, while 0.25%, 0.5%, and 1% addition of kenaf fibre absorbed 3.93%, 3.99%, and 4.35%, respectively. The same trend was noticed at 56 and 90 days. Water absorption is affected by the concrete mixture proportions, duration of curing and type, age or degree of hydration, micro-cracks, and the entrained air content (2013).

The reduction in the water absorption capacity of control concrete specimens results from the density of the specimen with close particles and less concentration of pozzolanic materials, which instead enhance the porous characteristics of the foam concrete specimen. Also, there was reduced water ingress for the control foamed concrete due to the absence of fibre with hydrophilic characteristics in nature, which tended to attract more water.

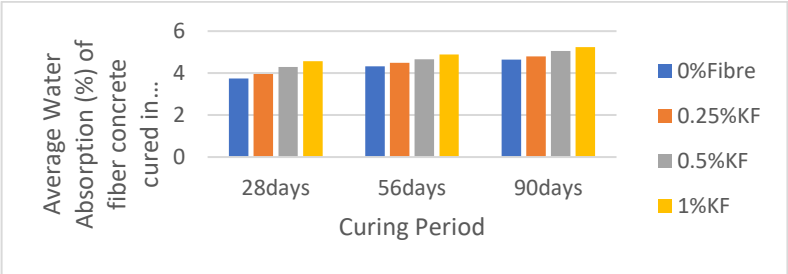

Figure 5: Water absorption test of Foamed Concrete with Fiber

3.8 Sorptivity of Fiber Reinforced Foamed Concrete

Figures 6, 7 and 8 plot the cumulative sorptivity against time for RHA foamed concrete produced with Kenaf fibre at (0.25%, 0.5% and 1% weight fractions) and tested at 28 days, 56 days and 90 days. The control foamed concrete is 9.7 x 10^{-8} mm/$mm^{0.5}$. 0.25% has a value of 10.5 x 10^{-8} mm/$mm^{0.5}$, 0.5% has a value of 11.1 x 10^{-8} mm/$mm^{0.5}$, while 1% KF content has 11.5 x 10^{-8} mm/$mm^{0.5}$ at 28 days. The value of sorptivity increased with an increased percentage of rice husk ash in concrete; the control concrete gave lower sorptivity, while 1% kenaf fibre content gave the highest sorptivity value. The lower sorptivity value of the control concrete may result from fibre not being present in the control concrete. The trend was also noticed at 56 days and 90 days of curing. The graph trend describes the sorptivity of the foamed concrete specimens from 10 to 30 min, with the trend linear. Accordingly, water movement through concrete is hindered due to the presence of fibre. From the result obtained in this study with the required concrete density, there is predictable minimal swelling and shrinkage.

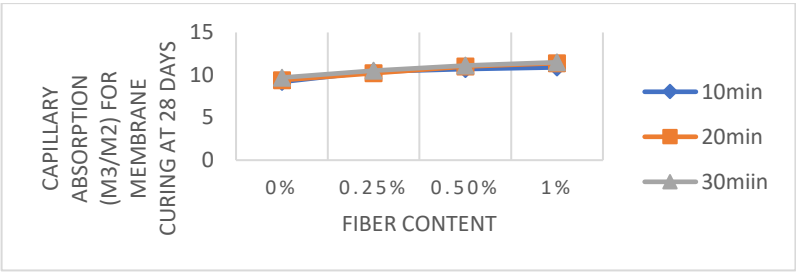

Figure 6: Sorptivity test of Foamed Concrete with Fiber at 28 days

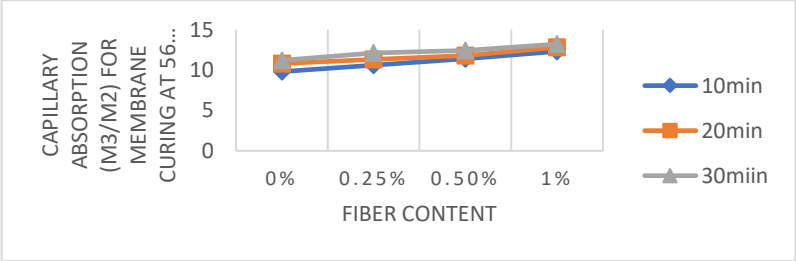

Figure 7: Sorptivity test of Foamed Concrete with Fiber at 56 days

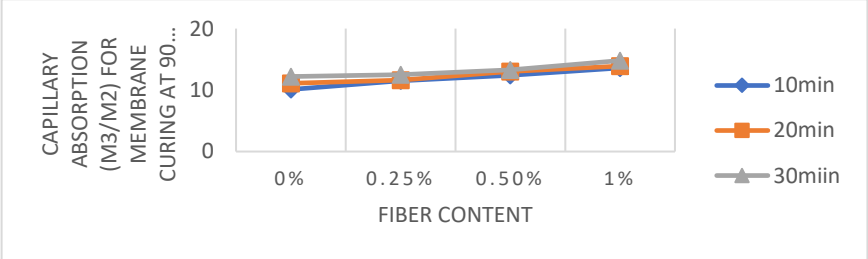

Figure 8: Sorptivity test of Foamed Concrete with Fiber at 90 days

4. Conclusion

The addition of kenaf fibre to foamed concrete mix reduces its density. There was no significant change in the compressive strength of foamed concrete, but a significant improvement was observed in tensile and flexural strength. The 28-day compressive strength of foamed concrete in this study at the designed density of 1600kg/m^3

was higher than the minimum strength requirement for classification as a structural lightweight of 15N/mm^2 as per (ACI 213R). 0.5% fibre content has the highest flexural and split tensile strength across all curing ages. Also, all kenaf fibre additions have improved splitting and flexural strength beyond the control of foamed concrete at all curing ages. The 28-day split tensile strength for control foamed concrete with 1.66N/mm^2, the lowest strength achieved, meets the ASTM specification for lightweight concrete. The 28-day flexural strength for foamed concrete with 2.51N/mm^2, the lowest value achieved, meets the ASTM specification for lightweight concrete. Up to 1% kenaf fibre addition and 10% RHA as cement replacement can produce foamed concrete without losing its classification as lightweight concrete according to ASTM standards. Because of a more robust fibre-cement matrix interface and matrix densification, foamed concrete containing kenaf fibre and rice husk ash has improved flexural and split tensile strength at all curing ages. Water absorption of control foamed concrete at 28, 56 and 90 days was the lowest. Control foamed concrete has the lowest sorption rate at all curing ages than all other fibre addition samples. The use of kenaf fibre in the production of foamed concrete will significantly help improve tensile performance. Using kenaf fibre will also promote the utilization of natural fibres available locally. Recycling agro-waste, such as rice husk ash, in concrete production is significant in meeting the requirement for a cleaner atmosphere and sustainable environment and also encourages green concrete production. Further investigation is needed to develop compatible chemical admixtures that will improve the capacity of foamed concrete produced with pozzolanic material and nature fibre material with hydrophilic properties. With the advancement of fibres, the study of a wide range of properties and characteristics of foamed concrete can be further developed. An area for further studies is the examination of bubble sphericity precisely and, in general, the microstructure of the whole matrix containing fibre and pozzolanic materials.

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Assessment of the Impact of Kainji Lake National Park on the Host Communities

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Abstract

When Parks are developed on a community land, household's means of livelihood are affected. It is in this light that this paper examined the impact of Kainji Lake National Park on its host communities. The study used mixed method of research. Purposive sampling was used in selecting the study areas. Ten communities that fall within 3 to 5-kilometer distance from the park were selected for the study. These communities include Ibbi, Doro, Malale, Kizhi, Wawa, Kuble, Mazakukuk, Worunmakto, Mulea and Felegi. A total of 370 structured questionnaires were administered randomly to respondents while focused group discussion including stakeholders' interviews was carried out. Data obtained were analyzed using descriptive statistics and presented in frequency tables. The data analyzed revealed economic, social and environmental impacts of the park on the communities. Positive impacts identified in the study show that the host communities benefited in the area of employment with 36%, community cohesion 12%, skill acquisition 32% and preservation of cultural heritage 65.7%. However, there have been identified negative impacts of the park on the residents of the communities. These includes, increase in price of goods and services 29.5%, loss of agricultural land 74.3% and displacement of residents 27%. The study further found out that the Park has contributed positively to communities but needs to do more in order to mitigate the negative impacts as identified. The paper concluded by making recommendations based on the impacts of the park. The need for National Park Service to focus more on local priorities that reflect poverty reduction was emphasized and suggested by the paper.

Keywords: Development, Host communities, Impact, Kainji Lake National Park, Tourism

1. Introduction

Tourism is one of the world's largest employers of labour and among the major sources of foreign exchange earnings (Blank, 1991 and Richards, 2003). It is from this view that most people believe that the industry is one of the major means through which local communities' development can be achieved (Beeton, 2006). Tourism has been an effective contributor to improving the income level of the host community and has the potential to improve the quality of life in general (Andereck and Nyaupane, 2011). The perception of locals on the impact of tourism, whether positive or negative, is important in influencing their participation and support for further tourism development (Almeida-Garcia *et al*., 2016) and will affect their quality of life. The quality of life influences the way communities perceive tourism and its development. When tourism development generates positive impacts, the quality of life of the local communities is enhanced (Ma and Kaplanidou, 2017). However, community may not experience any impact as some are dependent on natural resource features (mountains, coral reefs) or development and spatial forms (special "tourist zones"). Others relate to the social condition of the host community, particularly the ability to culturally or socially connect with tourists. Parks have generally been studied from the socio-economic perspective and management challenges by scholars in the past (Elochukwu 2013; Okochi *et al*., 2016), and the effects of human activities on the environmental conditions (Adebayo, 2015). But the limited knowledge on the impacts of Parks on their host communities from both economic, social and environmental aspects is what calls for this study. Hence, based on the background above this paper aimed to examine the impact of Kainji Lake National Park on the host communities in view to identify the nature and level of possible impacts, and their implications on the host communities.

2. Review of Literature

2.1 Impacts of Tourism on the Host Communities

The impacts of tourism have been deliberated vastly in various contemporary studies. Generally, these impacts are typically identified as either positive or negative, in one of three particular groups i.e. economic, environmental and socio-cultural impacts.

i. Positive impacts

The economic benefit entails the effect that the production, distribution and consumption of wealth in the human society have on one another (Moffatt, 2008). So, tourism is a concept of economic activities with great benefit on the society as it is an instrument for host community development. As highlighted by (Vilayphone, 2009) it also creates new employment opportunities both directly and indirectly, stimulates the growth of the tourism industry and through that it helps to enhance the economic growth and poverty reduction of host communities. For instance, study results by (Maryam *et al*., 2018) indicated that Kainji Lake National Park has contributed positively to the growth and development of the host communities, and has contributed economically in the area of job creation and revenue generation to the government of Niger state and also helped in the conservation and preservation of flora and fauna in the park

The socio-cultural impacts are the human impacts of the tourism industry, with an emphasis on changes in the quality of local residents' daily life at the tourist destinations. As highlighted by (Ogorelc 2009) who argued that the socio-cultural benefits of tourism are forming because of the direct contact between the host (locals) and the guest (visitors). For example, a study by (Zaei and Zaei, 2013) also divided the socio-cultural benefits of tourism into seven aspects, including the improvement of local facilities and infrastructure, the availability of more events, the conservation of the local cultural heritage, a decrease in the movement of people from rural areas to urban areas, and an increase in youth exchange programmers. Furthermore, Tourism can be an important means to encourage and help to pay for conservation of the man-made environment. Many researchers have acknowledged the positive impacts of tourism on the manmade environment. Such as, enhance residents' living: more and better leisure, recreational, shopping and health facilities, greater recognition of the importance of saving historical buildings, improved communication systems and transportation.

ii. Negative impacts

Several host communities had negative attitudes towards tourism due to the economic costs of tourism. One of such economic costs is high consumer prices in the host communities. Kreag, (2001) argue the fact that booming tourism industry places a huge pressure on the limited resources such as food, transport, land, water supply, electricity, etc. in the host economy and the increasing demand on these limited resources and facilities may lead to inflation, causing negative effects on the host communities. The industry creates jobs which are not sustainable, do not require professional skills and do not provide a sufficient salary to afford family expenses.

Mbaiwa (2004), who examined the socio-cultural influence of tourism development in the Okavango Delta, Botswana, found that tourism development had a negative socio-cultural effect on the host communities, posing a threat to the quality of life of locals. These include racial discrimination, enclave tourism, the resettlement of traditional communities, the breakdown of the conventional family structure and relations, and an upsurge in crime and prostitution. The extent of the environmental impact depends on the type of transport used. Even cycling, although it is considered an environmentally friendly mode of transport, can damage environmental sensitive areas. Other tourist vehicles, such as buses, cars and motorcycles can cause air pollution, and damage-built structures.

3. METHODOLOGY

3.1 Study area

The study area (Kainji Lake National Park) was established in 1979 by the amalgamation of former game reserves, the Borgu game reserve (in Niger and Kwara States) and the Zurguma game reserve (in Niger State). The KLNP is geographically located at Latitude 9º 50' 19" N, Longitude 4º 34' 24" E. The area has savanna vegetation with a total area of 5,340.82 sq km and is located in the Northwest central part of Nigeria between Niger and Kwara States. The area has two distinctive sectors known as the Borgu and Zurguma sectors.

3.2 Sampling Procedure

The sample for this study was drawn from the total population of some selected communities that are at the fringe of the park. However, ten communities that falls within 3km to 5km distance from the park were purposively selected for the study. These criteria used in selecting the communities is within the (World Tourism Organization [WTO], 1996) recommendation for a good coverage of host communities of National Parks. These include; Ibbi, Doro, Malale, Kizhi, Wawa, Kuble, Malale, Mazakukuk, Worunmakto, Mulea and Felegi. Therefore, the total population of this communities from which samples were drawn is 14,962, and the sample size of 370 was adopted which indicates a proportion of about 2.4% of the total population was used to administer questionnaires. The questionnaires were randomly administered to the respondents. (See Table .1)

Table 1: Selected communities and their distance from the park

s/no	Sample communities	Population	Distance of village to park
1	Ibbi	3,945	50m
2	Kizhi	421	1km
3	Doro	1,114	1km
4	Kuble	465	4km
5	Malale	524	4km
6	Mazakukuk	1,492	2km
7	Worunmakoto	422	2km
8	Wawa	4,438	5km
9	Mulea	541	50m
10	Felegi	1,600	100m
Total		14,962	

Sources: Authors computations based on the Primary Health Care Unit and Kainji Lake National Park, 2022

Focused group discussion was organized along with the local chiefs and some selected local members who are quite conversant and knowledgeable about the park, and the communities. Each group meeting comprised of four (4) to six (6) participants for effective discussions. The focused group discussions were used to understand the impacts of the park on the communities. Key Informants Interviews were also conducted as follow up to the group discussions to gather more primary information from the stakeholders. The key informants are individuals who because of their position or experience have a good understanding of what is being investigated; therefore, interviews were conducted with staff of the park, community's leaders, and local government representatives in order to establish the level of this park impacts on the communities. Generally, this is to help uncover participant's experiences and subjective attitudes that are usually inaccessible through other method.

4. Results and Discussions

4.1 Positive impacts

The analysis in table 1 present the Economic benefits of KLNP on the local communities studied. The result of the analysis shows that, most of the respondents (36%) indicated that employment opportunities is one of the economic benefits of the park on the communities, followed by creation of new businesses (33%) and increased household income (31%). The findings indicated an improved quality of life to the host communities.

Table 1: Economic benefits from the park

Benefits	Number of respondents	Percentage
Stimulate new businesses	122	33
Contribution to household income	115	31
Employment opportunities	133	36
Total	**370**	**100.0**

Source: Field Survey, 2022

In terms of social benefits, the analysis in table 2, shows a good number of respondents with about 22.2% of locals confirmed that enlightenment campaign organized by the park improved the community's social wellbeing, while the least element of social development recorded was lost in confidence to live in the community (8.6%). The findings indicate poor sense of community among the host communities because of poor security and safety in the areas.

Table 2: Social development by KLNP

Activities	Number of respondents	Percentage
Skills acquisition	37	10
Community cohesion	66	17.8
Health care	44	11.8
Access to education	73	19.7
Enlightenment campaign	82	22.2
Security and safety	36	9.7

Attract people to live in the community	32	8.6
Total	**370**	**100.0**

Source: Field Survey, 2022

Analysis on the environmental benefits to the communities, 65.7% of the local respondents believed that the presence of the park helps to preserve their local cultural heritage and this true because of the effort of the park to pursue and deliver its corporate social responsibility to the host communities as one of the core policies of the KLNP.

Table 3: Contribute to local environmental protection and conservation

Benefit	Number of respondents	Percentage
Preservation of cultural heritage	243	65.7
Improvement of community environment	127	34.3
Total	**370**	**100.0**

Source: Field Survey, 2022

The analysis further identified other benefits such as provision of financial support, conflict resolution, information dissemination and source of labour to the residents of the community. The findings agree with the earlier study by (Oladeye, 2000) which established that the existence of Kainji Lake National Park in the neighborhoods where they are situated has made significant impact on the status and economy of the residents of the communities.
The result of this findings also differs from the conclusion of the findings made by (Haralambopoulos and Pizam, 1996), which found that, tourism depends very much on external demand factors, and that creates over dependence on tourism related products, while ignoring the local traditional ways of earning income.

4.2 Negative impacts

Analysis of the negative impacts of the KLNP on the host communities, it was found out that, certain impacts of the park was considered negative by the respondents. It was established that there is an increased cost of living, about 29.5% of the respondents are with the view that there is an increase in the prices of goods and services due to the Park operations in the area, 27.3% claimed that there is high joblessness during off season, 26.4% opined that cost of transports has increased, while 16.7% attributed increase in low pay-jobs in the area. All these were attributed to the presence of KLNP close to the communities.

Table 5: Increased cost of living

Variables	Number of respondents	Percentage
Increases cost of transports	98	26.4
Low pay-jobs	62	16.7
Increase in price of goods and services	109	29.5
Unemployment during off season	101	27.3
Total	**370**	**100.0**

Source: Field Survey, 2022

This finding also agrees with the conclusion made by (Pearce, 1989) and concluded that as tourism grows, the supply of services and goods is not sufficient to meet the increased demand and very often a disparity exists between the spending power of tourists and of host communities. Consequently, prices of land, goods and services increases in tourist areas and residents may have to pay higher prices. The responses of the local communities also established that the presence of KLNP has resulted to an induced negative environmental impact to the host communities as presented in Table 6.

Table 6: Irreversible change on the local environment

Variables	Number of respondents	Percentage
Loss of agricultural land	275	74.3
Destruction of vegetation	95	25.7
Total	**370**	**100.0**

Source: Field Survey, 2022

Further analysis on the negative impacts of the KLNP on its host communities, indicates insecurity in the tenure across host communities. The findings shows that about 42.4% of the respondents indicates that residents were restricted from the use of the forest resources, and 30.5% responded that there is loss of grazing light, while 27% indicated that there is displacement of residents due to the park operations.

Table 7: Compulsory acquisition of community land

Variables	Number of respondents	Percentage
Restriction from natural resources	157	42.4
Loss of grazing right	113	30.5
Displacement of residents	100	27
Total	**370**	**100.0**

Source: Field Survey, 2022

Generally, as revealed from the group discussions and interview; that Park jobs do not provide a reasonable income to cover household expenses and those local members working in the park cannot make a long-term financial decision.

5. Recommendation and Conclusion

Based on the findings of this study, the following recommendations were made for the full realization of the park benefits to the host communities in the future.

Since the study have established that the local communities are being prohibited from the park resources. The National Park service should institute more training program and agriculture extension related opportunities to more members of the communities. The displaced communities such as, New kali and Tunga maje should be given additional consideration in the area of empowerment and projects. This should be based on the status of community poverty mapping, and the availability of existing community facilities. Furthermore, the National Park service should provide more alternatives for the local farmers. The study further recommends that resident's knowledge and opinion should be consider, and factor in to all park decision making, as this may likely compel the local's community to commit themselves to conservation strategies. There is the need to review the current National Park policy inline of the current realities in shaping the wellbeing of the local host communities.

In conclusion, this paper investigated the impacts of Kainji Lake National Park on the local communities. The research has made an important practical contribution to the understanding of tourism in the KLNP, particularly in relation to the key concepts discussed in this research: The study found out that the local residents have benefited from the park existences specifically in the areas of formal and informal employments, and generally in the area of social development etc. However, so much need to be done so as to further improve the condition of the host communities and also to avert the negative impacts as revealed from the paper. Finally, future studies on the impacts of the park on the host communities should focus on the obstacles that hindered communities enjoying the full benefits of the park to full integration and participation of the local people.

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Appraisal of the Role of Urban Governance in Tackling Insecurity in Abuja Municipal Area Council (AMAC) of Federal Capital Territory (FCT)

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Abstract

This study explores the impact and effectiveness of urban governance structures in addressing the challenges of insecurity within Abuja Municipal Area Council AMAC. The framework of this study is the rising concern of insecurity in urban areas of the Federal Capital Territory (FCT), particularly in AMAC, which has seen an increase in crime rates and security threats. The objective of this study is to assess the role urban governance plays in tackling insecurity in Abuja Municipal Area Council AMAC and their effectiveness in mitigating insecurity. The study employs a mixed-methods approach, integrating both quantitative and qualitative data collection techniques. Survey instrument was distributed among residents to gather quantitative data, while in-depth interviews with government officials, security personnel, and urban planners provided qualitative insights. The study employed stratified random sampling to ensure representation across different wards of the AMAC population. Data were analyzed using statistical tools for quantitative data and thematic analysis for qualitative data to identify key patterns and themes related to urban governance and insecurity. The findings reveal several critical insights. Firstly, there is an annual increase of reported crime by 21.05%. Secondly, Crime Prevention Programmes is the highest ranked urban governance strategy in tackling insecurity with a chi square of .000, while urban governance initiatives such as community policing, surveillance systems, and public awareness campaigns have been introduced, their implementation has been inconsistent and fragmented. There is a significant gap between policy formulation and execution, largely due to inadequate funding, bureaucratic inefficiencies, and lack of coordination among security agencies. Community engagement emerged as a crucial factor in the study. Recommendations include targeted interventions aimed at addressing root causes of insecurity, revamp existing strategies for improved effectiveness. Improving inter-agency collaboration and ensuring consistent policy implementation are vital for achieving sustainable security improvements.

Keywords: Governance, Insecurity, Policy, Urbanization.

1. Introduction

Urbanization is an inevitable consequence of economic growth and development in both developed and developing countries (Aldrich and Meyer, 2015; World Bank, 2018). As cities continue to expand, the challenges of managing them effectively become increasingly complex (Davoudi, 2012; United Nations, 2018). One of the most pressing challenges facing urban areas today is ensuring security for their residents. In Abuja Municipal Area Council (AMAC), rapid urbanization has led to an increase in crime rates, which has significant implications for the safety and well-being of its residents (Onuoha, 2018; Oyedokun and Salami, 2020). With Research Questions; what are the primary security challenges currently faced by residents in the Abuja Municipal Area Council (AMAC), Federal Capital Territory (FCT)? What socio-economic, demographic, and environmental factors influence the prevalence of security challenges in AMAC? How effective are the current urban governance tools and strategies in addressing insecurity and improving governance in AMAC? What factors hinder the effectiveness of urban governance tools and strategies in achieving urban security in AMAC? What policies and strategies can be implemented to enhance urban security through improved governance in AMAC? Rapid urbanization in the Abuja Municipal Area Council (AMAC) of the Federal Capital Territory (FCT) of Nigeria has led to a range of urban governance challenges, including urban security. Despite the implementation of various urban governance initiatives crime rates in the FCT remain high, particularly in urban poor areas. The effectiveness of urban governance in addressing the root causes of urban security challenges in the FCT remains unclear. Furthermore, these studies often assessed government interventions in isolation without adopting a holistic, systems-based approach and provided limited critiques of the AMAC and FCT administration's urban governance based on established principles of good governance. This study is out to assess the role of urban governance in tackling insecurity in AMAC, FCT.

2. Literature Review

Urbanization presents both opportunities and challenges. On one hand, cities can serve as engines of economic growth, innovation, and cultural exchange. They offer better access to education, healthcare, and employment opportunities. On the other hand, rapid urbanization can lead to social inequalities, inadequate housing, congestion, pollution, and strains on infrastructure and public services. These challenges can contribute to urban insecurity, including crime rates, social tensions, and insufficient provision of basic services (Onuoha, 2018; Oyedokun and Salami, 2020). One of the key implications of urbanization on urban security is the increase in crime rates. Rapid urbanization often leads to overcrowding, inadequate housing, and the concentration of disadvantaged populations in certain areas, which can contribute to social tensions and higher crime rates (Olofinjana *et al*., 2019; Onuoha, 2018). Urban areas provide opportunities for criminal activities such as theft, robbery, drug trafficking, and gang violence. The density of population and the presence of valuable resources make cities attractive targets for criminal elements. Urbanization can lead to social inequalities, which further exacerbate urban security challenges.

Urban governance plays a crucial role in addressing urban security challenges by providing the framework and mechanisms to ensure the safety and well-being of urban populations. Effective urban governance enables the formulation and implementation of policies and strategies aimed at enhancing public safety, crime prevention, and emergency management (Carmona *et al*., 2003). It ensures that urban areas are well-planned, designed, and managed to minimize security risks and vulnerabilities. Urban governance involves the provision of basic services and infrastructure that contribute to urban security. Moreover, urban governance frameworks promote citizen participation and community engagement, fostering partnerships between communities and authorities to create safer and more secure urban environments (Glaeser *et al*., 2016). Consequently, according to the Federal Capital Territory Authority (FCTA) the Community policing, Closed-circuit television (CCTV) surveillance, public safety and emergency response unit (PSERU) are the strategies put in place to tackle insecurity in AMAC (FCTA, 2019) while Gated Communities, and Angels watch are the new prevailing strategies used by individuals and communities in tackling insecurity (Landman, 2000).

3. Methodology

The methodology involved a descriptive survey with a structured questionnaire administered to residents of Abuja Municipal Area Council (AMAC) FCT. This study adopted stratified random sampling technique to select its respondents. With a population of 1,967,500 the sample size was derived using the Krejcie and Morgan (1970) table was used to arrive at the sample size of 384 respondents to represent the sample population. The sampling frame, included various groups such as AMAC residents, security agencies, government officials and urban planner will ensure the sampling frame is comprehensive, up-to-date results, and ensure the sample's representativeness. A total of 384 questionnaires was answered from the questionnaires administered to respondents and analyzed. The questionnaire was divided into four sections: the first section was committed to the respondents' background; the second section was committed to Security State in AMAC, the third part was committed to Urban Governance Tools Effectiveness in Tackling Insecurity in AMAC and the final section was dedicated to Urban Governance Tools effectiveness in Tackling Insecurity in AMAC. Primary data sourced from surveys and interviews and Secondary data from government reports, academic research and crime statistics will be used in this study. Microsoft Excel and the Statistical Package for Social Sciences (SPSS) software were the statistical tools adopted for analysis with tables, charts and maps used for data presentation.

4. Results and Discussion

4.1 Security State in AMAC

To have a perspective of the state of security in AMAC there is a need to have an understanding of the rate at which insecurity grows within the city therefore making it necessary to analyse the official statistics on crime from the Police in preceding years which lead to a trend analysis of reported crimes from 2018-2022 to know if crime has been in an increase or decrease.

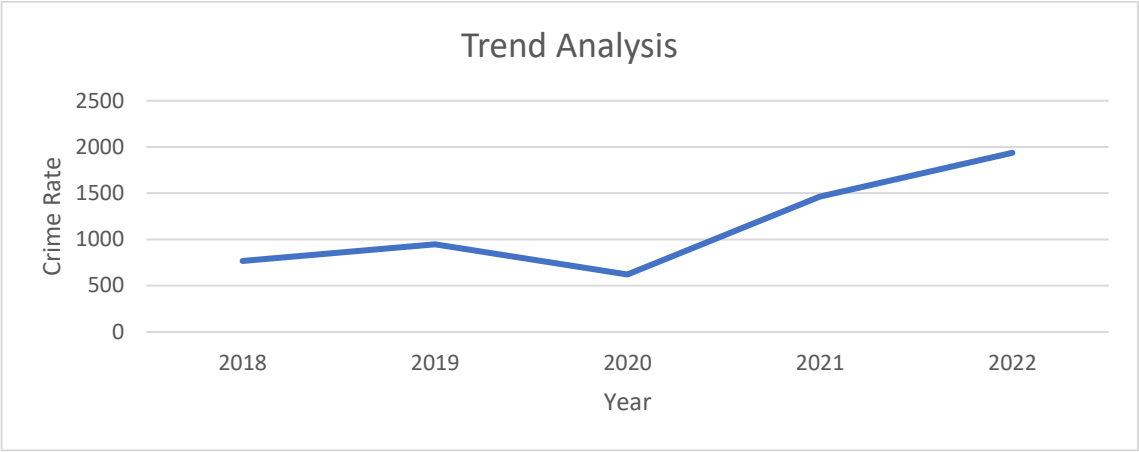

Figure 1: Annual Trend of Crimes Reported

Figure 1 presents data on crime rates over a period of five years, from 2018 to 2022. The general upward trend in crime rates over the five-year period. Despite a dip in 2020, the crime rates have been consistently increasing from 2018 to 2022. From 2018 to 2019, there was a significant increase of 21.05% in the crime rate. In 2020, the crime rate decreased by 327 compared to 2019, impacted of external factors (e.g., lockdowns, restrictions) that may have contributed to the reduction. In 2021, with an increase of 841, in 2022, an additional increase of 475 was reported.

Table 1: Satisfaction Level of Various Government Policies and Strategies in Tackling Insecurity

Government Policies and Strategies	**Satisfactory Level of Respondents**				
	Very Dissatisfied	**Dissatisfied**	**Neutral**	**Satisfied**	**Very Satisfied**
Law Enforcement and Policing	36	80	96	41	9
Community Policing Initiatives	38	84	88	45	9
Crime Prevention Programmes	38	84	88	45	9
Surveillance and CCTV systems	12	43	62	34	5
Social Welfare and Support Programmes	9	31	47	23	7
Urban Planning and Design	4	20	32	13	3
Community Engagement and Participation	4	11	13	28	3

Table 2 employs Spearman ranking analysis to analyze the hierarchy of significance of each urban governance policy or strategy in addressing insecurity. By ranking the effectiveness of these strategies based on respondent perceptions, this table provides valuable insights into which measures are deemed most impactful in resolving insecurity. Understanding the hierarchy of significance helps policymakers prioritize resource allocation and focus efforts on the most effective interventions.

Table 2: Effectiveness of Strategies to Resolve Insecurity

Policies and strategies	**Spearman ranking of policies and strategies**							**Ranking**
Crime Prevention Programmes	.000	.000		.000	.000	.001	.435	1
Surveillance and CCTV Systems	.001	.217	.000		.000	.000	.614	2
Urban Planning and Design	.303	.128	.001	.000	.000		.000	3
Social Welfare and Support Programmes	.203	.948	.000	.000		.000	.013	4
Community Engagement and Participation	.072	.803	.435	.614	.013	.000		5
Law Enforcement and Policing	.004	.067	.000	.001	.203	.303	.072	6
Community Policing Initiatives	.067		.000	.217	.948	.128	.803	7

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The analysis of the Spearman ranking for policies and strategies to address insecurity in the Abuja Municipal Area Council (AMAC) reveals that Crime Prevention Programmes and Surveillance and CCTV Systems are the most effective. Urban Planning and Design also shows considerable effect, ranked third, highlighting the importance of strategic urban development in enhancing security. Social Welfare and Support Programmes, and Community Engagement and Participation follow, indicating reasonable effectiveness through socio-economic improvements and community cooperation. Law Enforcement and Policing, while necessary, shows mixed results and ranks sixth, signifying traditional methods alone are insufficient. Community Policing Initiatives rank lowest, underscoring the need for improved implementation and support to increase their effectiveness.

1. Urban Security and Governance Strategies

Carrying out a thematic analysis revealed that several recurring issues mitigate against the effectiveness of urban governance tools and strategies in AMAC. Key factors include inadequate resource allocation, poor implementation quality, lack of community engagement, fragmented coordination among agencies, insufficient training, and lack of transparency and accountability. Addressing these challenges requires a comprehensive approach involving better resource management, improved policy implementation, enhanced community involvement, stronger inter-agency coordination, comprehensive training programs, and increased transparency and accountability.

Table 3: Summary of Urban Security and Governance Strategies

Strategy	Implementation Process	Stakeholder Dynamics	Outcome	Recommendations
Gated Cities Approach	Private sector engagement, community involvement, government support.	Residents, private security firms, local authorities.	Enhanced security within gated areas, social segregation, and potential crime displacement.	Implement
Private Security Approach (Vigilante)	Community mobilization, training and equipping, integration with formal security forces.	Community members, traditional leaders, government and security agencies.	Enhanced local security, trust between residents and security providers, challenges with legal and accountability issues.	Revamp
Community Policing	Training and sensitization, establishment of community policing committees, patrol and engagement strategies, collaborative problem solving.	Police officers, community members, local leaders and organizations, government authorities.	Improved trust and cooperation, enhanced crime prevention, empowerment and ownership, challenges with resources and resistance to change.	Revamp
Crime Prevention Programmes	Education campaigns, community outreach, youth engagement activities.	Community members, local organizations, government authorities.	Reduced crime rates, increased community awareness, sustainability challenges.	Effective
Surveillance and CCTV Systems	Installation of cameras, monitoring systems, integration with police operations.	Local authorities, police force, private security firms.	Enhanced monitoring and crime detection, privacy concerns, maintenance challenges.	Effective
Urban Planning and Design	Development of urban infrastructure, zoning regulations, integration of safety features in urban design.	Urban planners, local authorities, community members.	Enhanced urban safety and livability, long-term crime reduction, implementation challenges.	Revamp

Table 3 summarizes various strategies for urban security and governance, highlighting their implementation processes, stakeholder dynamics, outcomes, and recommendations for future action. Strategies such as the Gated Cities Approach, Rapid Response Service, Angels Watch Approach, Crime Prevention Programmes, and Surveillance and CCTV Systems are deemed effective and recommended for continued implementation. On the other hand, strategies such as the Private Security Approach (Vigilante), Community Policing, Police Checkpoints, Law

Enforcement and Policing, Social Welfare and Support Programmes, and Urban Planning and Design are recommended for revamping. These approaches, although beneficial in certain aspects, face significant challenges like legal and accountability issues, resource constraints, potential for corruption, and implementation difficulties. Revamping these strategies is necessary to address these challenges and improve their effectiveness in enhancing urban security and governance

5. Conclusion

Educational Level is identified as a significant contributor to insecurity, consistent with research demonstrating the association between Illiteracy level and increased crime rates Drug abuse, economic inequality, rapid urbanization, political unrest, ethnic/religious tensions, and poor infrastructure are all identified as contributing factors to insecurity, aligning with broader understandings of the complex socio-economic and political dynamics shaping urban security

The disparities in crime incident rates among different wards highlight the need for targeted and localized security measures. The data indicated that while some areas experience high levels of insecurity, others benefit from more effective security practices, suggesting that successful strategies could be adapted and applied to more vulnerable areas.

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Evaluation of the Integration of Passive Design Techniques in Hotel Buildings for Low Energy Use in Minna

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Abstract

This paper addresses the urgent need for energy-efficient solutions in the hospitality sector. Given that Minna has a tropical savannah climate, the integration of passive design techniques is seen as crucial for reducing energy consumption and enhancing sustainability. This study evaluates passive design techniques and their applications in hotel buildings, aiming to provide insights for built environment stakeholders. The methodology for this study employed a mixed-methods approach, integrating both qualitative and quantitative techniques to evaluate passive design techniques in hotel buildings in Minna. Data was collected through checklists from physical observations of twelve hotels in the Tunga area of Minna, selected via purposive sampling. This direct observation allowed for an assessment of various design elements, including external shading devices, building orientation, and window-to-wall ratios. The results indicate that overhangs are the most common passive design technique, utilized by 29% of surveyed hotels, effectively reducing heat gain and enhancing indoor comfort. Favorable building orientations and distances between structures were observed, reflecting an awareness of their benefits, although the the utilization of deeper reveals seems limited. Therefore, while overhangs are the predominant passive design technique in the hotel buildings in Minna, effectively contributing to solar shading, techniques such as curved ceilings and tree landscaping promote natural ventilation, yet limited reveals restrict potential energy efficiency gains in some of the hotels. The findings from this study shows that there is a room for research into the long-term performance and user perceptions of passive design techniques in hotel buildings.

Keywords: energy conservation, hotel buildings, Minna, passive design techniques, sustainability

1. Introduction

The increasing global concern over energy consumption in the built environment necessitates innovative approaches to building design, particularly in hospitality sectors where energy demands are substantial. In Minna, Nigeria, the integration of passive design techniques offers a promising pathway to enhance energy efficiency in hotel buildings, aligning with sustainable development goals. This paper is significant as it addresses the critical need for passive design strategies to achieve low energy use within the hospitality industry, which is often characterized by high energy consumption and environmental impact. By evaluating passive design techniques, this study not only contributes to academic discourse but also provides practical insights for architects and developers aiming to reduce energy consumption in hotel buildings.

Furthermore, the application of these techniques in hotel buildings is critical for achieving low energy use, particularly in regions like Minna, located in the tropical savannah climate (Asonibare, 2023). Due to the utilization of natural resources and environmental conditions, passive design techniques help maintain comfortable indoor climates without relying heavily on mechanical systems (Omar, 2020). This study also has the potential to contribute to both reduced energy consumption and enhance the sustainability of hotel operations. In Minna, where the climate can be hot and humid, the application of passive design techniques can significantly mitigate energy use and operational costs while improving guest comfort and satisfaction (Bagio, 2023; Shehu *et al*., 2019).

Energy consumption in hotel buildings is a significant concern. Studies have shown that space heating, cooling, and lighting contribute to the energy use in hotel buildings by about 42% to 50%(Mensah, 2013; Borowski & Zwolińska,

2020). This presents a pressing challenge, as the hospitality industry grapples with balancing guest comfort, operational efficiency, and environmental sustainability. Addressing this challenge is crucial, not only for reducing the environmental impact of the hotel industry but also for improving the financial bottom line. Depletion of energy stocks and rising energy costs, driven primarily by fluctuations in global oil prices, have led to a significant increase in operational costs for hotels, ultimately hurting profit margins (Cingoski & Petrevska, 2018).

Despite the availability of various passive design strategies, their integration into hotel buildings in Minna remains underexplored, leading to missed opportunities for optimizing energy performance. This paper tackles the problem of identifying and evaluating the extent to which these techniques are currently implemented, as well as their effectiveness in promoting low energy use in the local context.The paper is structured to first present a comprehensive literature review on passive design technologies relevant to hotel buildings, followed by a detailed methodology utilizing a mixed-methods approach. The methodology includes observations and checklists, complemented by figures and descriptive analysis. Subsequent sections will present the results of the research, followed by a discussion of the findings, ultimately concluding with implications for practice and future research directions.

1.1 Passive design techniques in hotel buildings

There is a variety of passive design techniques that have been examined with respect to their effect on energy use in different climes and other building type in previous research. Nasir (2023) in a study bin Penang, showed that the orientation of buildings, window-to-wall ratios (WWR), and the selection of materials play crucial roles in determining the energy performance of hotels. Carrera (2024) and Yulianti *et al*. (2021) also added that Effective use of natural ventilation, daylighting, and thermal mass can contribute to reducing reliance on artificial heating and cooling systems, thus lowering energy consumption.

Sogut & Oz, (2019) agreed with Stylos *et al*. (2018) on the importance of passive design strategies through energy analysis alongside traditional energy audits to evaluate the holistic energy performance of hotel operations. This dual approach allowing for a more comprehensive understanding of energy flows and inefficiencies, showed the targeted improvements in design and operational practices.

Moreover, the integration of green building practices, which encompass passive design elements, has been shown to enhance the overall operational efficiency of hotels. Hotels that adopt such practices not only benefit from reduced energy costs but also improve their marketability and guest satisfaction (Ahn & Pearce, 2013; Hou & Wu, 2020). The emphasis on sustainability in hotel design aligns with the growing consumer demand for environmentally friendly accommodations, which can influence guests' choices and preferences (Millar & Baloğlu, 2011).

In the context of Minna, the adoption of passive design techniques is particularly relevant given its location in a tropical savannah climate which is wet and dry as well as having a yearly mean temperature going above 26°C (Asonibare, 2023). The strategic placement of windows for optimal natural light, the use of thermal insulation, and the incorporation of shading devices can significantly enhance indoor comfort while minimizing energy use (Youssef & Zeqiri, 2022). Moreover, the local government and stakeholders can play a pivotal role in promoting these practices through policies and incentives aimed at encouraging sustainable building designs in the hospitality sector (Ba *et al*., 2022).

The integration of passive design techniques in hotel buildings in Minna presents a viable pathway to achieving low energy use and enhancing sustainability. By leveraging natural resources and optimizing building performance, hotels can reduce their environmental impact while simultaneously improving operational efficiency and guest experiences.

2. Methodology

The mixed method was adopted for this study, as both qualitative and quantitative techniques were applied for this study. This is because a mixed-method approach allows for a comprehensive evaluation of the passive design techniques in hotel buildings for low energy use in Minna, as it captures both the presence and performance of design elements in real-world contexts. The data for this work was collected with the aid of checklists through physical observation of twelve (12) hotel buildings found in the Tunga area of Minna through purposive sampling. The use of physical observation was used for the evaluation a it provides direct insights into how these techniques function in practice. By the use of this technique, this study would be able to reveal the effectiveness and potential of passive design techniques in the hotel buildings in Minna. The variables that were assessed in the field are the presence of different passive design techniques and they include; the presence of external shading devices (such as porches, central courtyards, curved profile ceiling, cerestory window, overhangs, trees and vegetation, textured surface, pools or fountains, and recesses). Other passive design techniques observed are Depth of reveals, windows

to walls ratio (WWR), building orientation, and distance between buildings. The level of application of the observed passive design techniques within the sampled hotel buildings was also checked in this study.

3. Results

In Figure 1, the results indicate that overhangs are the most commonly utilized exterior shading technique in hotel buildings, accounting for 29% of the strategies implemented. Curved profile ceilings and trees or vegetation follow closely, each representing 18% of the approaches used to reduce energy consumption. Other methods, such as pools or fountains, and porches, are less prevalent.

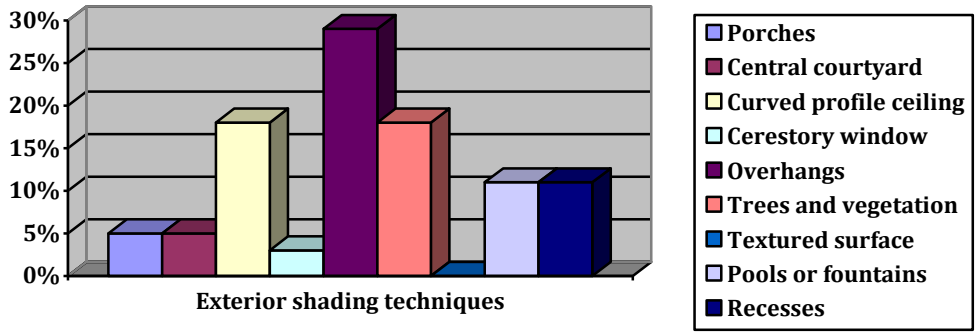

Figure 1: Exterior shading techniques

The depth of reveals, a significant portion of buildings (25%) were seen having no reveals at all (Figure 2). Among those with reveals, the most popular depth category is 151-300mm, comprising 17% of the buildings surveyed. The findings suggest a varied approach to reveals, with less emphasis on deeper configurations (301mm and above).

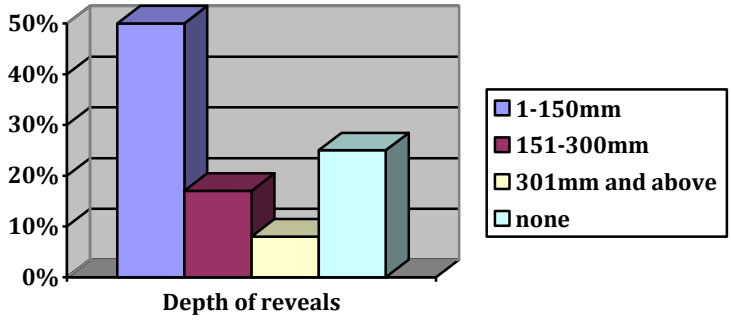

Figure 2: Depth of reveals

The data presented on Figure 3 reveals a high application of lower windows to walls ratio, with 50% of buildings maintaining a window to wall ratio (WWR) of 1-25%. This trend suggests a strategic focus on minimizing energy loss through windows, as the proportion of buildings with a WWR of 26-50% is also substantial at 42%. Notably, there are no buildings with a WWR exceeding 75%.

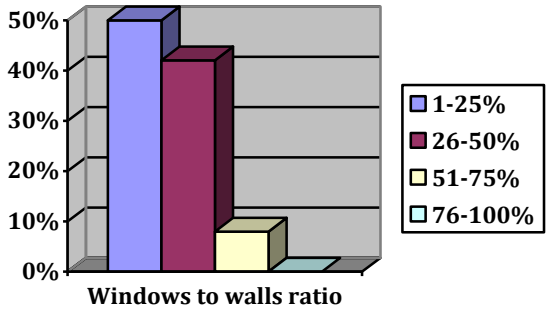

Figure 3: Windows to walls ratio

In the case of the building orientation of the hotels, Figure 4 illustrates that NorthWest and SouthEast orientations each have 19% of the surveyed hotels. However, the North and South orientations are less favored, each accounting for only 8%.

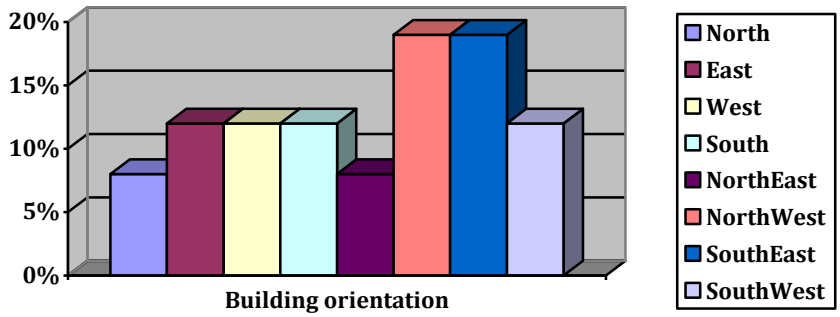

Figure 4: Building orientation

Figure 5 shows that 25% of the hotel buildings maintain a distance of 1-3 meters in the buildings within their layouts. Another 25% were also seen having a distance of 10 meters or more, while 17% of hotel buildings were seen with no other building within their layout.

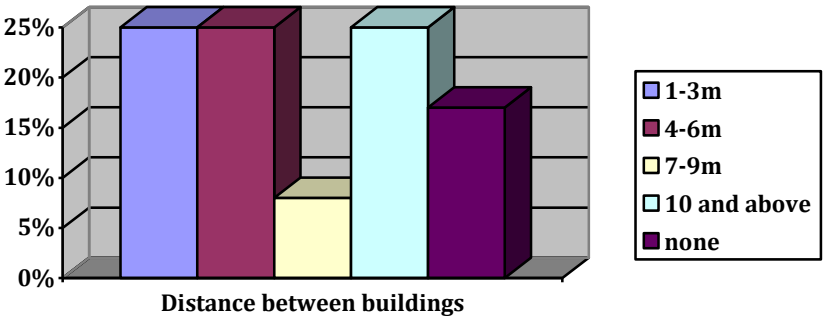

Figure 5: Distance between buildings

4. Discussion

The outcomes from this study suggest that overhangs are the predominant exterior shading strategy, employed by 29% of the hotel buildings surveyed. This choice is significant, as overhangs are effective in blocking direct sunlight during peak hours while allowing natural light to penetrate during cooler parts of the day (Sobhani, 2019, Bawa *et al* 2022). Such a design feature not only reduces reliance on artificial lighting but also contributes to maintaining a comfortable indoor climate (Szokolay, 2014), ultimately lowering energy consumption for cooling.

The next most common strategies are curved profile ceilings and the use of trees or vegetation, each representing 18% of the techniques employed. Curved ceilings can enhance airflow and reduce the heat gain in interior spaces (Ahmed *et al*., 2019), while landscaping with trees provides natural shading (Seçkin, 2018), further minimizing the need for mechanical cooling. Interestingly, other shading methods, such as pools or fountains and porches, are less frequently implemented. While these features can provide aesthetic and social benefits, their effectiveness in energy conservation might be limited compared to more direct shading solutions. The data suggests a concentrated effort in the most impactful passive strategies, indicating that hotel designers in Minna are prioritizing techniques with a proven ability to reduce energy use. These results imply that there are preferences for the application of exterior shading devices, curved ceiling profiles, water bodies, porches and vegetation in the study area and no integrated approach towards adopting most of them to help in reducing anergy consumption across all the sampled hotel buildings.

The results further revealed that 25% of the buildings surveyed have no reveals at all. This absence could lead to increased solar heat gain, as Ma *et al*. (2023) explained that reveals are essential for mitigating direct sunlight exposure on windows and enhancing thermal comfort. Among those with reveals, the most popular depth category is 151-300mm, encompassing 17% of buildings. This depth is generally effective in providing shade while still allowing natural light to enter the building. However, the overall lack of deeper configurations (301mm and above) may point to missed opportunities for improving energy efficiency. Deeper reveals can offer more substantial

shading and protect windows from the elements, thereby extending their lifespan and reducing maintenance costs (Abrahamsen, 2013). The limited emphasis on deeper reveals indicates a potential area for improvement in passive design practices among hotel developers in Minna, suggesting a need for greater awareness and education regarding their benefits.

Furthermore, the significant trend towards a lower window to walls ratio (WWR) in the surveyed hotel buildings, with 50% maintaining a WWR of 1-25%. This strategic focus is crucial for minimizing energy loss through windows, which Parsons (2011) described are often a significant source of thermal inefficiency. A WWR of 1-25% allows for sufficient daylighting while reducing the risk of overheating and glare, which can lead to higher cooling demands. Notably, the absence of buildings with a WWR exceeding 75% indicates a strong preference for conservative glazing strategies, which is essential in a climate like Minna's, where excessive solar gain can significantly impact indoor comfort and energy costs.

Data on building orientation, showed that NorthWest and SouthEast orientations are favored, each accounting for 19% of the surveyed hotels. Such orientations can optimize natural light exposure while reducing heat gain during peak hours (Offor & Emenike, 2019). The lesser prevalence of North and South orientations, at 8% each, may reflect an awareness of solar path considerations, as these orientations could expose buildings to higher levels of direct sunlight throughout the day. The strategic orientation of buildings is vital for harnessing natural ventilation and reducing energy loads. By prioritizing orientations that maximize passive solar benefits, hotel developers in Minna are demonstrating a commitment to sustainability and low energy use.

The distance between buildings, revealing that 25% maintain a close proximity of 1-3 meters, while another 25% report a distance of 10 meters or more. Close proximity can enhance shading but may also lead to reduced ventilation, which is crucial for maintaining indoor air quality and comfort.

The integration of passive design techniques in hotel buildings in Minna reflects a thoughtful approach to energy efficiency as and is in agreement with the position of built environment professionals (BEPs) in Zhiri and Akande (2018). While there are commendable strategies in place, such as the effective use of overhangs and a conservative WWR, the findings also reveal areas for improvement.

5. Conclusions

This study reveals that the hotels buildings in Minna do employ some passive design techniques. Although, overhangs are the most common exterior shading strategy in hotel buildings in Minna, effectively blocking some amount of direct sunlight. It alone might not be enough to significantly reduce the reliance on artificial lighting and HVAC systems for lighting, and space cooling. Other notable techniques observed include curved profile ceilings and landscaping with trees as well as pools and porches. Though some of these features can further promote natural ventilation and shading in different degrees, they were not seen spread across all the hotel buildings in the study area. A concerning finding is that reveals are limited, despite that they are crucial for mitigating solar heat gain, with most existing reveals limited to 151-300mm, indicating a missed opportunity for deeper configurations that could improve energy efficiency. The data also shows a strategic emphasis on a low window to walls ratio (WWR), crucial for minimizing energy loss, while the preferred building orientations (NorthWest and SouthEast) optimize natural light and reduce heat gain. Overall, while the integration of passive design techniques could reflect a move towards low energy use, the integration of exterior shading devices was below 30%, and depth of reveal above 150mm was at 25%. This shows that the tendency of exploring the potential of passive design techniques for low energy use in Hotel buildings in Minna might not be widespread. This also means that there are clear areas for improvement, particularly regarding reveals and ventilation strategies. One limitation of the study is the findings related to reveals and building orientation may not account for varying local climate conditions and architectural styles that could influence the effectiveness of these strategies.

Future research should explore the long-term performance and user perceptions of passive design techniques in hotel buildings, particularly focusing on energy consumption data and guest comfort levels over time. Investigating the integration of advanced technologies with traditional passive strategies could also provide insights into enhancing energy efficiency and sustainability in hotel design. Further studies could examine the impact of deeper reveals on energy efficiency and indoor climate, assessing how variations in design can influence overall building performance. Additionally, research into the interplay between building orientation and surrounding topography could yield valuable information on optimizing natural light and ventilation in Minna's unique context.

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Exploration of Resilience Strategies for Flood-Prone Cultural Landscape Communities in the Niger Delta, Nigeria

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Abstract

Flooding is a natural phenomenon that is found to be more in lowland areas such as the Niger Delta in Nigeria. Over time, communities in the area have developed resilience strategies for their building to the annual flooding as they rely on their environment for sustenance and livelihood, and as such cannot migrate. Additionally, the cultural, social and economic values of the people and their communities have strengthened over time as a result of place attachment. The consequence of this is the difficulty of integration of government policies due to little understanding of the world views of the local people about their environment. This study therefore explores the capacity of the flood prone communities to cope in the midst of the floods and in carrying out the research, three flood prone communities in Delta state Nigeria were studied qualitatively through observations and conduct of interviews of key respondents which included community leaders. The questions asked focused on resilience strategies of buildings to flood as well as coping strategies by community during flood periods. Using the projected estimated total population of 1,746,200 in the study communities, a total number of 390 households with a response rate of 92% (N=358) and 75 buildings were studied in the study areas. The data collected were content analysed and the findings showed that the local community have Traditional Ecological knowledge (TEK) which contributes to their resilience strategies during flood periods. More also is that the resilience strategies by the local people can be reinforced by Local Authorities and the extent to which these strategies can be applied in other similar cultural landscapes. A framework for rural flooding was therefore recommended to enhance existing coping strategies, ensure disaster risk reduction and intensify adaptation.

Keywords: Adaptation, Building, Culture, Flood. Resilience

1. Introduction

Climate change has been identified as a threat to humanity, as well as the built environment (Maslova, 2016). This is triggered by the burning of fossil fuels, resulting in the release of large amounts of greenhouse gases into the atmosphere (Hanewinkel *et al.,* 2013). Climate change has been projected to result in more record-breaking disasters in the near future (Zhu *et al.,* 2023). The risks associated with climate change on the built environment have necessitated the need for the development of resilience strategies to address the changes being experienced by way of design.

Flood is the most disturbing natural disaster in the world as it leads to more significant social and economic damages than any other natural disaster as reported by the Disaster Management Support Group (DSMG, 2019). Floods are also the most costly and most frequently reported natural disaster in the world (Hinkel *et al.,* 2014). It is worthy of note that though flooding is likewise a natural process with benefits such as maintenance of natural habitats and soil enriching (Kousky and Walls, 2014), it however becomes a reason for concern when it affects the lives and properties (Bich *et al.,* 2011).

The United Nations (UN) global assessment report states that hydro-metrological event disasters make up the mainstream of disaster risk events, which is a rising global dilemma (UN, 2017). Equally, Centre for Research on the Epidemiology of Disasters (CRED) reported that an average of 218 million persons globally are affected by flood on an annual basis (CRED, 2018). Similarly, the report of the International Federation of Red Cross Society (IFRC) reveals that 34 of the 36 States of Nigeria are at a risk of being submerged in flood waters, caused by the bank-bursting of the two major rivers- Niger and Benue in the country after heavy rainfall occurrences (IFRC, 2018). Similarly, Obi *et al*. (2021) asserts that Nigeria is predisposed to flooding, due to the absence of adequate storm water management.

The traditional buildings erected by the people of the Niger Delta have been observed several times to have given way in extreme cases of flood (Mmom & Aifesehi, 2013). As asserted by Restemeyer and van den Brink (2015), inspite of the damage caused by the flood which is usually catastrophic when traditional flood control methods fail, members of the communities of the Niger Delta have continually lived in these communities, therefore there is need to study the resilience of these communities. Indigenous flood control measures date back to pre-historic times with

the provision of pile dwellings, rafts and ships (Eboh *et al.,* 2017). This study therefore focuses on the study of the living methods and building materials of the Niger Delta people towards understanding the resilience of buildings in flood prone regions and how these can be enhanced into achieving flood protected rural communities in the Niger Delta of Nigeria.

The need for the study of the living methods of the Niger Delta people has necessitated the demand to swot the cultural landscape transactions of the people of the Niger Delta. Muhammad (2015) defines cultural landscape as the composition of the people of a particular area, alongside their landscapes. Landscape includes the visible entirety of an area of land. This includes buildings, vegetation and natural and artificial elements of the environment. This study therefore investigated the lifestyles and environments of the study communities with a view of understanding the resilience of the communities in the face of flooding.

Study Area

The core Niger Delta is the scope of this research. Bayelsa, Delta and Rivers states are estimated to be among the worst affected states where water levels continue to rise (NEMA, 2018). Amangabara (2015) asserts that Delta state has the highest number of communities at risk of flooding in the Niger Delta as water overflows its banks to about 500m. This is due to the presence of the highest number of rivers, and having communities that lie at the river banks. These rivers include Benin, Escravos, Forcados, Okumasi, Okpara, Edor, Ethiope, Warri and Ramos. The communities studied for the research include Okpara Waterside (Olabrakompre), Sandfill 2 and Desmond Island rural communities, all in Delta state of Nigeria. Okpara Waterside under Ethiope East LGA and Desmond Island and Sandfill 2 are under Warri South West LGA in Delta State. The following villages were chosen for this research as a result of their nearness to a water body. The choice for study is therefore primarily due to the strategic locations of these villages. Secondly, due to the nature of the research and the type of buildings under study, these locations were chosen because of their rural nature. These villages have been minimally affected by urbanisation as compared to their communities within the local government (Babatunde,2010; Olanrewaju *et al*., 2017; Wali *et al*., 2021; Mogborukor *et al*., 2021), hence the choice of communities.

Figure 1 Satellite Image of Okpara Waterside

Figure 2 Satellite Image of Sandfill 2

Figure 3 Satellite Image of Desmond Island

Approximately 13,500km^2 of the land area in Niger Delta is besieged by floods annually (Gobo *et al*., 2013). The National Emergency Management Agency (NEMA) established that between 1985- 2018, over one thousand deaths have been recorded to have been caused by flooding within the region, and can be easily considered as a National disaster (NEMA, 2018).

The Niger Delta accommodates and serves as a place of livelihood to186 local government areas lodging 2,148 communities and housing about 31 million people (Ajodo-Adebanjoko, 2017). However, the environment is prone to flood which acts as a threat to their existence. Ensuring building resilience in the face of climate change has increasingly become a matter of persistent concern, as the effects of global warming are gradually becoming

apparent. It is therefore important for architects in flood prone areas to be in the know of and understand the available resilience design strategies obtainable.

2. Materials and Methods

Primary data on the one hand was obtained from observation schedules and semi-structured interviews. Interview questions were generated from the research objectives, giving room for the participants to express themselves in their responses on flooding, coping strategies and adaptation measures.The observation schedule investigated a number of architectural elements such as the doors, windows, roofs, foundation types, thermal comfort and aesthetics, and their relation to flood events.

The secondary data for this research on the other hand, was obtained from the Federal Ministry of Lands and Housing and the NDDC. Relevant agencies responsible for disaster management in the country which include the National Emergency Agency and Federal Emergency Management Agency were as well contacted for data on previous flood happenings in the study area and local government areas most affected by flood.

The population for the study was made up of four communities from one selected states that comprise the core (riverine) Niger Delta. The selected rural local government areas selected were obtained from previous research as communities mostly affected by flood in the study states. In Delta state as well, Ethiope East, and Warri South were also selected for this research (Ofili *et al*., 2015). Ikwerre, Akpor and Emohua Local Governments were selected for this research from Rivers state, but were inaccessible because of the menace of insecurity experienced in those areas. The selected communities had been identified to experience devastating flood events, leading to severe economic, social, livelihood and environmental impairments, evident in extensive damage to property, social displacement, environmental degradation, livelihood contraction, destruction of farmlands and ultimately, loss of human and animal lives. The communities studied include Okpara Waterside (Olabrakompre), Sandfill 2 and Desmond Island rural communities, Delta state of Nigeria. Igbokoda is a village under Ilaje LGA, Olabrakompre under Ethiope East LGA and Desmond Island and Sandfill 2 are under Warri South West LGA. The following villages were chosen for this study as a result of their nearness to a water body.

The sampling method employed for the selection of traditional buildings studied , as well as the semi-structured interviews in this research was the probability random sampling method. According to Etikan and Bala (2017), random sampling method is one in which each respondent has an equal probability of being selected and sampled. The selection was however restricted, limiting the respondents to mature adult members of the community and indigenes or residents who have been in the community for over ten (10) years, hence the probability tag. The rationale behind the choice of this method is that every traditional building in the three selected communities had an equal chance of being selected. The sampling method for the selection of participants for the community group discussions was the stratified sampling method. Here, the members of the community were categorized based on age groups, and every group was represented in the community group discussions. For some of the communities, different age groups were met with and discussed with differently. Gender base groups were also interviewed in some of the communities in the course of the research. This ensured that adult members of the communities at all levels, were given a chance to air their perspectives on the matter of previous floods, coping strategies and flood recovery.

The sampling method for the selection of participants for the key informant interviews was the purposive sampling. Here, only key members of the communities, such as the community heads, gender leaders, key religious leaders, age group leaders and key spokespersons were interviewed to obtain data majorly on the engagement of the local and state governments for recovery from flood.

The Figure 1 presents the sampling techniques applied in the qualitative methods, used for this research. This include household observation, focus group discussions, key informant interview and semi structured interviews.

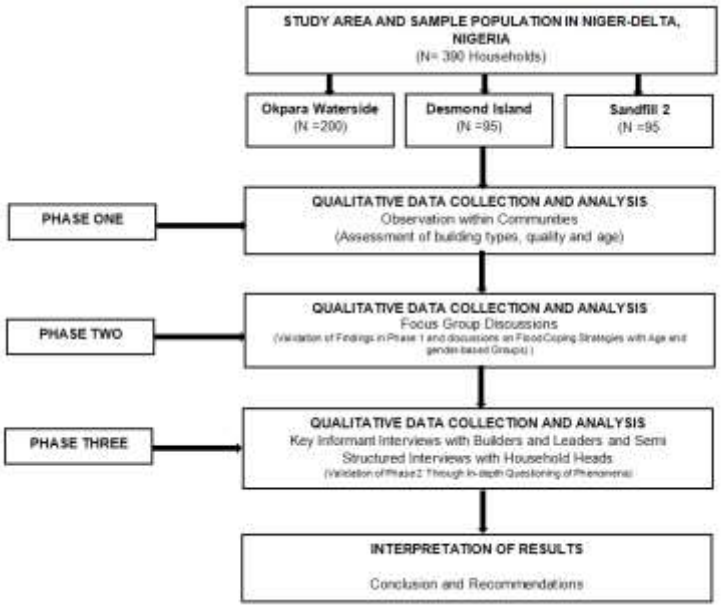

Figure 4 : Qualitative Strategy (Sequential) for the Collection and Analysis of Data
Source: Adapted from Morse (2010)

3. Results and Discussions

3.1 Architectural Character of the Niger Delta Communities

Architectural character of a building or set of buildings refer to the character defining elements of the building. This includes any feature which makes the building or set of buildings different from others hence, Porto and Cascone, (2013) assert that the architectural character of a building can be defined using the overall shape or design, building materials used for construction, craftsmanship, decorative elements, interior spaces and features, and the site and environment. Thus, the architectural characters of the traditional buildings in the Niger Delta communities are hereby analyzed under the above subcategories.

The major traditional building materials used were 16, however, the cluster analysis reveals that the most important material identified in the connectivity map is the Iron wood (*Omeghén*). Additionally, the most important spaces within the landscapes are the river (*Ívwori)*, jetty (*Jetti)* and market (*Eki)*.

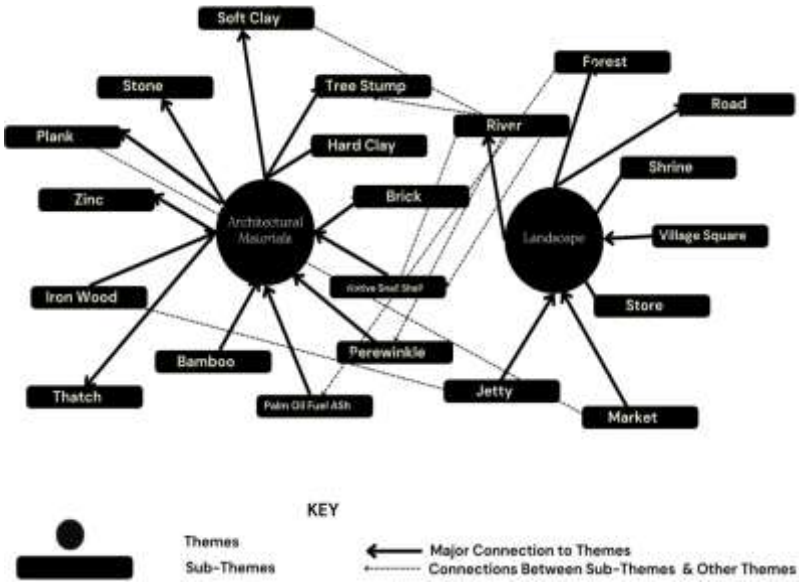

Figure 5 Thematic Map of Response on the Architectural Character of Buildings in the Niger Delta

The traditional house forms of the Niger Delta people, are informed on one hand by the climatic requirements and kinship organisation on the other. Traditional Verandah House account for 50.65% of the sampled buildings, Traditional Courtyard House (20.1%) and Bungalow House (17.4%). The building materials are usually basic, less expensive, easily assessable and readily available to meet the immediate shelter need of the people. Some of the materials have failed to stand the test of time structurally and modern technologies have been infused into the architecture in order to ensure stability of structure and building longevity over time. The process for the construction of traditional buildings in the Niger Delta is unique and exclusive to the area.

There are two building types peculiar to the study communities which include Plank houses (57.9%) and Brick houses (42.1%). The decorations reflect the symbol of heritage and cultural lifestyles of the people. They are made within and outside the buildings to showcase culture, religion, expertise and personal preferences. The traditional buildings of the Niger Delta, like other parts of Nigeria are being adorned by figures, murals and carved images on the exterior walls, usually at the major entrances of compounds. These figures differ from one compound to another and are created using clay and further decorated with shells of aquatic species found in the vicinity

Results from the cluster analysis on the role of place attachment and its effect on cultural landscape transactions of the niger deltareveal that the parts of the environment that give the people a sense of place and identity include the landscape (especially the rivers), the profession of the members of the communities (fishing (72.3%) & farming (21.4%) for men- and entrepreneurship for the women (82%) and the values of the people which are passed from one generation to another.

Table 1: Coping Strategies and Local Signs of Flooding

Study Communities	Local Signs of Floods	Coping Strategies
Desmond Island	- Calculation of months to predict the periods of high tides (September-February) - Continuous rainfall for more than 2 days	- Clearing of waterways by youths annually. - Raising of entrance veranda and cooking places temporarily. - Planting of Indian bamboo by river bank.
Okpara Waterside (Olabrakompre)	- Consultation of the river goddess to know the possibility of flood for that particular year.	- Warning of the fishermen to beware of their activities on water. - Relocation of women and children to neighboring villages and the king's palace. - Relocation of valuables and domestic animals to higher designated grounds.
Sandfill 2	- Thick clouds and heavy rainfall. - Rainy season.	- Raising of buildings at the point of construction. - Use of Iron wood for construction to withstand the effect of flood. - Sanitation from time to time.

3.2 Indigenous Practices Employed

Structural interventions employed by local communities to mitigate flooding, include the construction of levees, ridges, and embankments, as well as the strategic relocation of settlements from low-lying areas. Clearance of channels and pathways, as well as the removal of obstacles and debris to facilitate the unimpeded flow of rainfall.

Similarly, residents employed the planting of mangrove trees. The intricate network of fine and large roots inherent to certain tree species consolidates and binds soil, thereby stabilizing riverbanks and mitigating erosion. The intricate structure of trees, including roots and trunks, impedes and diverts floodwater flow, mitigating its velocity and altering its direction. Silt accumulation and the planting of invasive species like Water Hyacinth, and environmental sanitation initiatives.

Some of these approaches align with findings from the literature review on traditional flood management practices.

4. Conclusion

In conclusion, the architectural character of traditional buildings in the Niger Delta is a reflection of the region's unique cultural identity and environmental conditions. The materials used in construction, such as Ironwood (Omeghén) and basic, locally available resources, are chosen to meet the community's immediate needs while addressing the challenges of the flood-prone landscape. Despite the limitations of traditional materials in terms of longevity, the architectural design—including traditional verandah, courtyard, and bungalow houses—shows a strong adaptation to both climate and kinship structures. The use of decorations on the exteriors of buildings, often involving intricate carvings and aquatic-themed adornments, highlights the cultural significance of architecture in representing heritage and identity. However, with the introduction of modern technologies, there has been a transition towards more durable materials and construction methods, ensuring greater structural stability in the face of environmental pressures.

In terms of resilience strategies, communities in the Niger Delta have developed a variety of adaptive measures to cope with recurrent flooding. These strategies include traditional knowledge systems, such as the prediction of flood periods based on seasonal patterns, consultation of deities, and community-driven initiatives like clearing waterways and raising structures. Additionally, structural interventions such as levees, embankments, and the planting of trees like mangroves play a critical role in flood mitigation. The reliance on natural indicators and community cooperation demonstrates a deep connection to the landscape, while innovative responses like using Ironwood in construction and planting bamboo along riverbanks represent a synthesis of traditional knowledge and practical adaptation. These methods, along with modern environmental management practices, continue to be essential in maintaining the resilience and cultural continuity of these flood-prone communities.

5. Recommendations

Framework for Rural Climate Resilience

The framework for rural climate resilience aims at enhancing rural climate resilience in the Niger Delta region through a holistic approach that addresses the environmental, economic and social dimensions of climate change. It is given in Figure 6:

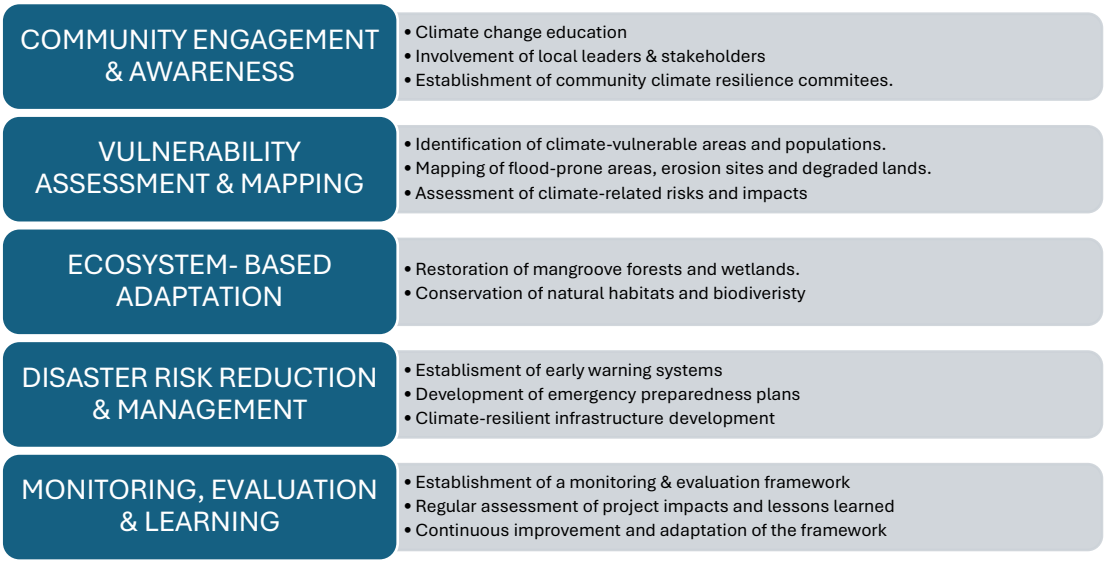

Figure 6 Framework for rural climate resilience in the Niger Delta

In recent times, flood risk management has been tailored towards novel ideas, such as the establishment of flood detention zones. In line with this, the new orientation and paradigm to flood management is recommended in the rural Niger Delta region to give room to water by the creation of flood retention zones, or the restoration of existing flood plains in the zone. This is encouraged, because while flood detention areas and zones are designed to temporarily store or hold rain or storm water runoff, a flood retention zone on the other hand is designed to permanently redirect the flood back to the larger water body and avoid flood situations. The strategy of flood retention is not capital intensive, as it can be achieved using readily available and sustainable materials, and can

therefore be easily actualized if the stakeholders responsible are ready to take on the projects in major communities within the region.

In addition, rural authorities most times lack the ability to generate sufficient revenue at the level of the local government. This results in the inability of the local governments to provide adequate services needed to handle the issues and disasters associated with floods, as there is low public investment in rural areas within Nigeria. To this end, it is recommended that local personnel are integrated into the discussion of flood management strategies in national planning at the higher government levels. Access to credit facilities should as well be enhanced to curtail the problem of poverty, through the establishment of small-scale financial institutions which will be dedicated to flood risk victims and other affected persons. In the Niger Delta, some organizations of such sort exist, which include the Niger Delta Patnership Initiative (NDPI), PIND foundation, amnesty office and others. However, the problem of adequate penetration into these core rural areas still exists. It is therefore recommended that these institutions are made mobile and easily accessible to all members of the society.

Furthermore, land use regulations must be adequately enforced if flood vulnerability be reduced in the study area. Efficient land use planning must be encouraged by stakeholders by getting members of the community involved in the process of knowledge management using a participatory approach. They must be informed that efficient land use will in the long run, serve as protection for them against floods and other natural disasters that exists within the communities. To make these resilience strategies more sustainable, there is need to provide modern facilities at subsidized rates to residents of the communities.

Finally, the role of educational enlightenment and literacy in terms of sustainability cannot be over emphasized. This is because residents are often times not intimated with flood signs, which should significantly reduce the effects of flood damage in these communities. The resources made available are often times misused and adequate data is not collected on river data. The available data has been identified most times to be inadequate and limited to few communities. Weather stations are therefore encouraged to be established within rural communities' to increase the availability of hydrological data and improve flood risk management and assessment in the Niger Delta.

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Assessing the impact of hazard management practices on construction sites in Kaduna state, Nigeria

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Abstract

Construction sites in Kaduna State, Nigeria, face various hazards which have led to accidents, injuries, and fatalities. Effective hazard management practices are crucial to mitigate these risks. This study investigates the impact of hazard management practices on construction sites in Kaduna State. A quantitative-methods approach was adopted using questionnaire survey. Data was collected from 15 construction sites, 37 site managers and safety officers. The data was analysed using relative important index technique because of its advantage of prioritising the variables based on their perceived impact. Results show that 80% of sites had implemented some form of hazard management practices. Site with robust hazard management practice reported fewer accidents compared to those with limited practices. The result also revealed that that Trip and slip hazard (uneven surfaces, spills) was the most significant hazards on construction sites in Kaduna State resulting in injuries and illnesses to the construction workers. Furthermore, Personal protective equipment (PPE)" was the most significant Hazard management practice as it protects workers from injuries and illnesses. Hazard management practices significantly influence construction site safety in Kaduna State. Implementing robust hazard management practices can reduce accidents, improve safety awareness, and enhance compliance among workers. Addressing barriers and improving safety culture are essential for effective hazard management in the construction industry.

Keywords: Hazard, Hazard Management Practices, Construction Sites, Kaduna State

1. Introduction

1.1 Background of the study

Construction sites are inherently one of the most hazardous environments, with workers exposed to slips, trips and falls, electrical and equipment malfunctions hazards (Ajith *et al*., 2020; Peir *et al*., 2022; Baka and Bakas, 2022). According to Peir *et al*. (2022) and Anantharaman *et al*. (2023) slips, trips and falls are the most common cause of injuries on construction sites, accounting for 25% of all non-fatal injuries. Furthermore, slips, trips and falls, noise, hand-arm vibration syndrome, material handling collapsing trenches, asbestors airborne fibre and material hazards pose significant risk to construction workers (Giri, 2020; Peir *et al*., 2022; Firdaus and Erwandi, 2023). Additionally, construction sites are notoriously loud exposing about 50% of workers to noise levels that exceed the safe limit of 85 decibels with continuous exposure leading to hearing loss, tinnitus and other health problems (Moreira *et al.,* 2024; Davis, 2021; Mostafavi and Cha, 2023). Some of the consequences of hazards in construction sites are injuries, fatalities, and significant economic losses (Zahid, 2021; Anantharaman *et al*., 2023; Moreira *et al.,* 2024). In order to minimize the possibility of experiencing workplace hazard during construction activities, hazard management on construction sites must be given first priority (Ajith *et al*., 2020; Albert *et al*., 2020; Fang, *et al*., 2020; Hussain *et al*., 2024).

Hazard management in construction sites is crucial to reduce work-related injuries and improve project managers' and organizations' image (Islam and Roy, 2019; Albert *et al*., 2020; Peir *et al*., 2022). Furthermore, to reduce fatality rates, hazard management need to focus on supervising workers from hazardous situations (Fang *et al.,* 2020; Zahid, 2021; Mastrantonio *et al.,* 2024). Furthermore, the implementation of hazard management strategies on construction sites influences overall safety, well-being of workers, and successful execution of construction projects (Ahn *et al.*, 2020; Giri, 2020; Peir *et al*., 2022). The prevailing incidents of hazards on construction sites resulting in continuous injuries and fatalities as a result of inadequate hazard management practices on construction sites in Kaduna state imamates the need for the study. This study addressed the following

i. Hazards on construction sites
ii. The impact of hazard on construction sites
iii. The impact of management practices on construction sites in Kaduna State, Nigeria

2. Literature review

2.1 Overview of hazard on construction sites

According to Giri (2020), hazards are situations, conditions, or objects that have the potential to cause injury, illness and damage to workers, property and the environment. commonly found on construction sites include working at height, moving objects, slips, trips, falls, noise, hand-arm vibration syndrome, material and manual handling, collapsing trenches, asbestos, electricity, and airborne fibers and materials. Construction site falls are the primary cause of injuries and fatalities in the US, accounting for almost 50% of all incidents reported each year (Hussain, *et al*., 2024). For this reason, it's critical that, in order to properly use multiple kinds of equipment, such as scaffolding and ladders, workers should have the appropriate training (Karakhan *et al*., 2018). Similarly, Kong and Tham (2024) discovered that from 2011 to 2015, falls from a height accounted for 34.14% of all occupational fatalities in the US, 52.80% in South Korea, 29.29% in the UK, 40% in Australia, 55% in China, and 46.28% in Malaysia. Falls to a lower level also accounted for more than half of construction accidents in South Korea highlighting the importance of implementing proper hazard management practices to prevent falls in the construction industry (Mastrantonio*et al*. 2018). Similarly, electric hazard is one of the most common causes of fires, electric shocks, electrocutions, and thermal burns at construction sites due to exposure to damaged electrical tools, equipment, and cords, which can lead to electrocution and fire hazards (Baka and Bakas, 2022; Mobasheri and Jafari, 2019).

2.2 Impact of hazard on construction sites

Construction sites pose significant hazards to workers, causing injuries, illnesses, and financial losses (Giri, 2020; Hussain *et al*., 2024; Kong and Tham, 2024). These hazards can damage equipment, materials, and property, leading to missed deadlines and increased costs (Firdaus and Erwandi, 2023; Albert *et al*., 2020; Fang *et al*., 2020). Delays can result in additional costs for medical treatment, legal fees, and repairs. Legal and regulatory issues can arise, and hazards can harm the environment, negatively impacting a company's reputation and potentially leading to catastrophic events (Firdaus and Erwandi, 2023; Davis, 2021; Mostafavi and Cha, 2023). Construction industry accidents and falls are major causes of fatalities, posing health risks such as lung damage, respiratory diseases, and hearing problems (Anantharaman *et al*., 2023; Firdaus and Erwandi, 2023; Kong and Tham, 2024). Exposure to airborne fibers, noise, and toxic substances can lead to financial consequences, lost workdays, increased claims, and project delays (Albert *et al*., 2020; Kaluarachchi *et al*., 2023).

2.3 Impact hazard management practices on construction sites

Hazard management practices in construction sites aim to reduce workplace hazards, reduce injuries, and prevent property damage (Kasim *et al.,* 2020; Albert *et al*., 2020). Hazard management process involves hazard identification, assessment, control, monitoring, and review (Kasim *et al.,* 2020; Ajith *et al.,* 2020). According to Wang *et al.* (2022), Real-time hazard tracking, daily assessments, and safety training are essential steps in hazard management. Furthermore, workers need proper training for working at heights, and employers must assess risks, plan work carefully, and follow safety procedures to prevent falls. Regular inspections and maintenance of electrical tools, switches, cables, and cords are crucial for safety (Zahid, 2021). Xiang *et al.* (2024) emphasize the importance of safety precautions, fire-retardant materials, risk assessments, regular safety training for staff and effective communication, such as safety briefings and hazard signs, is crucial for implementing a Safety Management System (SMS) like fall arrest system. Additionally, fall arrest systems, safety nets, slip-resistant footwear, clean walkways, regular cleaning, and implementing safety measures to ensure workers' safety on construction sites (Peir *et al.,* 2022). Hazard identification is also crucial in identifying noise pollution on construction sites, thereby minimizing its impact. These measures help to reduce accidents and ensure the safety of workers on construction sites.

3. Research methodology

A quantitative approach was used for the study which involves the use of questionnaire to collect data on the impact of hazard management practices on construction sites in Kaduna State. A pilot survey was first conducted within some construction sites in Barnawa Kaduna south local government area to determine the hazard management practices and their likely impact in the study area. This was important as it provided the researchers with a clearer inside as to how the main survey should be conducted. Personal protective equipment (PPE), Safety signage and Toolbox talks were among the identified hazard management practices with the greatest impact during the pilot survey which was included in the main survey. A structured questionnaire was designed with two sections, section A and section B. Section A, which is the demography of respondents consist of profession of respondents, academic qualification, and years of the respondents. Sections B on the other hand consist of the impact of hazard management practices in the study area. The target population was project managers and safety officers in construction sites in Kaduna south local government. Purposive sampling technique was used to select construction sites in Kaduna south local government due to its convenience of proximity to the researchers and it having numerous construction

activities and construction sites in Kaduna State. Snow ball sampling technique was used for the selection of respondents in which a total of 35 questionnaires were distributed by the researchers by hand. After exhausting all the referrals, a total number of 26 questionnaires which were appropriately completed and suitable for the research work were collected. This is so because snow ball sampling technique involves respondents referring the researcher to other respondent who also have similar experience or knowledge on the particular topic. Therefore, a total number of twenty-six respondents constituted the sample size for the study. The sampling frame for the research was project managers and safety officers of construction sites in Kaduna south and Kaduna north local government areas. The data obtained from the respondents was analysed using relative important index (RII) in other to ascertain the impact rate of hazard management practices in the area.

4. Data presentation and discussion

4.1 Demography of respondents

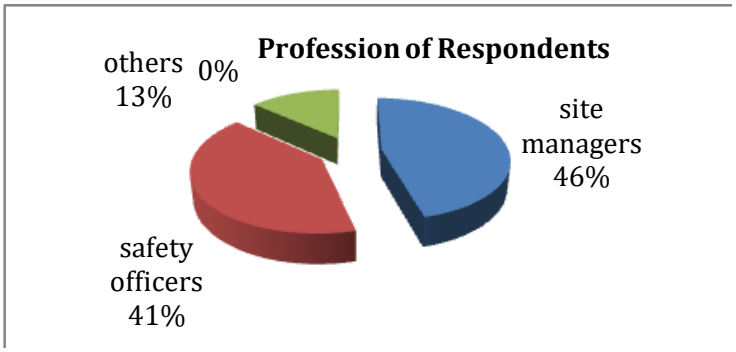

Figure 1: Profession of respondents

From the chart above, it can be seen that 46% of the respondents are site managers followed by safety officers representing 41%. This shows the most of the construction sites in Kaduna have a site manager and safety officers that coordinates safety activities on site.

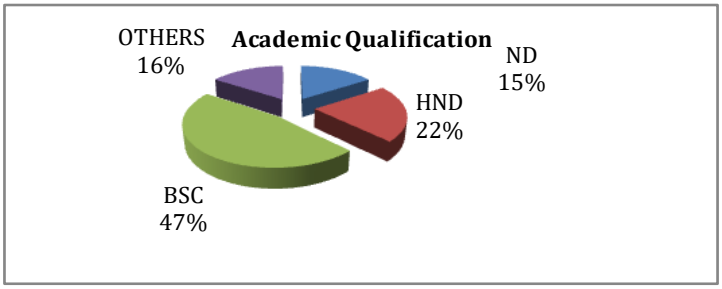

Figure 2: Academic qualification of respondents

From the chart above, it can be seen that 47% of the respondents are BSC holders followed by 22% HND holders representing the majority of the respondents. This shows a high literacy level among the professionals on construction sites in Kaduna.

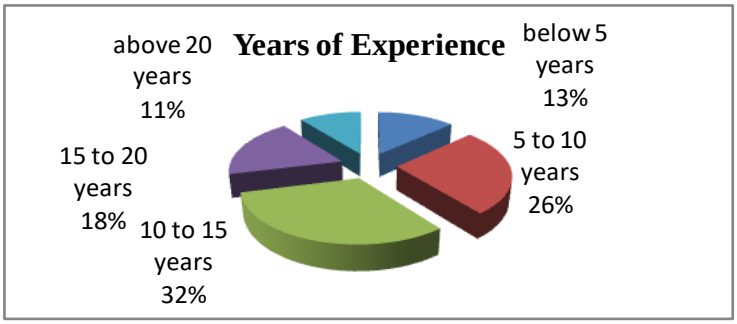

Figure 3: Years of experience of respondents

From the chart above, it can be seen that 32% of the respondents have 10 to 15 years work experience followed by 26% with 5 to 10 years work experience representing majority of the respondents.

4.2 Hazards on construction sites

Table 4.1: Hazards in construction sites

S/N	Types of Hazards	RII	Position
1	Falling objects	0.95	4th
2	Debris	0.82	7th
3	Electrical (exposed wiring, faulty equipment).	0.96	3rd
4	Height and fall risks (ladders, scaffolding, roof)	0.73	11th
5	Trip and slip hazard (uneven surfaces, spills)	0.98	1st
6	Noise and vibration exposure	0.97	2nd
7	Chemical and substance hazards (toxic materials, poor ventilation)	0.93	5th
8	Manual handling and ergonomic risks (heavy lifting, repetitive tasks)	0.71	13th
9	Confined spaces (tanks, tunnels, trenches)	0.70	14th
10	Vehicle and mobile plant hazard (heavy machinery, traffic)	0.76	10th
11	Fire and explosion risk (flammable, material, hot work)	0.91	6th
12	Weather condition (extreme temperatures, weather events)	0.72	12th
13	Poor lighting and visibility	0.80	8th
14	Poor site maintenance and house keeping	0.68	15th
15	Collapsing trenches and struck hazard	0.78	9th

Source: *field survey (2024)*

From table 4.1 it can be seen that the respondents ranked trip and slip hazard (uneven surfaces, spills) as the most significant hazard on the construction sites in Kaduna hazard ranking 1st followed by noise and vibration exposure and electrical (exposed wiring, faulty equipment) which are ranked as the 2nd and 3rd most significant hazard on construction sites in Kaduna. Similarly, manual handling and ergonomic risks (heavy lifting, repetitive tasks), confined spaces (tanks, tunnels, trenches), poor site maintenance and housekeeping are ranked as the least significant hazards on construction sites in Kaduna ranking 13th, 14th, and 15th respectively.

4.3 Impact of hazards on construction sites

Table 4.2: Impact of hazards in construction sites

S/N	Impact	RII	Position
1	Injuries and illnesses	0.98	1st
2	Property damage and equipment loss	0.92	4th
3	Project delays and disruptions	0.88	5th
4	Increased costs and expenses	0.93	3rd
5	Legal liabilities	0.78	7th
6	Environmental damage and pollution	0.60	12th
7	Reputation and credibility damage	0.71	9th
8	Worker morale and productivity	0.96	2nd
9	Increased insurance premiums	0.68	10th
10	Potential for catastrophic events	0.65	11th
11	Community impact	0.81	6th
12	regulatory fines and penalties	0.76	8th

Source: *field survey (2024)*

From table 4.2 it can be seen that the respondents ranked injuries and illnesses as the most significant impact of hazards in construction sites in Kaduna hazard ranking 1st followed worker morale and productivity and increased costs and expenses which are ranked as the 2nd and 3rd most significant impact of hazards in construction sites in Kaduna. Similarly, reputation and credibility damage, increased insurance premiums and potential for catastrophic events are ranked as the least significant impact hazards on construction sites in Kaduna ranking 9th, 10th, and 11th respectively.

4.4 Impact of hazard management practices on construction sites

Table 4.3: hazard management practices on construction sites

S/N	Types of Hazards	Description	Position
1	Risk assessments	0.86	8th
2	Safety protocols	0.96	2nd
3	Personal protective equipment (PPE)	0.97	1st
4	Training and education	0.73	12th
5	Toolbox talks	0.89	6th
6	Incident reporting	0.79	11th
7	Safety inspections	0.82	10th
8	Emergency preparedness	0.91	4th
9	Contractor management	0.69	13th
10	Continuous monitoring	0.75	11th
11	Worker participation	0.86	8th
12	Hazard control measures	0.90	5th
13	Safety signage	0.95	3rd
14	Permit-to-work systems	0.62	14th
15	Regular audits	0.88	7th

Source: *field survey (2024)*

From table 4.4 it can be seen that the respondents ranked Personal protective equipment (PPE) as the most significant hazard management practice on construction sites in Kaduna ranking 1st followed by Safety protocols and Safety signage which are ranked as the 2nd and 3rd most significant hazard management practice on construction sites in Kaduna. Similarly, Contractor management and Permit-to-work systems are ranked as the least significant impact hazards on construction sites in Kaduna.

4.5 Discussion of result

From the survey carried out, trip and slip hazard (uneven surfaces, spills)" noise and vibration exposure and electrical (exposed wiring, faulty equipment) were found to be the most significant hazards on construction sites in Kaduna State. This is as a result of poor site maintenance in most of the construction sites as there is unorganised storage of materials and tools, uneven terrain, insufficient lighting, poorly maintained access roads and un kept sanitary facilities on most of the construction sites. Similarly, injuries and illnesses, worker morale and productivity and increased project cost were found to be the most significant impact of hazards on construction sites in Kaduna State as they affect workers health, well being and medical expenses, treatment, rehabilitation significantly affecting the entire project. Also, workers absenteeism significantly impacts project timelines and budgets. Environmental damage and pollution was the least significant impact of hazards on construction sites in Kaduna State. This is because most construction sites were the study was carried out does not emit harmful substances to the environment. On the issue of the impact of hazard management practices in construction sites in Kaduna State personal protective equipment (PPE), safety protocols and safety signage were found to be the most significant Hazard management practice as it protects workers from injuries and illnesses as a result of hazard on construction sites. The results reflect a growing awareness of safety issues on construction sites in Kaduna state that can inform targeted interventions that focus resources on addressing the most critical hazards, improved safety measures to enhance site safety protocols and reduced accidents minimizing injuries, illnesses, and fatalities. This will increase productivity as safer sites boost worker morale, efficiency and increased competitiveness.

5. Conclusion and recommendation

5.1 Conclusion

The study on the impact of hazard management Practices on construction Sites in Kaduna State, Nigeria revealed that Trip and slip hazard (uneven surfaces, spills) was the most significant hazards on construction sites in Kaduna State resulting in injuries and illnesses to the construction workers. Furthermore, Personal protective equipment (PPE)" was the most significant Hazard management practice as it protects workers from injuries and illnesses. Some injuries and illnesses can have long-term or permanent effects, impacting workers' future employment and well-being. Therefore, prioritizing safety and mitigating hazards, construction sites can reduce the risk of injuries and illnesses, protecting workers and minimizing these significant impacts.

5.2 Recommendation

Construction companies should therefore set a standardized and mandatory policy for the training and use of Personal protective equipment (PPE) for all workers in construction sites in Kaduna state and Nigeria. This will help in mitigating the impact from injuries and illnesses due to hazards on construction sites. Construction firms should make hazard training for workers daily routine exercise as this will provide early preparation strategies, reduce the response time in accessing hazards on construction sites.

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Assessing the suitability of course contents and learners' satisfaction in open and distance learning programmes in Dual-Mode Universities in North-Central, Nigeria

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Abstract

This study assessed the suitability of course contents and learners' satisfaction in open and distance learning programmes in Dual-Mode Universities in North-Central, Nigeria. The population of the study was 193 undergraduate distance learners drawn from dual-mode universities in North-Central Nigeria. The sample of the study comprised 59 undergraduate distance learners selected from the University of Ilorin and the Federal University of Technology, Minna. The study adopted a descriptive survey research design in which three research questions guided the study with one null hypothesis. The instrument for data collection was an 18-item closed-ended questionnaire. The instruments were validated by experts and subjected to a reliability test using Cronbach's alpha and the reliability coefficient of the constructs for learner's satisfaction was 0.89, and for suitability of course contents 0.84. Data collated from the administration of the research instrument were analysed using descriptive statistics of mean and standard deviation and inferential statistics of correlation coefficient analysis for the research hypothesis. A decision rule was set in which a mean score of 3.0 and above was considered agreed, while a mean score below 3.0 was considered disagreed. The finding revealed that the average mean for the suitability of course contents was 4.10 while the average mean of learners' satisfaction with the course contents was 3.76 which is above the decision mean of 3.0. The finding also revealed further that there is a high, positive association with a Pearson correlation coefficient of 0.838 between variables suitability of the course contents and satisfaction of distance education learners with the course contents in dual-mode universities in North-Central, Nigeria. The study recommended that universities should implement a regular review process for ODL course content to maintain its relevance and effectiveness.

Keywords: *Assessment, course content, distance learning, education, satisfaction, suitability*.

1. Introduction

The world is changing, and so is the field of education. Education as the process of acquiring knowledge, skills and other capabilities is a universal aspect of any culture. Although society is ubiquitous, educational systems vary according to organizational structures, pedagogical practices, and philosophical and cultural organisations. Education is a continuous process through conscious and deliberate effort to create an atmosphere of the learning process (Ilufoye, 2018). Education as an essential instrument of development and growth in our society cannot be overlooked, because of its effect on national development (Fägerlind & Saha, 2016). Investment in the education sector can be regarded as a business with the greatest profits because it can produce unquantifiable benefits such as character formation and the development of innate power for individuals, organisations, and society. Education could be accessed through formal learning with clearly intended consequences and informal learning with unintended consequences (Qayyum & Zawacki-Richter, 2019). Open and distance learning (ODL) is a rapidly evolving area of formal education delivery that has seen significant growth in recent years. With new technologies, such as online learning platforms and virtual classrooms, ODL has become increasingly accessible and sophisticated. The demand for open and distance learning has also risen due to its flexibility and convenience for learners who want to balance work and study commitments (Miller *et al.* 2017). Distance learning is a learning in which the teacher and students who are separated either by time or geographical space will bridge the separation through web-based technologies. According to Simonson *et al.* (2019), open and distance learning use various media and

technologies to provide or improve access to quality education for learners, which could be acquired from institutions offering ODL programmes.

The rationale of ODL from its earliest days has been to open opportunities for learners to study regardless of geographic, socio-economic or other constraints. In contemporary times, many countries consider open and distance learning a critical component of their strategy to increase opportunities for higher education for learners (Bubou & Job, 2021). Creating a learning environment that could motivate and stir interest in students to become actively engaged and independent, a lifelong learning is the main aim of 21st century pedagogy and a challenge for teaching and learning institutions. Given the complexity and challenges of designing an effective open educational system that considers the content, the learners, and the pedagogy and technology involved, an iterative planning cycle that supports the refinement of an assessment is needed (Ronghuai *et al*., 2019). With the increasing acceptance of ODL as widening access to higher education in developed and developing countries like Nigeria, issues relevant to the quality assurance and effectiveness of distance learning programmes in dual-mode university education system compared to conventional educational patterns must be assessed.

Assessment is a process of collating, analysing, and interpreting outcomes to determine the extent to which institutions and learners achieve the purpose or objectives of setting up the distance education sector. Mohan (2023) defines assessment as the gathering, analysing, and interpretating of outcomes about any aspect of the educational programme or training, whether in a single or dual-mode institution, as part of a recognized process of judging its effectiveness, efficiency, and any other outcomes it may have. Assessment is one of the critical steps in the process of performance improvement. Satisfaction is an attitude that is decided based on the experience which is gained. It is an assessment of the features or distinctions of a product or service. The level of satisfaction in this study is about the suitability of the course contents to students in the implementation of online learning. Distance learners' satisfaction can be seen from several aspects, such as the content, pedagogy, resource materials, assessment, and the virtual learning environment (interface) conditions (Siregar *et al*., 2020).

With the outbreak of the Coronavirus (COVID-19) pandemic in the year 2019/2020 which caused the global lockdown of conventional learning centres for some time, there was massive enrollment in distance learning programmes because distance learning appears to meet the needs and aspirations of citizens future education. As people continue to crave knowledge but may not have the opportunity to go beyond their immediate environment, this scenario has called for a paradigm shift from the conventional method of teaching and learning to open and distance learning mode as a complementary avenue for providing access to education for the fast-growing numbers of learners (Yusuf, 2020). The NUC is increasingly granting universities access to operate as dual-mode institutions (NUC, 2021). This implies that such universities now offer both conventional and distance learning programmes. Thus, the accessibility of the programme to citizens can be ensured through open and distance learning. Many Open and Distance Learning Centres and Universities are being set up (Ukaoha *et al*., 2018), in quantity there are many, but the quality measures of such programmes are a serious issue that cannot be overlooked. Quality issues are more important, calling for meaningful assessment of the course contents and learners' satisfaction with the open and distance learning programmes.

The expansion of open and distance learning (ODL) in dual-mode universities in North-Central Nigeria highlights the importance of suitable course content in influencing learners' satisfaction. Effective ODL content should be comprehensive, adaptable, and engaging to cater to diverse learners needs. However, studies highlight that course materials in some Nigerian universities often lack interactive elements and real-world applications, adversely impacting the learning experience (Egielewa *et al*., 2022). Quality of course content, coupled with instructor support and technological access, significantly affects learners' satisfaction. For instance, findings show that up-to-date and engaging content enhances learners' satisfaction (Atolagbe *et al*., 2021). Nonetheless, there are persisting gaps regarding the direct influence of content suitability on student satisfaction in dual-mode universities in North-Central Nigeria, which need further exploration (Itasanmi *et al*., 2020). Previous studies often highlight enrolment growth and general implementation of distance learning but overlooks assessing the educational effectiveness of the suitability of course contents and its impact on learners' satisfaction, especially in dual-mode institutions in Nigeria (Yusuf, 2020; Ukaoha *et al*., 2018). This research addresses these gaps by evaluating course content suitability, gathering direct learner feedback, and exploring the relationship between content quality and learners' satisfaction to enhance understanding of distance learning quality (NUC, 2021). This study aims to assess the suitability of the course contents and satisfaction of undergraduate learners undergoing distance learning programmes in Dual-Mode Universities in North-Central, Nigeria. Specifically, the study will: 1. Ascertain the suitability of the course contents used for distance learning programmes in dual-mode universities in North-Central Nigeria. 2. Determine the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria. 3. Check whether the suitability of the course content influences the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central

Nigeria. There is no significant relationship between the suitability of the course content and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central Nigeria.

2. Methodology

This study adopted quantitative research methods using descriptive survey research design with online questionnaires to gather essential information from distance learners regarding the suitability of the course contents and their satisfaction with the Open and Distance Learning (ODL) programmes. The population of the comprised of 193 learners who are undergoing ODL programmes in dual-mode universities in North-Central Nigeria. The sample size consists of 59 undergraduate distance learners enrolled on a full distance learning programme from University of Ilorin and Federal University of Technology Minna Distance Learning Centre. Purposive sampling was used to select distance learners across the selected institutions since the research is on ODL programmes. This study applied purposive sampling among the different sampling methods because purposive sampling is a method well-suited for targeting individuals with specific characteristics relevant to the research objectives. Purposive sampling was chosen to ensure that the sample included only undergraduate distance learners enrolled in Open and Distance Learning (ODL) programs at dual-mode universities in North-Central Nigeria. The validity of the research instrument was ensured through expert reviews, where content experts examined the questionnaire for clarity, relevance, and comprehensiveness. This validation process helped refine the questions, aligning them closely with the study objectives to ensure they accurately captured the constructs of course content suitability and learner satisfaction. Reliability was tested using Cronbach's alpha, yielding coefficients of 0.89 for learner satisfaction and 0.84 for course content suitability. These values, being above the generally accepted threshold of 0.7, indicate high internal consistency, confirming the questionnaire's reliability for data collection. The research instrument used for this study was a structured closed-ended questionnaire to assess whether students are satisfied with their distance learning experience and the suitability of the course contents. To ensure consistency during data collection, a standardized process was adopted. The questionnaire was distributed electronically through a secure link sent to a designated faculty member (gatekeeper) at each selected university, who then forwarded it to participating students. This method helped maintain control over how the questionnaire was disseminated and who received it, minimizing bias and ensuring that only eligible respondents participated. Clear instructions were provided with the survey to guide participants in completing it accurately, contributing to the consistency of responses. Data were subsequently analysed using IBM SPSS Statistics (version 27), employing descriptive statistics and correlation analysis to answer research questions and test the hypothesis at a 0.05 significance level.

3. Results

3.1 Research question one

To what extent are the suitability of course contents being used for distance learning programmes in dual-mode universities in North-Central, Nigeria?

Table 4.1 presents the mean and standard deviations of respondents' opinions regarding the suitability of the course contents being used for distance learning programmes in dual-mode universities in North-Central, Nigeria. The table provides insight into the suitability of the course contents being used for distance learning programmes to impact knowledge to learners in open and distance learning environments. The table consists of eight statements rated by the respondents on a Likert scale. The respondents' mean scores ($\bar{X}$) and standard deviations (SD) are provided, indicating the average level of agreement or disagreement among the respondents for each statement.

Table 4.1: Mean and Standard Deviation of Learners' Response on Suitability of the Course Contents Being Used for Distance Learning Programme in Dual-Mode Universities in North-Central, Nigeria.

S/No	Statement	N	$\bar{X}$	SD	Decision
1	The course content is relevant and aligned with the learning objectives of ODL in the 21st century	59	4.22	0.618	Agree
2	The course content is comprehensive and covers all the necessary topics.	59	4.07	0.785	Agree
3	The course content is presented clearly and understandably.	59	4.00	0.809	Agree
4	The course content is engaging and promotes active learning.	59	4.00	0.983	Agree

5	The course content is up-to-date and reflects current knowledge and practices.	59	4.02	0.861	Agree
6	The course contents provided are in line with the goals of the programme of study	59	4.24	0.727	Agree
7	The course materials provided are accessible and easy to use	59	4.17	0.746	Agree
8	The course content includes appropriate multimedia and interactive elements (e.g., videos, quizzes, simulations).	59	4.08	0.836	Agree
	Average mean		4.10		

Source: Author Fieldwork, 2024

Table 4.1 illustrates the mean and standard deviation of respondents' opinions on the suitability of course contents used in distance learning programmes at dual-mode universities in North-Central Nigeria. The table reveals that all mean scores ranged from 4.00 to 4.24, well above the decision threshold of 3.0, suggesting strong agreement among respondents about the suitability of the course contents. The grand mean of 4.10 supports the conclusion that the course content is generally considered suitable, indicating it effectively meets the learners' needs and contributes to their academic experience.

3.2 Research question two

What is the satisfaction level of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria?

Table 4.2 presents the mean and standard deviations of respondents' opinions regarding the satisfaction level of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria. The table provides insight into the satisfaction level of learners to acquire knowledge in open and distance learning environments. The table consists of 10 statements rated by the respondents on a Likert scale. The respondents' mean scores ($\bar{X}$) and standard deviations (SD) are provided, indicating the average level of agreement or disagreement among the respondents for each statement.

Table 4.2: Mean and Standard Deviation of Learners' Response on the Satisfaction Level of Distance Learning Programmes in Dual-Mode Universities in North-Central, Nigeria.

S/No	Statement	N	$\bar{X}$	SD	Decision
	I am satisfied with the:				
1	quality of course content and materials provided for the courses	59	4.07	0.868	Agree
2	clarity and organization of course structure	59	3.90	0.941	Agree
3	assessment methods and feedback provided	59	3.56	1.178	Agree
4	technical support and assistance by the instructor	59	3.53	0.989	Agree
5	mode of communication (audio, video, audio-visual, images, and text) with the instructors and/or tutors in the courses	59	3.53	1.120	Agree
6	level of support and guidance provided by the instructors and/or tutors	59	3.68	1.074	Agree
7	tools and resources provided for online learning (e.g. course platforms, multimedia resources, and discussion forums) for supporting the learning	59	3.80	0.906	Agree
8	level of engagement and interaction with other students in my courses through the student chatting platforms to share ideas and solve problems.	59	3.83	1.162	Agree
9	level of flexibility and convenience provided by open and distance learning	59	3.85	1.157	Agree
10	the overall quality of education, I am receiving through the open and distance learning programme of the school.	59	3.81	1.058	Agree
	Average mean		**3.76**		

Source: Author Fieldwork, 2024

Table 4.2 presents data on the satisfaction levels of learners participating in distance learning programmes. The mean scores for all 10 items range from 3.53 to 4.07, exceeding the decision mean of 3.0. The grand mean score of 3.76 indicates that learners are satisfied with their distance learning experiences in dual-mode universities. The standard deviations, varying between 0.868 and 1.178, indicate moderate variability but confirm a consistent positive sentiment toward the programmes.

3.3 Research question three

The relationship between the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria? Table 4.3 presents the mean and standard deviations of respondents' opinions regarding the relationship between the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria. The respondents' mean scores ($\bar{X}$), standard deviations (SD) and standard error mean were provided, indicating the association level of agreement or disagreement between the suitability of the course contents and the satisfaction of learners.

Table 4.3: Mean and Standard Deviation on Association Between the suitability of the course contents and the satisfaction of learners in Distance Learning in Dual-Mode Universities in North-Central, Nigeria

Classification	N	$\bar{X}$	Std. Deviation	Std. Error Mean
Suitability	59	28.58	4.234	0.552
Satisfaction	59	37.54	8.169	1.064

Source: Author Fieldwork, 2024

Table 4.3 details the relationship between course content suitability and learner satisfaction. The findings reveal a substantial difference in mean scores between groups, with scores showing consistency in the relationship between course content and satisfaction. This analysis is supported by Table 4.4, which presents the Pearson correlation coefficient analysis.

3.4 Testing of Hypothesis

There is no significant relationship between the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria.

To test this hypothesis, Pearson correlation coefficient analysis was conducted on the responses of the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria as presented in Table 4.4

Table 4.4: Pearson product-moment correlation analysis on the responses of the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria.

		Suitability of course content	Satisfaction
Suitability of course content	Pearson Correlation	1	0.838
	Sig. (2-tailed)		0.000
	N	59	59
Satisfaction	Pearson Correlation	0.838	1
	Sig. (2-tailed)	0.000	
	N	59	59

Significant Level = 0.05

Table 4.4 presents the result of the Pearson correlation coefficient analysis of the responses on the suitability of the course contents and the satisfaction of learners undergoing distance learning programmes in dual-mode universities in North-Central, Nigeria. The correlation coefficient of 0.838, with a significance value of 0.000 (less than the 0.05 threshold), indicates a high, positive relationship between course content suitability and learner satisfaction. This result confirms that when course content is well-suited to distance learning, learner satisfaction significantly increases. These findings align with the hypothesis testing, which rejects the null hypothesis and demonstrates that the suitability of course content positively correlates with and enhances learner satisfaction in dual-mode universities in North-Central Nigeria.

The study establishes a significant positive relationship between the suitability of course content and learner satisfaction in open and distance learning (ODL), demonstrated by a strong Pearson correlation of 0.838. This indicates that learners' satisfaction is greatly influenced by the relevance and value of course materials, which is in line with prior findings by Palmer and Holt (2009) and Dziuban *et al*. (2015). The study aligns with existing literature, including research by Rajabalee and Santally (2021) and Chen and Yao (2016), emphasizing that high-quality, well-structured content enhances learner engagement and satisfaction. The findings suggest that dual-mode universities in North-Central Nigeria should focus on continuous content review and modernization to boost learner satisfaction. This involves using student feedback and integrating interactive multimedia, as supported by Simonson *et al*. (2019). However, the study's small sample size (59 participants) limits its generalizability. Future research should include larger samples, employ mixed-methods approaches for deeper insights, study the impact of technology on content suitability, and conduct comparative analyses across different educational models. These steps would enhance curriculum development and promote learner satisfaction in ODL programmes.

Additionally, Li *et al*. (2016) support this study's conclusions by emphasizing that content quality, assessment strategies, and appropriate workloads directly impact learner satisfaction in online and blended settings. Similar trends were reported by Rajabalee and Santally (2021), who noted that course engagement and satisfaction are positively associated, suggesting that suitable course design contributes to higher engagement, leading to increased satisfaction.

4. Conclusions and Recommendation

The study assessed the suitability of the course contents and satisfaction of undergraduate learners undergoing distance learning programmes in Dual-Mode Universities in North-Central, Nigeria. It was concluded that the course contents being used for distance learning programmes in dual-mode universities in North-Central, Nigeria are suitable for the learners and the learners undergoing distance learning programmes are satisfied with the programme. Dual-mode universities in Nigeria should implement structured and regular review processes for ODL course materials to ensure they remain relevant, current, and aligned with industry standards and student expectations. This process should include feedback from learners and subject matter experts to incorporate recent developments in various fields. Course content should be adaptable to cater to diverse learning needs. Allowing learners to choose certain modules based on their interests or career goals can improve satisfaction and retention rates and implementing robust feedback channels that allow students to share their experiences and suggestions for course content improvement is crucial.

Future research could focus on longitudinal studies to observe the long-term impacts of improved course content and learner satisfaction on academic performance and career outcomes. Further research can also investigate the role of instructor involvement in learner satisfaction and outcomes, focusing on how different teaching strategies affect student experience in ODL settings.

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Assessment of Sustainability Principles in Design of Visual Art Centre Lafia, Nigeria

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Abstract

The importance of studying sustainable design principles in the context of visual art centres is underscored by the growing significance of green architecture. Buildings have a major environmental impact, contributing between 45% and 65% of waste disposed of in landfills, consuming about 40% of the natural resources used in industrialized nations, and accounting for around 70% of energy use and 12% of potable water consumption. Moreover, the operation of buildings generates substantial emissions of harmful gases, which contribute to approximately 30% of greenhouse gas emissions, with an additional 18% indirectly linked to transportation and material extraction. Given these challenges, this project investigates sustainable design principles within the context of Nigeria, aiming to propose a Visual Arts Centre that incorporates green architectural elements to help mitigate climate change and global warming. The goal is to reduce carbon dioxide emissions, minimize environmental damage, and decrease the energy required for heating and cooling. To support this investigation, a descriptive research method was employed, gathering qualitative data through case studies, observation schedules, and insights drawn from a variety of sources, including books, journals, and online materials. The study revealed that the extraction, processing, use, and disposal of building materials come with significant environmental costs, including habitat destruction, resource depletion, energy consumption, and contamination of air, water, and solid waste. However, by integrating sustainable design principles, these negative impacts can be greatly reduced or even eliminated. Consequently, the study recommends promoting the use of recyclable, renewable, and reusable materials in the construction of visual art centres. It also advocates for reducing waste throughout the material life cycle by using building materials more efficiently during assembly, manufacturing, and construction processes. This approach not only minimizes environmental harm but also encourages a more sustainable model for future building practices.

Keywords: Art Centre, Green, Principles, Sustainability, Visual Art.

1. Introduction

Over the past years, there has been a growing concern regarding the impact of human activity on the environment. Materials have supported human life with advantages and conveniences but unfortunately, they also impose a wide variety of burdens on the environment through each and every step of production. According to Mohamed *et al* (2019), extracting, producing, and using ever-increasing volumes of material resources-most of which are finite will inevitably have vital environmental consequences. The implications of current patterns of economy, our continued existence with materials used which are unsustainable to the environment, have influenced the potential of climate change. Hence, the crises raise the bar for new materials solution. Today, sustainable material is believed to be the solution for an integrated approach toward managing material life cycles to achieve both economic efficiency and environment viability. Considering the current global urbanization rate and the speed of growth of the planet, what is developed needs to perform in all categories, economically, socially, and environmentally (Tiza *et al*, 2021). The properties, performance and content of these materials make a significant contribution to reduced environmental impact, from lowering carbon emissions to maximizing use of the earth's limited resources (Mohamed *et al*, 2019). Art on the other hand, has been described by different writers in several ways, and according to Azuka (2014), Art is life and life is Art. Art is a deliberate or conscious employment of skill and creativity to produce visually aesthetic and other functional art images. Meanwhile, throughout history, humans have cultivated a deep-seated yearning for arts in beautification and ornamentation. According to Olaniyan *et al* (2023), this is visible in various artistic expressions ranging from paintings, markings, and piercings on the body; the use of jewelries to adorn the body; craftsmanship of objects, artefacts, carvings and sculpture; to the decorations and artistic expressions on buildings, temples and other physical structures. The context of ornamentation is invariably expansive and can be constrained only to the limits of human imagination. Aside ornamentation, art is one of the most potent tools for the promotion of cultural heritage and the preservation of family values especially in traditional African societies (Olaniyan *et al*, 2023). Visual Arts as a subject spark creativity in diverse ways, and according to Enamhe & Nnochiri (2013), a well-

trained visual artist explores and experiment constantly in line with the changing society. Art and architecture according to Olaniyan *et al* (2023), have been intertwined through the various epochs of architectural history as an age long phenomenon transcending beyond the earliest human civilizations to the pre-historic period. It is evident in the paintings of walls and roofs of the caves that provided shelter to the cave dwellers. The aesthetic ambience of architecture can be perceived in its artistic expressions and visual forms which transcend beyond the structural envelope and utilitarian reflections. The articulation of artfully embellished architecture with symbolic meanings, and the adornment of cityscapes with monumental structures drive cultural emancipation and promote cultural heritage.

According to Haab (2022), the primary challenge of sustainability is how the environment can remain intact to support human existence and growth, which requires the maintenance of a natural equilibrium. Developing and maintaining low carbon, zero-waste cities and infrastructure for improving our ecosystems is not an easy task. Scientists believe we use more materials and resources which produce more damaging greenhouse gasses, toxics and non-degradable waste than our planet's capability. These manmade processes and activities will create pressures on the ecosystem and our future generation needs (Mohamed *et al*, 2019). Challenges in sustainable materials use can be focused on natural resources and raw materials, relationship between production and consumption patterns, designing for sustainable product, production of waste and emissions and current focus on energy and transportation efficiency. Sustainability as an alternative criterion for building materials and are generally selected through functional, technical and economical specifications. The construction sector, directly or perhaps indirectly creates a substantial portion of the annual environmental destruction (Umar *et al*, 2012). Additionally, Enamhe & Nnochiri (2013) pointed that visual arts as a profession has been extremely neglected in Nigeria and throughout West Africa where its importance is still not recognized. They further revealed a lot about the poor state of the African arts lacking broad general education and early specialization of West African intellectuals certainly accounting for the decline of the art of West Africa. This showed that there is a gap created in the visual arts that seeks redress as visual arts has been poorly addressed and so much left to change. People ought to realize that art is the crafted representation by man which requires the application of skill to refine into valuable possession. Nonetheless, other important terms related to sustainability that will be referenced throughout this study are green, biodegradable, carbon footprint, recycle, and renewable. Green, as defined by Dwyer (2021), refers to products and behaviours that are environmentally placid, and green design refers to building and design methods that reflect green ideals. Secondly, the word biodegradable refers to the ability to break down completely and naturally into safe materials for the environment. Thirdly, carbon footprint is a measure of the impact human activity has on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide. Fourthly, the term recycle means to transform into something else either another version if itself, or into another useable material. Finally, a renewable resource is a resource that regenerates or somehow replaces or repeats itself, preferably rapidly (Dwyer, 2021). All of these terms are integral components of sustainability and are important to this topic. Thus, this study provides a review on the challenges of building materials and shows the future prospect through utilization of sustainable materials for a visual art centre.

2. Literature Review

2.1 Visual Art Centre

The concept of culture, according to Olaniyan *et al* (2023), is defined as a complex whole that consists of all the skills and habits that people acquire as members of a society, including knowledge, beliefs, art, morality, law, and customs. Cultural phenomena are subject to change and spread since culture is a dynamic entity. On the other hand, it is crucial to remember that, for the purposes of this research, year-round, multidisciplinary facilities that promote a variety of professional art forms are considered arts centres and venues. As per Sterry & Sutrisna (2007), art centres are regarded as special and intricate because of the need to satisfy stringent technical specifications and accommodate the divergent and occasionally contradictory demands of artists and performers, administrative personnel, funding agencies, and the broader public. Olaniyan *et al* (2023) defined material culture as a branch of culture that is expressed in sculpture, visual arts, architecture, and artwork. The built environment, which includes all structures and areas, is a very expansive microcosm of civilization. Buildings are always one of the most powerful examples of cultural heritage because they serve as a platform for everyday interactions and as the centre for the transmission of societal norms and values. Art centres recommend diverse degrees of user engagement in the project because, as noted by Sterry & Sutrisna (2007), they prescribe different levels of user involvement, especially in the early stages of the project. Conversely, Olaniyan *et al* (2023) revealed that heritage is the storehouse of a people's values, customs, and accomplishments. It is an assemblage of historical information filtered via romantic notions, nationalism, mythology, pride in one's hometown, or simple marketing. Art centres, on the other hand, recommend diverse degrees of user interaction with the project, based on proposed levels of user involvement. Accordingly, Sterry & Sutrisna (2007) found that one issue is the absence of precise standards about who should be

consulted, as the term "users" is ambiguous and might cause confusion for organisations in the arts that lack expertise. Given this, in order to create effective performing arts facilities that meet user demands, it is imperative to establish the spectrum of real users for any art institution early in the project.

2.2 Overview of Sustainability

Sustainability has grown in popularity over the last decades as a result of the compelling need to modify human actions in order to ensure that the environment remains healthy for future generations. According to Umar *et al* (2012), the term "sustainability" first appeared in common usage in 1969 when the National Environmental Policy Act (NEPA) was developed. The goal of NEPA was to establish and preserve an environment that would allow humans and nature to coexist in a productive way and allow for the satisfaction of the social, economic, and other needs of both the present and the future generations. Recognising that the environment, economy, and society are the three interconnected pillars of the sustainable framework is crucial. In addition to providing resources for building shelters, the environment also pollinates plants and foods that humans consume, breaks down waste and recycles it into new growth, and much more. Supporting this, Goncalves & Martins (2012) pointed out that sustainable development is development that satisfies current demands without jeopardising the capacity of future generations to satiate their own. Though this movement started long before environmental preservation and protection gained widespread recognition on a global scale, the term sustainability is now used to refer to eco-friendly actions. Reclite (2016) contends that as public knowledge of how humans affect the environment increased in the 1960s, sustainability emerged as a recognised movement. Industrialization and several published studies demonstrating the detrimental effects of human activities on the environment led to this increased awareness. The notion of sustainable development is gaining significance in the construction sector due to the obstacles it encounters, including energy consumption and climate change, effects on natural resources, waste management, and user welfare (Goncalves & Martins, 2012). The ecological footprint of the planet is a gauge of how much human activity is placed on its ecosystems. It is a measure of the quantity of biologically productive land and ocean that the global population needs to maintain at current levels of resource consumption and waste output. As a result, with the disastrous impacts of global warming continuing, environmental sustainability has gained prominence in discourse. Generally, organisations and communities are making an effort to reduce their environmental impact in an effort to mitigate the adverse consequences of climate change.

Dwyer (2021) also revealed sustainability as "meeting today's needs without compromising the ability of future generations to meet their needs" as described by the US Environmental Protection Agency (EPA). It involves adopting steps that are economically feasible, long-term positive for human health and well-being, and socially advantageous in order to save our common environment, which includes the air, water, land, and ecosystems. The global research community has made significant efforts to discover low-tech construction techniques and substitute sustainable building materials that can provide more economical and sustainable construction that yet meets today's comfort requirements. Umar *et al* (2012) suggested that using green construction materials is a great way to achieve this goal. A nation's sustainable development benefits from the use of building materials with the fewest negative environmental effects possible. According to Reclite (2016), sustainable construction involves the use of products and materials in structures and construction that will utilise fewer natural resources and enhance their reusability for the same or comparable function, thereby minimising waste. Planning and design are the first steps in achieving sustainable building, thus these professionals' duties are crucial. According to Dwyer (2021), ecologically sustainable practices are those that depend on recyclable or renewable resources as well as eco-friendly or environmentally benign procedures. The fundamental point to be grasped by the definition is that because Earth's natural resources and ecosystems are essential to the survival of all species, it is humanity's duty to protect them. Making eco-friendly product choices for a building is a great way to improve its environmental performance (Umar *et al*, 2012).

2.3 Climate Change and its Impact on Sustainability

The ecological footprint of the planet is a gauge of how much human activity is placed on its ecosystems. It is a measure of the quantity of biologically productive land and ocean that the global population needs to maintain at current levels of resource consumption and waste output. However, it is crucial to remember that the goal of environmental sustainability was to counteract and adapt to climate change. There cannot be environmental sustainability without climate change. Climate change refers to alterations in the typical weather patterns of a region, such as variations in temperature or precipitation levels. Umar *et al* (2012) often referred to it as variations in the Earth's surface temperature. The average temperature of Earth has been measured by scientists to be 1.5 degrees Celsius higher than it was before the industrial era. Snow and ice in the north and south poles are melting quickly due to the rising temperatures. This adds to increasing ocean levels and causes floods in places that cannot contain the extra water. It's the ideal illustration of how minor adjustments can have a big impact. Eight of the 10

strongest storms ever recorded have occurred since 1990, and both the average annual frequency of heat waves and their average length have more than doubled since 1920 (Umar *et al*, 2012).

2.4 Sustainable Principles in Construction

The main objectives of "green" building, according to Cole (2019), are to enhance building inhabitants' quality of life while lessening the built environment's negative social and environmental effects. It advocates using more environmentally friendly materials, implementing resource-saving and waste-reduction techniques, and enhancing indoor environmental quality in order to lessen the impact of buildings throughout their life cycle. The concept of Green Building encompasses several aspects, including the efficient use of resources (such as electricity, water, and materials), waste reduction through recycling, efficiency in processing and building, storm water re-use methods, biodiversity preservation, and the protection of the natural environment. According to Haab (2022), waste must be released in a quantity that the ecosystem can absorb and natural resources must be utilised in a way that promotes their regeneration. The development of renewable energy, waste and resource recycling, resource conservation and reuse, transferable technology, and structural changes to transition in usage are all necessary for the transformation of the economy into a circular economy, given the economic impact (Tiza *et al*, 2021). Moreover, Goncalves & Martins (2012) noted that in order to address these issues, applying sustainability principles appropriately to construction projects will help develop and implement new solutions at various stages, such as building design, functional performance, or material selection. However, the fragmentation of the construction industry is a hindrance to innovation, thus progress requires the participation of all relevant parties. Building from the perspective of environmental impact, sustainable construction calls for the engineering, management, and application of renewable energy resources in the building, operation, and maintenance processes, along with the utilisation of related technologies. This applies to all aspects of construction, including infrastructure, urban development, and structure.

2.5 Sustainable Construction Materials

It appears that becoming green is the newest and current thing to do. It is a simple statement to say, yet it provides very little information on how one would deal with a problem this large. A substance can be considered "green" if it has at least one beneficial effect on the environment, according to Umar *et al* (2021). The choice of environmentally friendly construction materials, goods, assemblies, and components necessitates taking into account a variety of effects on the environment at different stages of their life cycles.

2. Bamboo: Bamboo has long been used in the building industry around the world because of its low weight and strong tensile strength, and regenerates itself after harvesting without the need for replanting. Bamboo is lightweight and durable, making it perfect for areas that are difficult to access. It is frequently utilised in reconstruction efforts following natural disasters (Tiza *et al*, 2021).
3. Wool (Sheep Wool Fibre): Tiza *et al* (2021) stated that wool insulation from herds may be utilised to isolate a floor, and the millions of microscopic air pockets that the crimped shape of the wool act as a heat barrier. It is noise-isolating, doesn't burn, and can regulate moisture. Wool is renowned for its capacity to absorb airborne contaminants, improving the health of interior environments. It is also readily removed and reused, refurbished or repurposed if the building is demolished (Buildertechnifus, 2024). Its production process uses extremely little energy and is safe for people, animals, and the environment.
4. Fibre Cement Board: The constituents of fibre cement boards include organic fibre, chemical binder, and organic cement sand. Because of its strength, durability, and ability to withstand any adversity, it can withstand even the most extreme circumstances (Econaur, 2023). Dalply (2023) asserts that fibre cement board satisfies the sustainable goal since it utilises less water and recycled materials than regular cement, which significantly improves the environment.
5. Stone: Found naturally in the soil, stone may be utilised for worktops and other home furnishings as well as for construction. Stone is a low-maintenance and long-lasting material that generates minimal to no waste in construction projects because of its flexibility. Naturally occurring materials frequently don't require factory manufacture, reducing the amount of CO2 emissions produced (Bigrentz, 2023).
6. Reclaimed Wood: Wood is the most often used building material because of its inherent beauty and ease of usage. Unfortunately, throughout a deconstruction job, it frequently ends up unused. With the use of reclaimed wood technology, timber from ancient buildings may now be disassembled without compromising its integrity. It is a useful step in lessening deforestation since it lessens the need to cut down and harvest trees for fresh wood.
7. Recycled Plastic: According to Bigrentz (2023), due to recent developments in technology and engineering, we can now recycle plastic to make building materials like bricks, timber, and plastic sheets. Recycled plastic does

not require the same harmful preservative coatings that timber requires, and it reduces the amount of debris that ends up in landfills, waterways, and other contaminated regions.

8. Cork: The cork oak tree yields cork, which is manually removed from the bark of the tree and, most significantly, doesn't require the tree to be killed. Cork is an environmentally friendly substitute for manufactured conventional insulation since it is a renewable and recyclable material (Bigrentz, 2023).

2.6 Problems of Inadequate Knowledge of Sustainable Construction Materials

The creation and construction of sustainable structures are greatly hampered by a lack of awareness and comprehension of sustainable building materials. Umar *et al* (2021) claim that while an architect is supposed to counsel and inform their client about sustainability, the lack of awareness among experts on sustainability has also affected the client. Because of the anticipated increase in demand for building materials and its significant influence on environmental sustainability, building designers need to be conversant of and comprehend the complexities associated with building materials and their relationship to sustainable development. The fact that so few people outside the building business are aware of the many advantages of constructing green still presents a difficulty, though. There are several reasons why public education about green building is important. First of all, humans are lifelong consumers of buildings, and those who live there may play a significant role in bringing about change for resource conservation strategies like material recycling and energy efficiency (Cole, 2019). For this reason, further research must to be supported in order to identify new advantageous applications for sustainable and green construction materials.

3. Methodology

This study primarily employed a descriptive research approach, complemented by qualitative data to gain in-depth insights. The primary data were collected through case studies and observation schedules, while secondary data were gathered through a comprehensive literature review. The central aim of the study was to explore sustainable design principles in the context of a proposed Visual Arts Centre in Lafia, Nassarawa State, with the ultimate goal of integrating green architectural elements that contribute to reducing climate change and global warming. To identify the key green architectural components, an observation schedule was developed, focusing on sustainability principles. The study specifically examined several critical variables that affect the environmental performance of a building, which included: building materials, natural ventilation, natural lighting, rain water harvesting, landscape, solar panel and shading devices. By incorporating these green building strategies, the project seeks to make a positive impact on the local environment, contributing to the fight against climate change and promoting sustainable urban development in Lafia.

4. Discussion

Recent catastrophic weather events and scientific studies have demonstrated the connection between human activity and global warming and climate change (Reclite, 2016). Nevertheless, there is a need about the rising necessity for visual art institutions to adopt green and ecological methods. As the public's go-to source for knowledge, visual art institutions are ideally positioned to lead by example and make a significant contribution to the environmental sustainability movement. Since a social green trend has emerged as a result of increased awareness of the need to protect the environment through sustainable and green practices, all kinds of organisations continue to include such activities (Reclite, 2016). One of the most effective instruments for preserving ancient customs and promoting cultural heritage is art. According to Olaniyan *et al* (2023), society benefits from artistically decorated architecture with symbolic connotations when it is present in the built environment. This includes cultural liberation, cultural renaissance, and cultural preservation. A cultural heritage asset with significant current and future economic, social, political, and cultural worth is created when a symbolic art centre incorporates sustainable design elements into its building. This reaffirms the idea that architecture is a hybrid of science and art, with an artistic bent that promotes principles of beauty derived from ornamentation and embellishment. Common procedures in visual art institutes are changing as a result of the necessity for a mentality shift about human activity and the environment. Visual art centres are in a good position to integrate sustainable practices into their work culture and utilise them to educate the public in meaningful ways that are backed by practical applications since they are reputable public organisations. Modern society expects more from cultural organisations; more open communication channels and increased transparency and expectations. It is imperative that visual art centres maintain transparency on the changes they are making as they integrate more sustainable practices into their daily operations. They will be able to gain public recognition as a reliable source of instruction and an inspiration due to this. According to Reclite (2016), institutions may become more sustainable by implementing a variety of little but meaningful improvements, such as recycling, material reuse, purchasing eco-friendly goods, and lowering energy

use. Gaining insight into sustainable materials and making sensible use of the life-cycle of materials approach may result in enhanced product design and technology innovation that boosts resource efficiency for improved waste management techniques and more successful policies. We can meet our material demands at reasonable economic and environmental costs by keeping an eye on trends in material use and becoming accustomed to the life-cycle of materials management. To sum up, Mohamed *et al* (2019) established that using more sustainable materials with greater efficiency can reduce the development of hazardous waste, protect the ecosystem, consume less resources overall, and increase recycling and reuse rates.

5. Conclusion

Art can be seen as a reflection of people's way of life, a tool subject, the core of other subjects and aid to technological advancement. He further noted that art reveals cultural traits and that it is one of the principal cannons for judging a nation. It reflects the past, the present and the future. Art, is a lingua franca through which thoughts are made clearer, and it provides the mirror through which other disciplines of life are seen clearly (Azuka, 2014). Therefore, it can be seen as an aid to learning. However, over the years, the application of art in its various forms in architecture has played a vital role in the lives of African people, serving as a media of communicative expression of religious beliefs and socio-cultural norms (Olaniyan *et al*, 2023). Nevertheless, its form, presentation and significance vary from one cultural setting to another, and in many cultures, public buildings such as palaces and town halls provide a facade for art and ornamentation. Recently, the traditional town halls have evolved into visual arts, cultural and civic centres. When visual art is re-invigorated, there will be employment opportunities and expansion of labour market. The experimental nature of the discipline has the capacity to continue to break new grounds for more employment opportunities culminated into self-reliance. Visual Arts, train students for productivity, and this comes from the philosophical notion that real knowledge is experimental (Enamhe & Nnochiri, 2013).

In conclusion, as the presence of green practices has gained increased recognition in society, a demand for environmentally-friendly products have come to the forefront. Reclite (2016) revealed that this awareness of environmental impact and consumer demand has resulted in shifting practices in cultural heritage institutions, including museums and visual art centres. Professionals in the field have long recognized that art centres require significant amounts of energy and materials to fulfill their educational and public service missions. However, with the increasing awareness of global warming and climate change, there is a growing need to reassess traditional approaches to preventive conservation. It has become clear that the extraction, processing, use, and disposal of building materials carry considerable environmental costs, including habitat destruction, resource depletion, energy consumption, and contamination of air, water, and solid waste. In response to these challenges, the adoption of sustainable principles has proven to be an effective way to mitigate or even eliminate the negative effects of development on the environment and its inhabitants. This shift has led to the incorporation of green and sustainable practices into the operation and design of visual art centres. In light of this, this study explores sustainable design concepts in the context of Nigeria, with the aim of proposing a Visual Arts Centre that integrates green architectural elements to address the issues of climate change and global warming. The proposed design will not only help reduce carbon dioxide emissions and environmental harm but also lower the energy demands for heating and cooling, aligning with broader sustainability goals.

6. Recommendations

The following suggestions have been proffered as green architectural solutions in Visual Art Centres, significant to knowledge acquired in the course of this study, with respect to improving sustainability in Lafia, Nasarawa State. Firstly, promote the use of recyclable, reusable, recycled, and renewable resources. Secondly, to increase output per unit input, resources must be employed more effectively and efficiently during construction as well as in the manufacturing of materials, products, components, and assemblies. Thirdly, select materials, and assemblies that improve indoor air quality and human health, such as those with low carbon emissions and low toxicity. Fourtly, choose materials and components that require insignificant maintenance or cleaning. Fift, to minimise the energy effect of transportation, select locally produced goods and materials whenever possible. And finally, select durable and long-lasting materials, to reduce waste generated during the material life cycle.

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Influence of Adoption of Natural Language Processing on Construction Site Management in Abuja

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Abstract

The increasing complexity and size of projects in the construction sector make it difficult to identify and verify initial requirements expressed in natural language. As a result, there are numerous errors and shortcomings in the definition of requirements at the early stages of concept and design of construction works with inefficiencies in terms of time, cost and quality. Therefore, this study assessed the influence of the adoption of Natural Language Processing (NLP) on construction sites management in Abuja with a view to enhancing effective information management in construction projects. In order to achieve the aim, the study adopted a survey research design with the use of quantitative research approach. Data collection was undertaken with the use of structured questionnaires administered to eighty-five (85) construction professionals of Federal Capital Development Authority, Abuja. Analysis of data collected was done with the use of descriptive and inferential analytical techniques. Findings from the study revealed that the most significant drivers for the effective adoption of NLP for effective construction site management are "Efficiency" (RII = 0.83) and "Accuracy" (0.82); the most severe barriers to the effective adoption of NLP for effective construction site management are "Ambiguity" and "The manual conformity control process is time-consuming, costly, and error-prone of construction firms should develop a mechanism for enhancing the adoption of NLP for effective information management in construction projects by using the strategies" (RII = 0.74 respectively); there exists a significant relationship between the adoption of NLP and construction sites management (p = 0.001; r = 0.452); and the most effective strategy for enhancing adoption of NLP for effective construction site management is "Allowing potential non-compliance cases to be identified in advance" (RII = 0.80). The study therefore concludes that the influence of the adoption of NLP on construction sites management in Abuja is very significant. It was recommended that management developed the study as a basis for improving information flow for effective site management.

Keywords: Adoption; Construction sites; Influence; Information management; Natural Language Processing.

1. Introduction

The construction industry is well known for its fragmentation which dramatically affects two characteristic aspects of the sector: the intensive use of information in decision making and the limited access to, and consequently the insufficient use of, pertinent information that is potentially available (Kovacevic *et al*., 2008). Studies have established that the lack of effective access to information is the primary cause of loss of productivity in the building design and construction process (Abanda *et al*., 2022). As a result, party cooperation within a construction project may not work smoothly among all phases, including planning, procurement, etc. Party members may need to face consequences by poor management, which may be as serious as litigation (Cheung *et al*., 2015; Hsu *et al*., 2019; Mahfouz and Kandil, 2012; Wang *et al*., 2021a and b). A need to facilitate management process and lower barriers among all contract parties is overwhelming. Therefore, it is important and cost-effective to extract and understand text data automatically and intelligently.

It is becoming increasingly clear that exploitation of Natural Language Processing (NLP) can fulfil the above purpose (Siebelink *et al*., 2018; Abanda *et al*., 2022; Corneli *et al*., 2023). One of the most significant benefits of NLP assistant is the ability to understand and respond to natural language queries. The use of NLP can help the project manager and the client to express project requirements in alphanumerical and quantifiable terms avoiding misunderstanding and increasing the project's chances of success (Di Giuda *et al*., 2020a). The use of NLP in the early stages of defining project requirements can be therefore considered a risk mitigation technique. This means that project participants can simply ask questions in natural language rather than having to navigate through the system using traditional means (such as clicking through menus or typing in keywords) and receive accurate and relevant information without the necessity of deep knowledge of Industry Foundation Classes (IFC) or other standards (Dar *et al*., 2019).

In the light of the above background, it is obvious that information flow management has historically been a problem in the construction industry. Fragmentation of processes within the sector, interdisciplinarity, and lack of unambiguous methods for passing information are some of the obstacles that make it difficult to have a non-splintered flow of data (Di Giuda *et al*., 2020a). BIM approach is, if well adopted, a valuable support for optimal information flow management. Therefore, studies suggest that the use of NLP with vocal assistants can facilitate the access and understanding of the information to non-technical users (Siebelink *et al*., 2018; Abanda *et al*., 2022; Corneli *et al*., 2023). This necessitated an assessment of influence of adoption of NLP on construction sites management in Abuja with a view to enhancing effective information management in construction projects. In order to achieve this aim, the study: examined the drivers and barriers to the effective adoption of NLP for effective construction site management; determined the effects of the adoption of NLP on construction site management capabilities in construction projects; and developed the strategies for enhancing the adoption of NLP for effective construction site management in Abuja.

2. Literature review

2.1 Drivers for Effective Adoption of NLP for Effective Construction Site Management

NLP is a set of techniques that aid machines in comprehending human languages by analyzing text structures and meanings (Wu *et al*., 2020; Rampini and Cecconi, 2022). In the same vein, Leidner (2023) reported that it is notoriously difficult to construct conventional software systems systematically and timely, with up to 20% of industrial development projects failing. Even for NLP applications, none of the existing studies seem to have estimated project failure rate. The risks of failure seem even higher in this area. However, the language engineer can address additional complexity due to these risks by embracing several drivers. These drivers are: Accuracy; Efficiency; Flexibility; Productivity; Robustness; Scalability; Multimodality; and Multilinguality. In terms of accuracy, a fundamental difference between NLP systems and conventional software is the incompleteness property: since current language processing techniques can never guarantee to provide all the correct results, the whole system design is affected by having to take this into account and providing appropriate fallbacks. In terms of efficiency, human users are very demanding; Leidner (2023) reported that system response times in which scenarios natural language interaction with machines is superior to menus, keyboard commands or other means. In terms of flexibility, like any software, NLP systems need to be flexible: a parser developed primarily to analyze written online newspaper text might well be employed tomorrow to process business e-mails. Different data formats have to be handled, so representational and input/output knowledge needs to be factored out from core linguistic processing knowledge.

2.2 Barriers to Effective Adoption of NLP for Effective Construction Site Management

Artificial Intelligence (AI) is a fast-growing area of study that it stretching its presence to many business and research domains. Machine learning, deep learning, and natural language processing (NLP) are subsets of AI to tackle different areas of data processing and modelling (Abioye *et al*., 2021; Shaik *et al*., 2022). In addition to this, Shaik *et al*. (2022) identified six (6) main barriers to effective adoption of NLP for effective construction site management. These barriers are: Domain-Specific Language; Sarcasm; Ambiguity; Emoticons and Special Characters; Aspect-Based Sentiment Analysis; and Data Imbalance. In order to classify academic dataset or students' feedback, it is required to understand core factors of teaching context. This is considered one of the challenges in implementing NLP in education domain. Considering abundant student feedback being generated from different surveys, questionnaires, and other educational feedback acquiring portals on a course teaching or a learning management system.

2.3 Effects of Adoption of NLP on Construction Site Management Capabilities in Construction Projects

NLP is a natural tool for the asset management industry because many activities of asset managers are driven by text data. Indeed, many of the alternative data trends require NLP capabilities to fully leverage their potential. It studies theories and method for realizing human-computer interaction based on natural language (Chowdhury, 2003). NLP applications in construction have mostly invested the following processes: document management (Wu *et al*., 2020), safety management (Cheng *et al*., 2020), compliance checking (Xue and Zhang, 2020), risk management (Lee *et al*., 2019) and BIM management (Xie *et al*., 2019; Zhou *et al*., 2020). As far as the latter is concerned NLP has been adopted to solve a well-known problem of AECO sector: information retrieval. Wu *et al*. (2019) presented a natural-language-based intelligent retrieval engine for the BIM object database and Revit modelling. They developed first and IFC-based BIM object database and then a search engine that speeds up the process of retrieving building components for modelling. Therefore, the use of NLP can help the project manager and the client to express project requirements in alphanumerical and quantifiable terms avoiding misunderstanding and increasing the project's chances of success (Di Giuda *et al*., 2020b). In addition, the use of NLP in the early stages of defining project

requirements can be therefore considered a risk mitigation technique. An approach to NLP also allows to define requirements and predictions in order to monitor the progress of the project. This, in turn, leads to an optimization of the definition of requirements and the assessment of the project progress.

2.4 Strategies for Enhancing Adoption of NLP for Effective Construction Site Management

Studies have established that the use of NLP for the definition of initial requirements would have a greater impact if applied at an early stage (Di Giuda *et al*., 2020b; Abioye *et al*., 2021). The NLP approach could be used for the definition of the initial requirements of a public client helping the public actor to define requirements on a numerical and alphanumerical basis and not on a simple text basis. Through the alphanumeric requirements translation, the public client would be the main actor in a Data-driven construction process, increasing its ability to understand, manage and direct the outcome of the design (Xie *et al*., 2019; Zhou *et al*., 2020). The numerical translation of the requirements would make the entire process computable, and digitally manageable, which would see the client as able to contribute directly to the design process. NLP supports requirements engineering by transforming the classic qualitative demand based on text data into a computational demand based on formal and structured data. During a data-driven process, the monitoring of the objectives to be achieved can be more effective and immediate, reducing the risk of overcoming time and costs and not reaching the expected quality level.

3. Methodology

This study adopted the survey research design. Therefore, a quantitative research approach was adopted for this study. Therefore, the use of structured questionnaire was employed to collect data. The population for the study was made up of the 197 professionals that are engaged in construction projects executed by Federal Capital Development Authority (FCDA) in Abuja. Based on three (3) major criteria set for qualifying professionals chosen for the study, 85 professionals made up the sample size for this study. Therefore, purposive sampling technique was used in selecting the professionals based on the awareness of respondents on NLP; active involvement in construction site, on-site communication and management activities; and involvement in the decision-making of the organisation. In the course of the fieldwork, eighty-five (85) copies of questionnaires were distributed to construction professionals that are engaged in construction projects executed by FCDA in Abuja of which fifty (50) copies were retrieved and used for analysis. Therefore, the response rate was 58.82%. The analysis of data was undertaken with the use of Relative Importance Index (RII) and Spearman Rank correlation analysis. The decision rule "to be adopted for the RII analysis are summarized in Table 1".

Table 1: Decision Rule for RII Analysis

Scale	**Cut-Off Point**	**Interpretation**			
	RII	***Level of Importance***	***Level of Severity***	***Level of Significance***	***Level of Effectiveness***
5	0.81 - 1.00	Extremely Important	Extremely Severe	Extremely Significant	Extremely Effective
4	0.61 - 0.80	Very Important	Very Severe	Very Significant	Very Effective
3	0.41 - 0.60	Important	Severe	Significant	Effective
2	0.21 - 0.40	Less Important	Less Severe	Less Significant	Less Effective
1	0.00 - 0.20	Least Important	Least Severe	Least Significant	Least Effective

Source: Adapted and Modified from Shittu *et al.* (2021) and Shittu *et al*. (2022)

For the Spearman Rank correlation, the decision rules for the nature of correlation state that if coefficient of correlation (r) = 0.10 to 0.29, then there is small amount of correlation; if r = 0.30 to 0.49, then there is medium amount of correlation; and if r = 0.50 - 1.0, then then there is large amount of correlation between the variables, as opined by Pallant (2013).

4. Findings and Discussion

4.1 Examination of Drivers for Effective Adoption of Natural Language Processing for Effective Construction site Management

It was revealed from the results of the RII analysis presented in Table 2 that the most significant drivers for the effective adoption of NLP for effective construction site management are "Efficiency" (RII = 0.83) and "Accuracy" (0.82). The least significant driver for the effective adoption of NLP for effective construction site management is "Robustness" (RII = 0.70). On the average, all the drivers for the effective adoption of NLP for effective construction site management in Abuja are very significant (average RII = 0.95). Findings from past studies supports the results of this research here by establishing that in terms of multilinguality, in a globalized world, users want to work with a system in multiple languages (Wu *et al*., 2022; Rampini and Cecconi, 2022; Leidner, 2023).

Table 2: Drivers for the Effective Adoption of NLP for Effective Construction Site Management

Code No.	Drivers for the Effective Adoption of NLP for Effective Construction Site Management	RII	Rank	Decision
C2	Efficiency	0.83	1st	Extremely Significant
C1	Accuracy	0.82	2nd	Extremely Significant
C11	Automated compliance checking, i.e., automatically comparing as-is situation (e.g., working plans) with requirements (e.g., contracts and standards) and identifying non-compliance	0.79	3rd	
C6	Productivity	0.78	4th	Very Significant
C8	Filtering information, i.e., extracting key information from noisy texts for specific purposes (e.g., finding accident causes from reports)	0.78	4th	Very Significant
C9	Organizing documents, i.e., automatically grouping documents of different backgrounds (e.g., drawings from different disciplines) and enabling timely retrieval	0.78	4th	Very Significant
C5	Multilinguality	0.77	7th	Very Significant
C10	Expert systems, i.e., integrating expert knowledge and providing answers for engineering problems	0.76	8th	Very Significant
C3	Scalability	0.75	9th	Very Significant
C4	Multimodality	0.74	10th	Very Significant
C7	Robustness	0.70	11th	Very Significant
	Average RII	***0.75***		***Very Significant***

4.2 Examination of Barriers to Effective Adoption of Natural Language Processing for Effective Construction Site Management

It was shown form the results of the RII analysis presented in Table 3 that the most severe barriers to the effective adoption of NLP for effective construction site management are "Ambiguity" and "The manual conformity control process is time-consuming, costly, and error-prone" (RII = 0.74 respectively). The least severe barrier to the effective adoption of NLP for effective construction site management is "Homophones" (RII = 0.61). On the average, all the barriers to the effective adoption of NLP for effective construction site management in Abuja are very severe (average RII = 0.68). Past studies agree with the findings of this research in this area by reporting that construction workers often have to communicate with software applications e.g., BIM on the construction site, but typing on devices to retrieve information could lead to safety hazards (Abioye *et al*., 2021).

Table 3: Barriers to Effective Adoption of NLP for Effective Construction Site Management

Code No.	Barriers to the Effective Adoption of NLP for Effective Construction Site Management	RII	Rank	Decision
D1	Ambiguity	0.74	1st	Very Severe
D2	The manual conformity control process is time-consuming, costly, and error-prone	0.74	1st	Very Severe
D6	Lack of data inherent in natural language	0.73	3rd	Very Severe
D4	Usually very noisy, which puts unwanted information in the speech signal	0.71	4th	Very Severe

D17	Information flow management has historically been a problem in the construction industry	0.71	5th	Very Severe
D3	Safety hazards	0.70	6th	Very Severe
D9	Voice enhancement	0.69	7th	Very Severe
D14	Emoticons and Special Characters	0.69	7th	Very Severe
D8	Speaker variability	0.69	7th	Very Severe
D15	Aspect-Based Sentiment Analysis	0.69	7th	Very Severe
D7	Errors which may frustrate the users and eventually lead to discontinuity of use	0.68	11th	Very Severe
D11	Amount of data and search space	0.68	11th	Very Severe
D18	Fragmentation of processes within the construction sector	0.67	13th	Very Severe
D16	Data Imbalance	0.67	13th	Very Severe
D19	Interdisciplinarity	0.66	15th	Very Severe
D12	Domain-Specific Language	0.64	16th	Very Severe
D5	Imprecision	0.64	16th	Very Severe
D13	Sarcasm	0.63	18th	Very Severe
D10	Homophones	0.61	19th	Very Severe
	Average RII	***0.68***		***Very Severe***

4.3 Determination of Effects of Adoption of Natural Language Processing on Construction Site Management Capabilities in Construction Projects

The effect of adoption of NLP on construction site management capabilities in construction projects was determined with the use of RII and Spearman Rank correlation analysis of the perceived effects of adoption of NLP on construction site management capabilities in construction projects. On the other hand, Spearman Rank correlation analysis was used to inferentially determine the relationship between the benefits of adoption of NLP and the strategies for enhancing the adoption of NLP for effective construction site management.

4.4 Perceived effects of the adoption of NLP on construction site management capabilities in construction projects

The results of the RII analysis used to rank the perception of respondents on the perceived effects of the adoption of NLP on construction site management capabilities in construction projects are summarised in Table 4. It was revealed that the most significant effect of the adoption of NLP on construction site management capabilities in construction projects is "NLP is of significant benefits in the areas of: Information management; Procurement management; Risk management; Requirement management; Automated compliance checking; Construction management; and Construction safety" (RII = 0.84). The least significant effects of the adoption of NLP on construction site management capabilities in construction projects are "Time efficiency" and "Reduced mistakes and omissions" (RII = 0.70 respectively). On the average, all the perceived effects of the adoption of NLP on construction site management capabilities in construction projects are very significant (average RII = 0.73).

Table 4: Effects of the Adoption of NLP on Construction Site Management Capabilities in Construction Projects

Code No.	Effects of the Adoption of NLP on Construction Site Management Capabilities in Construction Projects	RII	Rank	Decision
E1	NLP is of significant benefits in the areas of Information management; Procurement management; Risk management; Requirement management; Automated compliance checking; Construction management; and Construction safety	0.84	1st	Extremely Significant
E2	The use of NLP can help the project manager and the client to express project requirements in alphanumerical and quantifiable terms avoiding misunderstanding and increasing the project's chances of success	0.76	2nd	Very Significant
E7	Simplified monitoring and control	0.76	2nd	Very Significant
E9	Ability to explain reasoning behind solution	0.76	2nd	Very Significant
E12	Improved safety	0.76	2nd	Very Significant
E4	Increased productivity	0.76	2nd	Very Significant

E3	It leads to an optimization of the definition of requirements and the assessment of the project progress	0.75	7th	Very Significant
E6	Cost effectiveness	0.74	8th	Very Significant
E8	Easy access to relevant information	0.73	9th	Very Significant
E10	Clear logic	0.73	9th	Very Significant
E14	Improves communication among stakeholders	0.73	9th	Very Significant
E5	Consistency and availability	0.72	12th	Very Significant
E11	Time efficiency	0.70	13th	Very Significant
E13	Reduced mistakes and omissions	0.70	13th	Very Significant
	Average RII	***0.73***		***Very Significant***

4.5 Relationship between adoption of NLP and strategies for enhancing the adoption of NLP for effective construction site management

Before carrying out Spearman Rank correlation analysis, the reliability and suitability of the data for Spearman rank Correlation analysis was first tested. In view of this, the reliability test carried out between the benefits of adoption of NLP and strategies for the adoption of NLP for effective construction site management in Abuja shows no evidence of scatterplot with the data points spread all over the place, suggesting a very high correlation. This shows that the data set is fit for Spearman Rank correlation analysis. Figure 4.3 shows the graph of the scree plot of the relationship between the benefits of adoption of NLP and strategies for the adoption of NLP for effective construction site management.

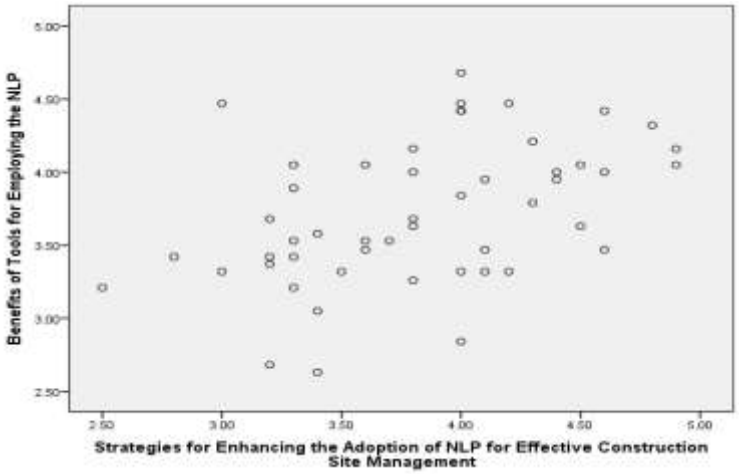

Figure 1: Scree Plot between Benefits of Adoption of NLP and Strategies for Adoption of NLP for Effective Construction Site Management

After confirming the reliability and suitability of the data for Spearman Rank correlation analysis, the relationship between the benefits of adoption of NLP and strategies for the adoption of NLP for effective construction site management was determined. The spearman rank correlation analysis results revealed that there exists a slightly strong, positive and significant relationship between the benefits of adoption of NLP and effects of adoption of NLP for effective construction site management in Abuja. The positive correlation indicates that improvement in the level of implementation of the strategies for adoption of NLP will result in the increase in the level of adoption of NLP for effective construction site management in Abuja. The correlation coefficient (*r* value) observed was 0.452 indicating slightly strong degree of association between the variables. Hence, the correlation between the variables is medium (Pallant, 2013). The probability (P_{value}) value of 0.001 observed was less than the level of significance adopted for the study (0.01). This implies a significant relationship between the variables. Therefore, the of effects of the adoption of NLP on construction site management capabilities in construction projects in Abuja is very significant. The results of the Spearman Rank correlation analysis are summarised in Table 5. In line with the findings of this study, findings from past studies also found a significant relationship between the adoption of NLP and construction site management capabilities in construction projects. This is because studies have discovered that the use of NLP can help the project manager and the client to express project requirements in alphanumerical and quantifiable terms avoiding misunderstanding and increasing the project's chances of success (Abioye *et al*., 2021; Di Giuda *et al*., 2020a).

Table 5: Relationship between Benefits of Adoption of NLP and Strategies for Adoption of NLP for Effective Construction Site Management

VARIABLES		OBSERVATIONS			INFERENCES	
X_1	X_2	*r* (%)	LOS	P_{value}	Strength of Relationship	Remark
Benefits of Adoption of NLP	Strategies for Effective Adoption of NLP	0.452	0.01	0.001	Slightly Strong	SS

KEY:

SS = Statistically Significant

r = Correlation Coefficient

LOS = Study's Level of Significance

P_{value} = Calculated Probability Value

4.6 Development of Strategies for Enhancing Adoption of NLP for Effective Construction Site Management

It was revealed from the results of the RII analysis presented in Table 6 that the most effective strategy for enhancing adoption of NLP for effective construction site management is "Allowing potential non-compliance cases to be identified in advance, which could save significant time and cost due to changes and/or rework" (RII = 0.80). The least effective strategy for enhancing adoption of NLP for effective construction site management is "Promoting the adoption of Building Information Modelling (BIM) and increase the cumulative benefits of adopting BIM as BIM would allow ACC" (RII = 0.72). On the average, all the strategies for enhancing adoption of NLP for effective construction site management in Abuja are very effective (average RII = 0.75). In line with the findings of this study, past studies have also established that the strategies for enhancing the adoption of NLP in construction projects are effective. This is because it was indicated by past studies that to adjust a pre-trained model for specific problems and domains, researchers fine-tune their models by further training them on the desired domain and making small adjustments to the underlying model to achieve the desired output or performance (Xie *et al*., 2019; Zhou *et al*., 2020; Di Giuda *et al*., 2020a).

Table 6: Strategies for Enhancing the Adoption of NLP for Effective Construction Site Management

Code No.	Strategies for Enhancing the Adoption of NLP for Effective Construction Site Management	RII	Rank	Decision
F6	Allowing potential non-compliance cases to be identified in advance, which could save significant time and cost due to changes and/or rework	0.80	1st	Very Effective
F1	Development of a robust dataset of common voice commands in different situations on the construction site should be collected	0.78	2nd	Very Effective
F9	Experimenting different design options and checking for compliance would be more efficient in terms of time	0.78	3rd	Very Effective
F4	Training and re-training of personnel on the desired domain and making small adjustments to the underlying model to achieve the desired output or performance	0.77	4th	Very Effective
F5	NLP approach can reduce time and cost in defining requirements by avoiding errors, loss of information and ambiguities in defining project objectives	0.77	5th	Very Effective
F8	Enabling more efficient integration of stakeholder inputs into the design and exploration of what-if design scenarios	0.77	6th	Very Effective
F10	Reducing violations of regulations, due to easier and more frequent Compliance Checking	0.77	7th	Very Effective
F2	The use of NLP with vocal assistants can facilitate the access and understanding of the information to non-technical users	0.76	8th	Very Effective
F3	Adoption of BIM approach as a valuable support for optimal information flow management	0.74	9th	Very Effective
F7	Promoting the adoption of Building Information Modelling (BIM) and increase the cumulative benefits of adopting BIM as BIM would allow ACC	0.72	10th	Very Effective
	Average RII	***0.75***		***Very Effective***

5. Conclusion and Recommendation

The most significant drivers for the effective adoption of NLP for effective construction site management were found to be "Efficiency" and "Accuracy". The study also revealed that most severe barriers to the effective adoption of NLP for effective construction site management are "Ambiguity" and "The manual conformity control process is time-consuming, costly, and error-prone". The study also found that the there is a significant effect between the adoption of NLP and construction site management capabilities in construction projects. Finally, the study revealed that most effective strategy for enhancing adoption of NLP for effective construction site management is "Allowing potential non-compliance cases to be identified in advance, which could save significant time and cost due to changes and/or rework". The study therefore concludes that the influence of the adoption of NLP on construction sites management in Abuja is very significant and capable of enhancing effective information management in construction projects provided some basic strategies are implemented.

In view of the findings and conclusion, the study recommends that the management of construction firms should place more priority on efficiency and accuracy in the transfer of information on site so as to enhance the adoption of NLP for effective information management in construction projects. In the transmission of information in construction projects, employees should avoid ambiguity and time-consuming, costly, and error-prone manual conformity control process in order to prevent the adoption of NLP for effective information management in construction projects from being inefficient. The management of construction firms should develop a mechanism for enhancing the adoption of NLP for effective information management in construction projects by using the strategies developed in this study as a basis.

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Potential Impact of Smart Building Elements on Commercial Property Investments in Lagos State, Nigeria

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Abstract

The impact of smart building elements on commercial property investment in recent years including the landscape of real estate investment has undergone significant transformation across the globe, particularly in emerging economies such as Nigeria. This study explores the potential effect of Smart Building Elements (SBEs) on commercial property investment in Nigeria, as the global narrative of real estate investment has been progressively influenced by the Fourth Industrial Revolution Technologies (Industry 4.0), particularly through the integration of (SBEs). In developed regions like the United States, evidence in literature suggests that investors are securing higher premiums in rents and transaction prices by incorporating technologies such as the smart building elements which include sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems into commercial properties. SBEs address the complex demands of commercial spaces which include enhanced comfort, improved accessibility, heightened security, and efficient energy management. The study methodology is based on a review of published articles in peer-reviewed journals and conferences, accessed from online search engines including Google scholar, ResearchGate and Scispace. Results show SBEs facilitate predictive maintenance, enhance space utilization, achieve significant returns on investment, increase tenant satisfaction and retention. Notably, stakeholders (investors, facility managers and tenants) in the real estate sector are aware and accept SBEs. Nevertheless, predominant literature did not capture the tangible economic impact and the operational benefits SBEs can deliver in Lagos state, Nigeria. This research gap underscores a critical need for in-depth empirical study on how SBEs specifically affect commercial property investment outcomes in Lagos state, Nigeria.

Keywords: Smart Building Elements, Real Estate Investment, Commercial Property, Returns, Technology

1. Introduction

In recent years, the landscape of real estate investment has undergone significant transformation across the globe. Especially in commercial real estate sub-sector, prime property locations, strategic capital enhancements, and the engagement of skilled professionals are pivotal to optimizing performance and generating substantial returns (Feng and Hardin, 2023). Commercial real estate investment, fundamentally, involves acquiring interests in properties with the aim of generating profits through rental income or capital gains.

The global narrative of real estate investment has been progressively influenced by technological advancements, especially through the integration of Smart Building Elements (SBEs). In developed regions like the United States, evidence suggests that investors are securing higher premiums in rents and transaction prices by incorporating smart building elements such as sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems into commercial properties (Bando-Hano, 2018). These smart building elements are energised by smart technologies including the Internet of things, Artificial Intelligence and Machine Learning, Building Automation, Building Management System, Artificial Reality, Virtual Reality and Aerial Drones. SBEs are revolutionizing the design, construction, and management of building infrastructures, significantly altering traditional real estate practices (Oluwatofumi and Hahn, 2021).

Smart building elements address the complex demands of commercial spaces which include enhanced comfort, improved accessibility, heightened security, and efficient energy management. Emerging literature points to the effectiveness of smart technologies in meeting these needs, offering compelling solutions that are increasingly recognized globally (Kumar *et al*., 2021). In the Asia Pacific region, for instance, the surge in smart building

implementations has been attributed to their substantial benefits to stakeholders, enhancing both operational efficiencies and user experiences (Wong *et al*., 2005).

2. Literature Review

In year 2023, the estimated value of the global commercial real estate market was approximately 37 trillion U.S. dollars, up from almost 35 trillion U.S. dollars the previous year. The North America region had the largest market size, valued at over 12 trillion U.S. dollars, slightly higher than Asia-Pacific and Europe, Middle East, and Africa (EMEA) (Statista Research Department, 2024). The dynamic trend in the real estate market activities has a strong impact on economic growth and a nation's wealth creation.

According to Abdulhakim *et al*. (2018), smart buildings could denote automated buildings; intelligent buildings and; buildings embedded with smart technologies. It is a term used to describe structures that include technologies such as digital infrastructure, energy efficiency measures, intelligent building management systems, wireless technologies, remote monitoring, information and communications networks, adaptive energy systems, networked appliances, data gathering devices, assistive technologies and automated systems. Furthermore, Smart building is the interplay of building automation systems, integration systems, and telecommunication systems geared towards the building's efficiency, functionality, optimisation, comfort, and economic stability (Indrawati and Amani, 2017). Figure 2.1 shows a building connected with smart elements.

Figure 2.1 Smart building (Source: Experts in Smart Buildings)

There exists interconnectivity among smart building elements. Therefore, it has become paramount to distinguish each element individually according to the unique layer of functionality. Smart building elements include: sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems.

2.1 Sensors

Sensors are devices that detect and measure physical or environmental parameters and convert them into electrical signals. These signals are then analyzed to provide valuable insights into building systems. Various types of sensors are commonly used in smart buildings, including temperature sensors, humidity sensors, occupancy sensors, and light sensors. These can detect changes in temperature, humidity, light, and occupancy, allowing for real-time adjustments to building systems and informed decision-making for building operations (Wu *et al*., 2023).

Smart sensors optimize Heating, Ventilation, and Air Conditioning (HVAC) systems, reducing energy consumption and operational costs (Aliyeva, 2023). By continuously collecting data on energy consumption, sensors provide valuable insights into energy usage patterns, allowing building managers to identify inefficiencies and implement energy-saving strategies. For example, sensors can adjust lighting levels based on occupancy, optimize HVAC systems based on temperature and humidity data, and manage power consumption during off-peak hours.

By monitoring air quality and temperature, these sensors improve indoor environments, positively impacting occupant health and productivity (Wu *et al*., 2023). Temperature control can be optimized based on real-time data collected by temperature sensors, ensuring a comfortable environment for occupants. Air quality monitoring sensors can detect pollutants and trigger ventilation systems accordingly, providing a healthy indoor environment. Additionally, occupancy sensors are used for security purposes, tracking the presence of occupants and triggering alarm systems in case of emergencies.

One among the key advantages of sensors is the ability to collect and analyze data, enabling data-driven decision-making and predictive maintenance in smart buildings. By continuously monitoring building systems, sensors can detect early signs of equipment malfunction or failure. This data is then analyzed to predict maintenance needs, preventing costly breakdowns and optimizing equipment performance, which invariably save cost and increase equipment lifespan.

2.2 Smart Meters

Smart meters are advanced digital devices that monitor and record electricity consumption in real-time, significantly enhancing energy management and consumer engagement (Batalla-Bejerano *et al*., 2020). They facilitate two-way communication between consumers and utility companies, allowing for accurate billing and efficient energy usage adjustments during peak demand periods (Pitì *et al.*, 2017).

In recent time, energy consumption and efficiency have become of critical concerns; smart meters have emerged as an innovative solution for managing small businesses and commercial energy metering more effectively (Sovacool, *et al.,* 2021). Unlike analog (traditional) metering, which requires manual readings by meter readers, smart metering provides accurate and up-to-date consumption data that enables both utilities and consumers to monitor and manage energy usage more effectively. Further, Smart meters provide immediate insights into energy consumption, enabling users to track usage patterns and costs (Batalla-Bejerano *et al*., 2020). Figure 2.2 shows a smart electric meter:

Figure 2.2: Smart electric meter (smsmetering.co.uk)

Smart meters deployment is crucial for a sustainable energy future in commercial properties, empowering consumers to make informed decisions about energy conservation (Batalla-Bejerano *et al*., 2020; Sovacool, *et al.,* 2021). More so, considering the fact that energy consumption and efficiency have become critical concerns, smart meters have emerged as an innovative solution for managing small businesses and commercial energy metering more effectively.

Smart meters represent a significant evolution from traditional mechanical meters, incorporating electronic technology for improved accuracy and stability (Chakraborty *et al.,* 2021). Because smart meters transmit real-time consumption data, utility companies can charge customers based on their actual usage rather than relying on estimates or manual meter readings. Further, smart meter data can help utility companies better understand and manage grid demand. By analyzing consumption patterns, utilities can identify peak demand periods and implement demand response programs (such as offering incentives for customers to reduce energy usage during peak times).

2.3 Smart Security Cameras

A smart security camera is a self-contained, standalone vision system that combines an image sensor, processing capabilities, and connectivity within the housing of the device. Smart security cameras utilize machine learning algorithms to detect intrusions and analyse behaviour, enhancing security by sending alerts to users (Yue *et al*., 2021). These cameras not only capture and store video footage but also have advanced features like motion detection, facial recognition and two-way communication. Connected to Wi-Fi network activates the ability to send the videos to smartphones or save them in cloud storage for conveniences.

Automated video analytics can identify deviant conduct, significantly reducing the frequency of burglaries (Pouyan *et al.*, 2023). This is as a result of being an internet-connected device that captures and stores video footage in cloud storage and local storage (especially microSD cards). Allowing users to remotely access the footage through a smartphone application (or web browser) and send real-time alerts when motion or sound is detected for monitoring purposes. Figure 2.3 shows a smart security camera:

Figure 2.3 Smart Security Camera (source: techserious.com)

Smart security cameras can be a worthwhile investment for the enhanced security, convenience and features they offer compared to traditional cameras. By providing remote access and real-time monitoring, smart security cameras give you peace of mind and flexibility in monitoring your property. While the initial cost can be higher than regular cameras, the benefits may outweigh the expense in various setting.

2.4 Smart Thermostats

A smart thermostat connects to a Wi-Fi using the internet and other features to optimize Heating, Ventilating, Air Conditioning (HVAC) systems' performance, automatically. (Guo and Rasmussen, 2023). Features like real-time monitoring and adaptive control allow for tailored temperature adjustments based on user preferences and environmental conditions (Li *et al.*, 2019). More so, some smart thermostats can be programmed to come-on when an occupant is a certain distance from the work space so the environment becomes properly heated or cooled once you walk in the door. User satisfaction surveys indicate improved comfort levels due to the convenience of remote control and personalized settings (Miu *et al.*, 2019), as shown in Figure 2.4.

Figure 2.4 *Smart Thermostat (*source: *edsairconditioing.com)*

2.5 Smart Lighting Systems

A smart lighting system is a lighting technology connected to the internet (Gowda *et al.*, 2021). These smart lights can make decisions, follow schedules and can be controlled remotely using a mobile application or voice-activated personal assistants. Smart lighting systems represent a significant advancement in illumination technology, integrating sensors and digital controls to enhance user experience and energy efficiency. These systems allow for customizable settings, such as maximum illumination levels and operational timings, tailored to user preferences and environmental conditions.

Smart lighting systems are designed to optimize energy usage, thereby minimizing wastage and reducing overall consumption (Chew *et al.,* 2017). This can be achieved through the utilization of energy-efficient lighting sources, such as LED lighting, compact fluorescent lamps (CFLs), and the implementation of advanced control mechanisms that enable the system to adapt to various factors in real-time. Furthermore, users can set parameters like light intensity and duration, preventing glare and darkness while improving convenience.

Smart lighting systems are typically integrated with a network, allowing for remote control and monitoring via a central hub or a connected device such as a smartphone. This connectivity also enables seamless integration with other smart light devices and systems, further enhancing the functionality and convenience of the lighting system. Additionally, advanced systems utilize position and brightness sensors to detect occupancy and external light levels, optimizing energy use by adjusting brightness accordingly (Zou *et al.,* 2018). Figure 2.5 shows a representation of a smart lighting system:

Figure 2.5 Smart lighting system (source: magikligjhts.com)

3. Critical Factors Influencing SBEs Adoption

According to Olushola (2019) factors affecting SBE adoption include; the intention to adopt and ten independent factors, which are technology readiness, compatibility, complexity, executive management support, firm size,

regulatory support, security concerns, cost savings, compatibility and relative advantage. The study of Sfakianaki (2019) on the other hand classified Critical Success Factors into five categories for the adoption and implementation of sustainable smart building concepts which includes environmental; economic; social; design and technique; policy and regulation factors.

Nevertheless, Owusu-Manu *et al.* (2022) stated the success factors influencing the decision to adopt Smart Building Technologies as Instrumentation and Control, Connectivity, Interoperability, Data Management and Analytics, Privacy and Security, IT Professional Support, Top Management Support, Viable Funding Strategy, Stakeholders' Computer Self-Efficacy, Stakeholders' Engagement and Participation and Participation and Collaboration. While Weerawardhana *et al.* (2024) distinctively identified the most essential elements impacting smart building adoption to be competency to utilize new technology, preference for smart building features, and user satisfaction. For the purpose of this study, the following factors influencing the adoption of Smart Building Elements were considered:

3.1 Environmental Factor

According to Amani and Rezasoroush (2021), one of the main reasons of environmental pollution is fuel consumption in commercial and residential buildings. Therefore, Khan *et al*. (2023) opined; the optimal control of building environmental variables such as temperature, humidity and light, have significant impacts on indoor environmental quality and building energy efficiency. And such control is usually depending on a variety of sensors to connect the built environment with lighting and heating, ventilation, and air-conditioning (HVAC) systems. Hence, it is important to reduce energy consumption in the built environment.

Additionally, Khan *et al*. (2023) further explained that the energy consumption in the built environment is directly connected to the occupant behaviour in the building. Therefore, knowing the fine-grained occupancy information in the building environment is an important parameter for efficient energy use. To understand the occupant behaviour pattern in the built environment, different kinds of sensors have been used (Xiong *et al*., 2015). The sensor information helps to analyze the occupant behaviour and presence patterns, and thermal and visual preferences, which facilitate the building automation system to create a better control of energy usage and indoor environment quality.

Guan *et al.* (2020) stated that human comfort is linked to occupants' health and work performance, which greatly depend on the indoor environment. Therefore, maintaining the optimal comfort zone and good thermal environment condition in buildings is critical to the built environment. Furthermore, the lighting condition in office buildings also contribute immensely to the occupant's productivity in accordance to the human physiology; daylight is more suitable for the better productivity of the occupant compared with artificial lights.

3.2 Technological Factor

Al Dakheel (2020) explained that in Smart Buildings, several technologies must be present in order to facilitate the application of smart features and considered the main key technologies related to the functions of Smart Buildings to include; control system, advanced HVAC and lighting system, renewable energy system, sensors and actuators, smart meters, and energy storage: **Energy Storage system** is identified as the technology that has the ability to capture energy (in batteries of several capacities) and release it subsequently for consumption; **HVAC systems** Smart Building HVAC systems adjust and adapt intuitively to the users' profile, preferences and needs, using real-time weather forecast and grid data; **Smart Lighting** is integrated with the BEMS system to allow information exchange, optimization, built-in occupancy sensors and logic systems to automatically adjust their luminance preference; **Sensors and actuators** are technological interfaces connected to features, functions, and technologies within smart buildings such as DSM, storage systems, real-time monitoring, and BEMS; **Smart Meter** is a technological interface connected to the BEMS that promotes communication between the smart grid and the smart buildings.

3.3 Economic Factors

Janhunen *et al.* (2020) discussed from a real estate market perspective the existence of multiple reasons to invest in smart technologies, including energy efficiency and lower operating costs with a predictable decrease in maintenance costs. In addition, to ascertain the impact of smartness on property value through savings in operating expenses and additional income (specifically in the context of energy storage systems and new cash flows from the reserve power markets), with a property case study, found that even a progressive smart building system investment was economically profitable, and the investment generated over 10% return-on-investment along with over EUR 10 million increase in property value. This value-influencing mechanism of a similar investment that enhances sustainability and decreases the operating expenses of properties was confirmed by surveyors in a study by Leskinen *et al.* (2020). Smart buildings have a positive impact on occupant comfort and well-being (Khan *et al*.,

2023) with features such as customized lighting, temperature control, and air quality monitoring, which invariably increase productivity of employees.

Paramount, implementing smart building technologies involves upfront costs that include; installation of sensors, control systems, and data analytics platforms. The study of Ejidike and Mewomo (2023) revealed the first most reported barriers undermining the adoption of smart building elements as the high cost of initial application, nevertheless, long-term financial implications must also be considered; reduced energy expenses and maintenance costs. By implementing energy efficiency measures such as occupancy sensors and smart thermostats technologies, there exists assurance of optimal energy consumption and reducing utility bills.

3.4 Social Factor

According to Khan *et al*. (2023) Social and behavioural factors play a significant role in indoor air quality, as they can influence safety, location choices, wellness programs, mental well-being, and human interaction. Building location decisions can consider factors such as proximity to pollution sources, access to green spaces and availability of clean outdoor air. Invariably, a healthy indoor environment facilitates positive human interaction, collaboration, and productivity, fostering a sense of community and satisfaction among occupants (Hafez *et al*., 2023).

It is essential to innovate new locally available systems that integrate cultural elements into the social dimension of sustainability (Sadrizadeh *et al*., 2022). Measuring and comparing indoor environmental quality against benchmark standards, alongside applying novel analytical techniques like option-based conjoint experiments, are essential steps. Models integrating renewable energy, optimized energy consumption, lighting optimization, construction waste management, storm-water quality control, heat-island effect on roofs, and outdoor and indoor air quality are valuable for reducing social impacts (Deng and Wu, 2014).

According to Ismail *et al.* (2023), the smart building concept in the real estate industry is essential for creating a sustainable building, contributing to building structures that meet people's social standards. Indrawati and Amani (2017) revealed that adopting the smart building concept in the Indonesian real estate industry plays an essential role in propelling the overall growth rate of urbanization compared to other non-conforming countries in South-Eastern Asia. According to Shurrab *et al.* (2019), social factors are essential in implementing social value that provides building and human shelter.

4. Effects of SBEs on Commercial real estate Investments

In the year 2021, the World Economic Forum convened a multi-stakeholder Taskforce on Digital Transformation to dissect some of the barriers preventing more widespread adoption of smart building solutions within the commercial real estate. One key finding was that technologies are often adopted without proper clarity on the business drivers and the metrics to measure return on investment. Incorporating smart building elements into real estate projects requires an initial investment, but the long-term benefits in terms of cost savings, efficiency, tenant satisfaction, and data-driven decision-making can significantly enhance Return on Investment (ROI) and make properties more competitive in the market (Froufe *et al.*, 2020). Smart building integration offers a number of key ways for real estate developers to maximize their ROI on building projects:

4.1 Energy efficiency and cost savings

Smart building elements improve energy efficiency and maximise energy savings over time of the building (Ismail *et al*., 2023). In the study conducted by Froufe *et al.* (2020), smart building elements ensure energy consumed within the building is controlled and monitored in real-time to improve the performance of the building and the environment friendly. Wang *et al.* (2020) evaluated occupants' comfort level using the adaptive model for six different control strategies, the result showed that the occupancy information-based control algorithm can save between 11% and 34% of energy without significantly risking the occupant's comfort level. Hence smart building elements have the potential for energy saving by reducing the unnecessary operation of the energy system in a building.

The integration of smart building elements into real estate projects offer a substantial advantage in terms of energy efficiency and cost savings. Smart buildings employ an array of sensors and automated systems that work in harmony to optimize energy consumption. For instance, advanced HVAC systems can adjust temperature settings based on real-time occupancy data, ensuring the rooms are heated or cooled only when needed. Similarly, intelligent lighting controls ensure that lights are turned off in unoccupied areas, mitigating energy wastage. Over time, the cumulative savings on energy bills contribute significantly to long-term return on investment (ROI) for real estate developers, making smart buildings a financially prudent choice.

4.2 Predictive maintenance

According to Minoli *et al.* (2017), among the areas building technologies would make considerable impacts is management. The role of a facility manager is often characterized as reactive, dealing with issues as they arise rather than proactively preventing them, which could be time consuming. However, the advent of smart building elements provides a potential revolution turning the facility management process into a proactive one. Smart buildings with their interconnected environments provide a holistic view of real-time operations across a facility. Through the use of sensors, data is continuously fed into a centralized control platform, providing a wealth of information that allows facilities managers to make informed decisions and focus their efforts on future planning. Furthermore, effective property management ensures that the value of buildings are enhanced and returns maximized, therefore property managers lookout for channels of enhancing the productivity of building assets by embracing modern technologies (Ogolla and Kieti, 2022).

Smart building elements use predictive analytics for resource consumption, operation safety, reduce the embodied and operational energy requirement and reduced operation cost (Baduge *et al.,* 2022). More so, the predictive planning made possible by smart buildings offers several significant advantages which includes unification of control of different types of technological equipment; remote control of technologies without physical presence on the device; the possibility of centralized interventions in the system in the event of a situation in the building or the needs of its users; storing information about actions taken by individual users; reducing the time and cost of monitoring the functionality of building technology.

One among the foreseeable benefits of the application of smart building elements is the ability to facilitate predictive maintenance. Sensors are used to collect the data from the building structure (such as elevators, HVAC systems, and plumbing), faults can be identified and suggestions of methods for rectification (Vaishnavi *et al.,* 2021). By collecting data on the performance of these systems, developers gain invaluable insights into the state of the structure and operational efficiency. This data-driven approach enables developers to schedule maintenance and repairs proactively, addressing potential issues before they escalate into costly breakdowns. By reducing the frequency of unexpected repairs and minimizing downtime, developers can allocate resources more efficiently and extend the lifespan of critical equipment. Consequently, the foresight offered by predictive maintenance is a pivotal factor in smart building ability to deliver sustained financial benefits to real estate developers in the long run.

4.3 Occupancy and space utilization

The concept of smart buildings is perceived to be the future of the real estate industry, in spite of the growing need for "smartization" it is still glaring that the performance of a building ultimately depends on its ability to satisfy the needs of those who use them (Hassanain *et al.,* 2024). This relates to the HVAC system because it is responsible for airflow and temperature; to the light system, because it regulates the positioning and intensity of the lighting points; to the telecommunications system, especially regarding the sources of information, entertainment, and internet access; to the vertical transportation system, by reducing efforts and increasing accessibility; and to the hydraulic system, mainly due to the degree of privacy of the facilities, type and convenience of the equipment, and the availability (Froufe *et al*., 2020).

Smart building elements have revolutionized the way real estate developers approach occupancy and space utilization. The systems continuously collect data on how spaces within a building are used, providing valuable information on tenant behaviour and preferences invariably; developers can strategically design layouts that maximize efficiency, optimizing the use of available space. This insight can lead to the creation of flexible co-working spaces or meeting rooms that align with tenant needs, ultimately attracting higher-paying tenants who value such amenities. Further, by tailoring the building layout and amenities to tenant preferences, developers can reduce vacancy rates and boost rental income resulting to bolstering the return on investment (ROI) for the property.

4.4 Enhanced security and safety

According to Apanavičienė and Shahrabani (2023), Smart buildings are gradually delving into the IoT applications which includes; physical security solutions, such as video surveillance, fire detection, disaster event communication, and smart security lights. Froufe *et al.* (2020) opined the health factor relates to the HVAC system, majoring on the quality of air, which invariably reduce the chances of contamination and maintain adequate temperature. Security and safety in smart buildings are paramount. Humans require complete safety and good health not minding the type of facility which could be a residential building or commercial building (Al-Betawi *et al*., 2020).

Access control systems and surveillance cameras are integral components of smart buildings, providing robust security measures. To *et al.* (2018) opined that the major factor to the desire to adopt smart building elements and increased effectiveness is the 'human element'; to achieve and satisfy occupants' comfort, safety, security, green environment, and community building. Tenants value a safe environment, and these features contribute significantly to their overall satisfaction. Inclusive in the smart security elements are mobile app-controlled access, smart locks, CCTV cameras and automated package delivery systems. These amenities improve the overall tenant

experience and increase the likelihood of tenant referrals and positive word-of-mouth recommendations. Hence, satisfied tenants are more likely to renew their leases; reducing turnover and vacancy rates which in turn positively affect return on investment.

The application of smart building elements are becoming invaluable sources for data, equipping real estate developers to make informed decisions. As technology advances, smart buildings are poised to play an even more pivotal role in shaping the landscape of real estate. This evolution is driven by a clear understanding of the ability of smart buildings to deliver tangible returns on investment (ROI) and enhance overall asset value. The demand for smart buildings is likely to surge as tenants and investors recognize their financial benefits and improved quality of life.

5. Potential Economic Impact of Smart Building Elements

Lagos state has been widely accepted as the economic hub of Nigeria, of particular significance is the absolute size of the economy. According to National Bureau of Statistics (2023), capital inflow into Lagos state as at the fourth quarter of 2023 constituted 65.38% of the total capital influx into Nigeria while Abuja (34.07%) and Rivers state (0.55%) followed. Lagos state also houses 70% of the country's total industrial investment and 65% of its commercial activities. This invariably means there exists in Lagos state, number of commercial properties higher than any other state within Nigeria to carry out these economic activities hence, the choice of the study area.

The study of Ngoc *et al.* (2023) investigated the factors that motivate investments in commercial real estate; findings show that cost drivers (payback period and anticipated financial returns) were the top two drivers. Nevertheless, according to the study of Rönkä (2019), smart building elements can enhance commercial real estate returns by increasing productivity, fostering innovation, and creating new income streams through demand response solutions, transforming buildings into active contributors to business success. Additionally, commercial properties can also produce gains streaming from rent and occupancy premiums, more attractive debt terms, higher occupancy rates, reduction in insurance costs, among others.

Smart building elements have the potential to advance the operation and maintenance processes (Marocco and Garofolo, 2021). Functionally, occupancy sensors utilize the ability to identify areas of high usage; enabling facilities managers to schedule preventive maintenance and avoid disruptive breakdowns. Similarly, current sensors can detect potential issues within machinery and supply cables, allowing for early intervention before a costly and time-consuming failure occurs. Invariably, proactive maintenance facilitated by data-driven insights, can extend the life of building elements resulting in cost savings and less environmental waste. And a well-maintained environment free from frequent breakdowns and disruptions, can significantly boost productivity and enhance occupant satisfaction.

The study of Bando-Hano (2018) opined, the adoption of smart building elements, offer a premium in rents (37%) and transaction prices (44%) in commercial real estate, while disintegrated solutions show smaller or no incremental value in the same neighbourhood and over the same time period of 2013 to 2017. According to Janhunen (2023) the economic benefits of smart building elements integration can be evaluated by using the property investment and property valuation perspectives. However, in Nigeria, the parameters to determining the economic impact of SBEs in commercial real estate in Lagos state have not been explored. Nevertheless, studies of Oyewole *et al.* (2019) and Alohan *et al.* (2023) considered the awareness and acceptance of the smart building concept, while the studies of Ejidike (2022) and Adebisi and Wahab (2023) focused on the adoption level of smart buildings, drawing data from construction professionals invariably gearing the studies toward the construction industry.

6. Findings

The study on Smart Building Elements (SBEs) and their influence on commercial property investment in Nigeria reveals several key findings:

Predictive Maintenance Benefits: Smart building technologies facilitate predictive maintenance through the use of sensors that monitor building systems like HVAC and elevators. This proactive approach helps identify faults early, reducing unexpected repairs and operational costs, ultimately extending the lifespan of critical equipment.

Enhanced Space Utilization: Continuous data collection on how spaces are used allows developers to optimize layouts based on tenant behavior and preferences. This leads to the creation of flexible spaces that can attract higher-paying tenants, enhancing overall property value.

Economic Viability: Investments in smart technologies are driven by the potential for lower operating costs and energy efficiency. Studies indicate that properties with smart systems can achieve significant returns on investment, with some cases reporting over 10% ROI and substantial increases in property value.

Tenant Satisfaction and Retention: The integration of smart security features, such as mobile app-controlled access and surveillance systems, significantly enhances tenant satisfaction. A secure and comfortable environment encourages lease renewals, reducing turnover and vacancy rates, which positively impacts return on investment.
Awareness and Adoption Trends: There is a growing awareness and gradual implementation of SBEs in Lagos, Nigeria, indicating a promising trend in the adoption of smart technologies in commercial properties. However, the overall adoption rate in Africa remains slow compared to developed regions.
Research Gaps: Despite the awareness of SBEs among stakeholders, there is a lack of empirical studies capturing the tangible economic impacts of these technologies. This highlights the need for comprehensive research to understand how SBEs affect investment outcomes in the commercial real estate market.
Future Implications: The demand for smart buildings is expected to increase as both tenants and investors recognize the financial benefits and improved quality of life that these technologies offer. This evolution is crucial for shaping the future landscape of real estate investment.
These findings underscore the transformative potential of smart building elements in enhancing operational efficiency, tenant satisfaction, and overall property value in the commercial real estate sector.

7. Conclusion

Despite the evident advancements, the adoption of smart building elements in Africa has been comparatively slow, this is evident in countries like South Africa (Kotzé, 2019), Kenya (Ogolla and Kieti, 2022), and Nigeria (Alohan *et al*., 2023; Ejidike, 2022; Oyewole *et al*., 2019). The study of Opawole *et al*. (2023) indicates a promising trend in Lagos, Nigeria, where there is an increased awareness and gradual implementation of smart building elements in commercial properties. These adaptations are primarily motivated by the potential for significant reductions in operational and energy costs, maximization of profits, and enhanced efficiency of building service appliances (Adebisi and Wahab, 2023). Smart integration may represent a pivotal breakthrough in Nigerian commercial real estate sector, signalling a paradigm shift towards more sustainable and economically viable practice.
The implications of these changes are profound, suggesting a critical need for comprehensive research to understand the specific impacts of smart building elements on the commercial real estate market in Nigeria. Holistic investigations should be made into the factors that influence the adoption of SBEs and the satisfaction level of stakeholders of commercial properties as to the effects of the SBEs on productivity, cost savings, energy efficiency, security and maintenance in the study area. Further, the returns on investments of commercial properties with and without SBEs integration should be assessed and compared to determine the dynamics of the investment returns in Lagos state, Nigeria.

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The Influence of Organizational Learning on the Performance of Small and Medium Sized Construction Enterprises in Nigeria

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Abstract

Small and Medius Sized Construction Enterprises (SMSCEs) play a pivotal role in transforming nations, generating up to 80% of jobs, export earnings, and industry capacity utilization. In Nigeria, the Construction SME sector has not been able to perform the expected vital role in bringing about economic growth and development of the country. This challenge is attributed to inadequate human resource development, insufficient educational resources, and limited awareness of optimal procurement practices. The study adopted a Quantitative approach via the use of a structured survey questionnaire. This study captures the opinion of construction stakeholders such as Clients, Contractors, and consultants. Out of 543 questionnaires distributed, 206 were duly filled by respondents and used for data analysis (representing 37.6%). SPSS as well as MS Excel were utilized for analysis of data, presented in charts, figures, and tables. The findings of this study indicate that Six out of the nine mediating factors of organizational learning were significant, based on a p-value less than 0.05. This implies that the significant mediating factors of organisational learning have a positive effect on the performance of construction SMES. These factors include "employee engagement, retention, and development" (MIS = 4.23, Kruskal-Wallis H value = 11.7 and Asymp. Sig. = 0.00); these are important impacts of organisational learning on the performance of construction SMES.

Key Words: Construction, Organizational Learning, Performance, SMEs

1. Introduction

Definitions of Small and Medium-sized Construction Enterprises (SMSCEs) vary across jurisdictions, with criteria including total employees, fixed assets, trade values, capital involved, and annual turnover (Ametepey *et al.,* 2022). For instance: In the UK, SMEs are defined as employing no more than 249 people according to Turner (2019). In Malaysia, SMEs have an annual turnover below 20 million ringgits ($5m USD) or fewer than 75 full-time employees (Nicholine & Soumonni, 2017). In South Africa, small enterprises typically have 20-50 employees, annual turnover of R3-6 million, and gross assets valued between R500,000 and R1 million, while medium enterprises have 51-200 employees, annual turnover of R1.1-5 million. Kale (2017) definition of SME adopts a classification based on dual criteria, employment and assets (excluding land and buildings) as shown in table 1 below.

Table 1: Classification of SME

S/no	Size category	Employment	Assets (₦ Million) excluding land and building)
1.	Micro enterprises	Less than 10	Less than 5
2.	Small Enterprises	10 to 49	5 to less than 50
3.	Medium Enterprises	50 to 199	50 to less than 500

Source: (Kale, 2017)

Kolawole *et al*. (2018) emphasize SMSCEs' pivotal role in transforming nations, generating up to 80% of jobs, export earnings, and industry capacity utilization. Turner (2019), opined that the role of SMEs in construction is more important than ever in supporting local communities. Robinson (2018), also stressed that support for the SMEs is therefore vital for both the economy, the future of the construction sector, and the local economies that they enrich. In South Africa, SMEs provide 91% of formal businesses, 51-57% of GDP, 60% of employment (Nicholine &

Soumonni, 2017). In Ghana, 70% of the GDP, 92% of all businesses are attributed to SMEs (Ametepey *et al*., 2022). In Malaysia, the SMEs has 90% of the construction industry size (Alashwal *et al.,* 2019). While in Nigeria, SMEs has 50% of employment, 30% of manufacturing output, and 97% of all businesses are SMEs (Nwokocha *et al.,* 2020).

Despite the valuable contributions of SMSCEs, they are fraught with numerous barriers that militate against their growth and survival. 80% of SMEs are not sustained beyond 5yrs because most SME owners lack the knowledge of sustainability strategies to enhance their businesses (Ajibola, 2020). According to Nicholine and Soumonni (2017), despite the noted contributions of SMEs, their failure rate in Africa is one of the highest in the world. About 70-80% of them fail within the first five years of existence.

In Nigeria, the SME sector has not been able to perform the expected vital role in bringing about economic growth and development of the country. According to Kolawole *et al.,* (2018), this challenge is due to the fact that SMEs are confronted with several drawbacks and challenges they have to overcome in order to operate successfully. Alashwal *et al.* (2019), also noted that SMEs are established within weak structures, systems and normal routine which cause difficulty in knowledge diffusion within the enterprise.

According to Ametepey *et al.,* (2022), the prevalence of SMSCES failures and stagnation can be attributed to inadequate human resource development, insufficient educational resources, and limited awareness of optimal procurement practices. Ivan (2019) stressed that this topic have been explored a number of times in large enterprises while there are, with a few exceptions mostly neglected in the case of small and medium-sized enterprises (SMEs). A careful inspection of existing literature revealed that the bulk of the empirical studies on organizational learning and firm performance are centered on large-scale enterprises in developed countries while the SME sector continues to be paid less attention when it comes to organizational learning (Ajibola, 2020).

It is evident that most of these past studies have not addressed the impact of organizational learning on construction SMEs performance in Nigeria. Ivan (2019), in a study on "Effect of Organizational learning on SMEs performance in Nigeria" only centered on five (5) SMEs sectors namely: Whole sale/Retail traders; Agriculture; Transport and Storage; Information and Communication and Education. While Alashwal *et al.* (2019), in their study on "Effect of inter-organizational learning on construction SMEs performance" was carried out in Malaysian construction industry.

Despite the importance of organizational learning in enhancing performance, there is limited empirical research on its mediating role in construction SMEs in Nigeria, thus, constituting a Gap this study intends to address. By addressing this gap, this study contributes to the understanding of organizational learning's role in enhancing construction SME performance in Nigeria with the following objectives;

1. To assess the Drivers of Organizational learning for construction SMEs in Nigeria.
2. To determine the effect of organizational learning on the performance of construction SMEs in Nigeria.

2. Literature Review

This literature review examines existing literature on the mediating role of Organizational learning on the performance of Construction SMEs. It synthesizes existing research on challenges faced by SMEs, mediating role of organizational learning, and best practices, identifying knowledge gaps and complexities to inform improved Construction SMEs performance in Nigeria.

2.1 Drivers of Organizational Learning for Construction Small and Medium Size Construction Enterprises

As noted by Alashwal *et al.* (2019), Small and Medium-sized Construction Enterprises (SMCEs) in Nigeria face numerous challenges that hinder their growth and sustainability. These challenges can be categorized into various aspects, including economic, regulatory, infrastructure, financial, and social factors (Tobora, 2014).

One of the main drivers of organizational learning, noted by Evenseth *et al.* (2022) is the dedication of leadership. When leaders emphasize and actively endorse learning efforts, it establishes the atmosphere for the entire organization. And Leaders who prioritize learning cultivate an environment where employees are motivated to pursue new knowledge and skills (Argote *et al.* 2000). Implementing efficient knowledge management systems can have a substantial influence on organizational learning. These systems aid in the acquisition, retention, and distribution of knowledge across the organization, ensuring easy accessibility for all employees (Dalkir, 2013). Through the utilization of technology to manage knowledge efficiently, organizations can promote learning at various levels. Investing in training and development initiatives is a crucial factor in fostering organizational learning. These programs offer employees the chance to gain new skills, improve current ones, and remain informed about industry developments. Developing strong feedback systems is crucial for encouraging organizational learning. Feedback enables employees to evaluate their work, pinpoint areas needing enhancement, and implement required changes. Positive feedback cultivates a culture of constant advancement and supports continuous learning (Edmondson and Lei, 2014).

2.2 Mediating Role of Organizational Learning on The Performance of Construction SMEs

In the context of construction SMEs, organizational learning plays a crucial role in enhancing their performance. Construction SMEs operate in a dynamic and highly competitive environment where they face numerous challenges such as changing customer demands, technological advancements, regulatory requirements, and resource constraints (Oluwadare, 2019). In order to survive and thrive in such an environment, construction SMEs need to continuously learn and adapt. The performance of construction SMEs is influenced by several factors, including project delivery time, cost control, quality of workmanship, customer satisfaction, and profitability (Alashwal *et al.,* 2019). Construction SMEs that actively promote organizational learning encourage employees to experiment with new ideas, technologies, and processes (Mu *et al.,* 2021). This can result in the development of innovative solutions to construction challenges, leading to improved project outcomes and increased competitiveness (Aina and Atan, 2020). This includes adopting new technologies, implementing efficient processes, and finding creative ways to deliver projects more effectively (Oluwadare, 2019).

Construction SMEs often face challenges related to knowledge retention due to factors such as employee turnover or retirement (Kokkaew *et al.,* 2022). Organizational learning processes, such as knowledge sharing and documentation, can help capture and retain valuable knowledge within the organization (Tran *et al.,* 2018). Construction SMEs operate in an industry that is constantly evolving. Organizational learning enables SMEs to adapt to changes in the external environment by continuously updating their knowledge base and adjusting their strategies and practices accordingly (Aina and Atan, 2020). Organizational learning fosters a culture of continuous improvement and employee development. Construction SMEs that prioritize learning provide opportunities for employees to acquire new skills, knowledge, and competencies (Oluwadare, 2019).

Organizational learning is closely linked to the performance of construction SMEs. By actively engaging in learning initiatives, these organizations can improve project management practices, enhance technical expertise, adapt to changing regulations, foster knowledge sharing and collaboration, drive innovation and continuous improvement, as well as increase employee engagement and retention (Ram and Vijayakumar, 2019). Embracing organizational learning can help construction SMEs navigate the challenges of the construction industry and achieve sustainable success (Swart *et al.,* 2022).

2.3 Gap in Literature

Organizational learning plays a vital role in ensuring the sustainability of Construction SMEs. However, research reveals significant gaps in Northern Nigeria's context. Current literature focuses on general survival strategies of SMEs in Nigeria (e.g. Aina and Atan, 2020) with litle consideration of how organizational learning can impact on the performance of Construction SMEs. This oversight results in inadequate exploration of the challenges faced by SMEs and solutions unique to Nigeria.

3. Methodology

Quantitative approach was employed for this study. The quantitative method was deemed appropriate for this study as it enabled the exploration of known variables and their relationships. In the context of this research, the target population for this study comprises professionals in the construction industry, including architects, quantity surveyors, builders, civil engineers, services engineers, and contractors operating in Sokoto and Kebbi State, Nigeria. To have a representative sample that was close to those of the population, upon which a general statement about the population was drawn, a simple random probability sampling was used for this study. This proves to be a good sampling frame for the study since the population is geographically concentrated within same geographical location, such that instead of pulling every head from a hat, a table of random numbers was used to obtain the samples as supported by Patel & Patel (2019). Questionnaires used for this study were developed and structured to be able to achieve the objectives of the study. Five hundred and forty-three (543) questionnaires were administered. Cochran formula was used to determine the sample size for this study due to limited information on the actual number of construction stakeholders as at the time of carrying out this survey.

$$n_o = \frac{Z^2pq}{e^2}$$

n_o = Sample size

Z = confidence level = 98% = 2.33 (from Z score table)

P = the (estimated) assumed proportion of the population which has the attribute in question = 50%

q = 1-p

e = is the desired level of precision (i.e., the margin of error) = 5%

therefore, $n_o = \frac{Z^2pq}{e^2} = \frac{2.33^2 \times 0.5 \times (1-0.5)}{0.05^2} = \frac{5.43 \times 0.25}{0.0025}$ $n_o = 543$

The data collected from the survey were subjected to descriptive statistical analysis, which involves the use of summary measures such as ANOVA, mean, percentages, and frequency to describe the basic characteristics of the data. This type of analysis provides a concise summary of the data, enabling the identification of trends and 7patterns (Creswell, 2014). The findings of the descriptive analysis were presented in a clear and organized manner using tables, which allowed for easy interpretation and comparison of the results. To facilitate the data analysis process, the numerical data were compiled and entered into the Statistical Package for Social Sciences (SPSS) software, version 20.0 (IBM, 2011). SPSS is a widely used statistical software package that offers advanced data management and analysis capabilities, making it an ideal tool for this research (Pallant, 2013).

4. Data Presentation and Analysis

Table 4.1 shows that 65.0% of respondents primarily engaged in consulting, while 25.7% were contractors, and 9.2% were clients. 58.3% of the respondents have 11 and above years of working experience, 29.6 % have 1–5 years of working experience, and 12.1% have 6–10 years of working experience. The respondents' academic qualifications indicated that 14.1% hold a Ph.D. degree, 29.6% hold an M.Sc. degree, and 56.3% hold a B.Sc. or HND degree. This indicate that the respondents possess sufficient education to provide valuable information for this study. Regarding the size of the respondents' firm or organisation, 44.2% have between 11 and 49 staff, 30.6% have between 1 and 10 staff, 13.6% have between 50 and 199 staff, and 11.7% have more than 199 staff. According to the National Bureau of Statistics (2017), the majority of the sampled firms can be classified as small enterprises based on their staff strength, which falls between 10 and 49.

Table 3: Demographics Characteristics of Respondents

Variables		**Frequency**	**Percentage (%)**
Nature of practice in the Construction Industry	Consulting	134	65.0
	Client	19	9.2
	Contractor	53	25.7
	Total	**206**	**100.0**
Years of work Experience	1-5 years	61	29.6
Profession	6-10 years	25	12.1
	11 and Above	120	58.3
	Total	**206**	**100.0**
Academic Qualification	Ph.D	29	14.1
	M.Sc.	61	29.6
	B.sc/HND	116	56.3
	Total	**206**	**100.0**
Size of organization with respect to number of staff?	1-10	63	30.6
	11-49	91	44.2
	50-199	28	13.6
	Above 199	24	11.7
	Total	**206**	**100.0**

Source: Author's Field Survey, 2024

4.1 Driving Factors of Organizational Learning for Construction SMEs in Nigeria

Table 3 displayed five (5) drivers of organizational learning for construction SMEs in Nigeria. Three out of the five drivers of organisational learning for construction SMES in Nigeria were significant based on their p-values less than 0.05. This implies that the implementation of drivers of organisational learning for construction SMEs in Nigeria has a significant impact on the performance of construction SMES. These range from "Feedback Mechanisms: Positive feedback cultivates a culture of constant advancement and supports continuous learning." (MIS = 4.87, Kruskal-Wallis H value = 0.02, and Asymp. Sig. = 0.98) to "Leadership Commitment: Leaders who prioritize learning cultivate an environment where employees are motivated to pursue new knowledge and skills." (MIS = 4.63, Kruskal-Wallis H value = 13.8, and Asymp. Sig. = 0.01). On average, all of the drivers of organizational learning for construction SMEs in Nigeria were important (average MIS = 4.78). This finding, which is in line with Oluwadare (2019) and Aina

& Atan (2020) confirms that the culture of continuous learning drives organisational learning and employee development. Construction SMEs that prioritise learning provide opportunities for employees to acquire new skills, knowledge, and competencies. This not only enhances employee engagement but also improves the overall capabilities of the organisation, leading to better performance. Construction SMEs that prioritise organisational learning tend to have higher levels of employee engagement and retention. When employees have opportunities for growth, development, and learning within the organisation, they are more likely to be motivated, satisfied, and committed to their work. This leads to increased productivity, better teamwork, and ultimately improved performance.

Table 4: Drivers of Organizational Learning

SN	**Drivers of Organizational Learning**	**MIS**	**Kruskal-Wallis H**	**Asymp. Sig.**	**Rank**	**Decision**
1	Feedback Mechanisms: Positive feedback cultivates a culture of constant advancement and supports continuous learning.	4.87	0.02	0.98	1st	Significant
2	Learning Culture: When employees perceive that their learning efforts are valued and supported, they are inclined to participate in ongoing learning activities	4.85	2.24	0.32	2nd	Significant
3	Knowledge Management Systems: Through the utilization of technology to manage knowledge efficiently, organizations can promote learning at various levels.	4.82	9.07	0.01	3rd	Significant
4	Training and Development Programs: programs offer employees the chance to gain new skills, improve current ones, and remain informed about industry developments	4.77	5.95	0.05	4th	Significant
5	Leadership Commitment: Leaders who prioritize learning cultivate an environment where employees are motivated to pursue new knowledge and skills.	4.63	13.8	0.01	5th	Significant
	Average MIS	***4.78***				***Most important***

Source: Author's Field Survey, 2024

4.2 Effects of Organizational Learning on the Performance of Construction SMES

Table 4 provides a summary of the MIS results for the impact of organizational learning on the performance of construction SMES. The Kruskal-Wallis H test was used to assess whether there are differences in central tendencies (medians) across multiple groups. The Kruskal-Wallis H test was used in this study to assess the differences in the nature of practice in the construction industry.

Table 5: Effect of Organizational Learning on the Performance of Construction SMES

SN	**Effect of Organizational Learning**	**MIS**	**Kruskal-Wallis H**	**Asymp. Sig.**	**Rank**	**Decision**
1	Employee engagement, retention, and development	4.23	11.7	0.00	1st	Important
2	Knowledge sharing, collaboration, and systematization of organizational data base	4.23	20.2	0.00	2nd	Important
3	Increased operational efficiency	4.17	9.54	0.00	3rd	Important
4	Enhance experimentation and reflection	4.13	3.30	0.19	4th	Important
5	Adaptability to change	4.10	3.93	0.14	5th	Important
6	Alternative learning and operation	4.03	17.3	0.00	6th	Important
7	Access to credit facilities	4.02	13.3	0.00	7th	Important
8	Enhanced innovation	3.99	8.17	0.01	8th	Important
9	Knowledge retention	3.94	0.43	0.81	9th	Important
	Average MIS	*4.09*				

Source: Author's Field Survey, 2024

Nine (9) effect of organizational learning on construction SMES performance were identified. Six out of the nine impacts were significant, based on a p-value less than 0.05. This implies that the significant mediating factors of organisational learning have a positive effect on the performance of construction SMES. These range from "employee engagement, retention, and development" (MIS = 4.23, Kruskal-Wallis H value = 11.7 and Asymp. Sig. = 0.00); "knowledge sharing, collaboration, and systematisation of organisational data base" (MIS = 4.23, Kruskal-Wallis H value = 20.2 and Asymp. Sig. = 0.00) to "knowledge retention" (MIS = 3.94, Kruskal-Wallis H value = 0.43 and Asymp. Sig. = 0.81). On average, all the identified impacts of organisational learning on the performance of construction SMES were important (average MIS = 4.09.). This finding, which is in line with Edmondson & Lei's (2014) research, confirms that developing strong feedback systems is crucial for encouraging organisational learning. Feedback enables employees to evaluate their work, pinpoint areas needing enhancement, and implement the required changes. Positive feedback cultivates a culture of constant advancement and supports continuous learning.

Table 6: ANOVA TEST

Model	df	Square mean	Mean Square	F	Significance F
Regression	2	2242.06	1121.03	4.183877	0.026
Residual	204	267.94	267.94		
Total	206	2510			

a. Dependent Variable: performance of construction SMES.

As shown in Table 4.6, the statistics indicated a P-value of 0.02, which is significantly less than the alpha value (0.05%). Because the p-value is less than the alpha value, it implies that organizational learning has a significant effect on the performance of construction SMES.

5. Summary of Findings

The study revealed that all the five drivers of organisational learning for construction SMES in Nigeria were significant based on their p-values less than 0.05. Feedback Mechanisms: Positive feedback cultivates a culture of constant advancement and supports continuous learning" is the most important drivers of organizational learning for construction SMES in Sokoto and Kebbi States (MIS = 4.87, Kruskal-Wallis H value = 0.02, and Asymp. Sig. = 0.98). Six out of the nine mediating factors of organizational learning that were identified were significant, based on a p-value less than 0.05. This implies that the significant mediating factors of organisational learning have a positive effect on the performance of construction SMES. These factors include "employee engagement, retention, and development" (MIS = 4.23, Kruskal-Wallis H value = 11.7 and Asymp. Sig. = 0.00); these are important impacts of organisational learning on the performance of construction SMES.

6. Conclusion

In Nigeria, the SME sector has not been able to perform the expected vital and vibrant role in bringing about economic growth and development in the country. In light of this, the study explored the influence of organisational learning on the performance of small and medium-sized construction enterprises, with the ultimate goal of enhancing the performance of these enterprises in Sokoto and Kebbi states. Based on the study's findings, it was concluded that organisational learning has a significant impact on the performance of small and medium-sized construction enterprises in Sokoto and Kebbi, Nigeria.

6.1 Recommendation

This study recommends the following;

1. Government agencies and industry association should provide training and resources to support construction SMEs in developing organisational learning capabilities
2. Regulatory bodies should encourage and incentivize construction SMEs to adopt best practices in organizational learning

6.2 Areas for Further Studies

The following areas for further studies were opened up by this study;

1. Further study can focus on conducting a comparative study on organisational learning practices across different regions and industries.

2. There is need to broaden this study by investigating the relationship between organisational learning and the financial performance of SMEs in Nigeria.

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Examination of the effectiveness of facilities management system in tertiary institutions: A case study of the Federal University of Technology, Minna, Nigeria

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Abstract

Facilities management is crucial in maintaining effective educational environments, particularly in tertiary institutions. This study evaluates the effectiveness of the Facilities Management system at the Federal University of Technology Minna, Nigeria, with a focus on identifying current practices and their impact on institutional performance. Utilizing a mixed-method approach, data were collected through questionnaires distributed to 110 Facilities management personnel, yielding a 60% response rate. The study assessed various Facility Management system, including reactive, reliability-centred, predictive, preventive, corrective, and proactive/planned systems. Results indicate a predominance of a reactive approach, with a mean score of 3.95, while proactive and planned approaches scored the lowest. The findings reveal that, despite a well-qualified and experienced Facilities Management staff, the institution's facilities management remains largely reactive and underutilizes proactive system. This study underscores the need for Nigerian tertiary institutions, including Federal University of Technology Minna, to adopt more proactive and strategic Facilities Management practices to enhance the effectiveness and sustainability of their facilities management systems. The implications of these findings suggest that addressing challenges such as inadequate funding and outdated infrastructure is essential for improving Facilities Management practices in Nigerian educational institutions.

Keywords: Facility management, facility management system, reactive and proactive approach, tertiary institution

1. Introduction

Facilities management which includes the organization, running, and upkeep of tangible assets, is a vital role in educational institutions (Miles, 2023). A favourable atmosphere for research, teaching, and learning is guaranteed by effective Facilities Management. In addition to serving as educational citadels, tertiary institutions enable countries to easily integrate into the emerging global knowledge system in any setting where efficient facilities management techniques are in place (Marmolejo, 2021). Poor facilities will seriously jeopardize the fulfilment of this goal, as Price (2013) said, as the learning environment is a crucial component in determining effective teaching and learning. Sustainable infrastructure management in Nigerian tertiary institutions, such as the Federal University of Technology Minna, depends on an awareness of the efficacy of Facilities Management systems.

Managing support services is Facilities management main responsibility in order to provide for the organization's fundamental operations, staff, and basic necessities (Chitopanich, 2014). According to udechukwu, (2022) a well-organized facilities management system can enhance a building's external look and functionality as well as increase end-user satisfaction and boost the effectiveness of building facility maintenance and operation. Even with Facilities management's significance, effective facility management still faces difficulties. These difficulties include a lack of finance, antiquated infrastructure, and a slow uptake of contemporary technologies. In this study, we specifically examine the issue of how successful federal university of technology Minna's facilities management system is with a particular emphasis on the Federal University of Technology Minna.

Anifowose and Lawal (2013) investigated the condition of physical infrastructures in Nigerian postsecondary institutions. The study evaluated the effectiveness of facilities managers, the accessibility of physical facilities, and the effect of maintenance expenses on the condition of physical structures. The results showed that the physical facilities were insufficient, and that the state of the structures was greatly impacted by the expense of upkeep. The characteristics of facilities management procedures in Nigerian public tertiary institutions were investigated by Gidanmana (2020). The report emphasized the difficulties, including limited technological proficiency, shoddy

policy execution, and insufficient finance. In order to raise the standard of instruction and learning, it was advised to outsource technical knowledge and take a proactive approach to facilities management.

Ogbeifun (2011) used the University of the Witwatersrand as a case study to examine facilities management in a multi-campus environment. The facilities management unit's performance evaluation, service procurement, and organizational structure were the main topics of the study. The research emphasized the significance of capacity building and strategic planning in augmenting the efficacy of facilities management. Therefore, this study draws insights from other Nigerian tertiary institutions to provide a broader context. This study aims to assess the nature of facilities management system and the effectiveness of facilities management system at the Federal University of Technology Minna, Niger state.

2. Literature review

The International Facility Management Association (IFMA) and the British Institute of Facility Management (BIFM) two of the top Facilities Management organizations in the world, have both published definitions of Facilities Management. According to BIFM (2010) Facilities Management is the integration of organizational processes to sustain and grow the agreed-upon services that support and enhance the efficacy of the organization's core activities. IFMA (2012) defines Facilities Management as the process of integrating an organization's work and personnel with its physical workspace, incorporating behavioral and engineering services, architecture, and business administration principles.

The value of facilities management to an organization has recently gained recognition among academics and practitioners (Heng *et al*., 2005; Alexander and Price, 2012). This is because, in addition to saving operating costs and optimizing usable space, Facilities Management supports and enhances both non-core and core business activities within an organization, necessitating strong support and approval from upper management (Tranfield and Akhlagi, 1995; Noor and Pitt, 2009; Barrett and Finch, 2014). Facilities Management thus acts as a means by which an organization provides and maintains its buildings, systems, and support facilities to meet strategic requirements in a supportive environment.

Although there is a dearth of research on the application of facilities management in higher education, Asiabaka (2008) in his study of the effects of Facilities Management in Nigerian schools, emphasized the significance of effective Facilities Management. He noted that effective Facilities Management involves the provision, maximum use, and optimal oversight of facilities, which is central to achieving the objectives of education due to the vital role they play in fulfilling educational aims and objectives.

Ogbeifun (2011) further explored Facilities Management in a multi-campus setting using the University of the Witwatersrand as a case study. The study focused on the facilities management unit's organizational structure, service procurement, and performance assessment. It highlighted the significance of capacity building and strategic planning in enhancing the effectiveness of facilities management. The study concluded that implementing FM strategies could significantly impact a school's overall performance, but for FM to be successful, there must be direct communication between the academic and Facilities Management departments.

These studies collectively highlight the critical role of facilities management in educational institutions. Effective Facilities Management ensures the provision, maintenance, and optimal use of physical resources, which in turn supports the core educational activities. Despite the recognized importance, challenges such as inadequate funding, outdated infrastructure, and slow adoption of modern technologies persist, particularly in Nigerian tertiary institutions. This review sets the stage for a detailed examination of the effectiveness of the Facilities Management system at the Federal University of Technology Minna, aiming to identify specific challenges and propose solutions for improvement.

3. Research Methodology

The establishment of the Federal University of Technology, Minna took place on the 1st of February in the year 1983. This institution stands as one of the specialized technological universities in Nigeria, with a primary objective of promoting self-sufficiency in the fields of science, engineering, and technology. Its inception was driven by the need to bolster Nigeria's pursuit of progress in technology and creativity. Federal university of technology Minna functions across two principal sites: Bosso and Gidan Kwano. The Bosso campus accommodates a limited number of departments and administrative facilities, while the Gidan Kwano campus sprawls across 10,650 hectares, housing essential amenities like sports facilities, staff residences, academic buildings, administrative offices, faculty areas, classrooms, a research centre, and a library.

The methodology employed for data collection involved the distribution of questionnaires to personnel responsible for Facilities Management (FM) within these academic institutions. The survey targeted individuals occupying roles in departments or units associated with Facilities Management duties, such as quantity surveyors, architects, engineers, builders, estate surveyors, valuers, among others. Their daily tasks involve engagement in the works and

maintenance department, physical planning and development department/unit, and power section. A random sampling approach was utilized to determine the sample size required to gather feedback from respondents regarding the research inquiries. A total of 110 questionnaires were dispersed, out of which 66 were retrieved, resulting in a response rate of 60%, deemed sufficient for subsequent data analysis. The adequacy of the data collected was supported by the prompt and comprehensive responses provided by the participants, facilitating the swift return of the questionnaires for analysis purposes. Questionnaire was developed from the literature reviewed; broken in two sections accompanied by a covering letter introducing the focus of research and instructions to be followed by the respondents.

4. Discussion of findings

The first section contained demographic information about the respondents. Table 1 presents the demographic data of participants, who are employees at the federal university of technology in Minna, Nigeria. The data provided includes their job positions, academic qualifications, and years of experience within the university.

Table 1 illustrates that 40.9% of the participants work as technical officers, while 31.8% hold managerial positions in facilities. This indicates a higher number of technical staff compared to managerial staff in the institution. Moreover, within the managerial group, 21.2% are principal FM officers, 36.4% are senior facilities managers, and 30.3% are facilities officers. Among the technical officers, 16.7% are chief technical officers, 18.2% are assistant chief technical officers, 22.7% are principal technical officers, and 39.4% are senior technical officers. This suggests a greater presence of experienced technical staff in facilities management at the university.

Table 1 also explores the job titles of the participants, revealing that 33.3% are engineers, 15.2% are architects, 12.1% are estate surveyors and valuers, 10.6% are Quantity surveyors, and 6.1% are builders. Additionally, 22.7% have other professional roles within the maintenance and works departments at federal university of technology Minna. The table further discloses the participants' highest educational attainments, with 12.1% holding Masters of Technology, 36.4% having Bachelor of Science/Technology degrees, 39.4% possessing Higher National Diploma/Post Graduate Diploma qualifications, and 12.1% holding National Diploma certificates. The academic background of the participants indicates the reliability of their data for research purposes.

Finally, the study examines the work experience of the participants, revealing that 12.1% have over 30 years of field experience, while 30.3%, 42.4%, and 15.2% have work experiences ranging from 20 to 30 years, 10 to 20 years, and 10 years, respectively.

Table 1. Demographic information of respondents

Demographic information	Respondent	Frequency	Percentage %
Functional category			
	Facilities Managerial officer	21	31.8
	Technical officer	27	40.9
	Users	18	27.3
	Total	66	100.00
Position of FM officer			
	Chief FM officer	2	3.0
	Assistant FM officer	6	9.1
	Principal FM officer	14	21.2
	Senior FM officer	24	36.4
	FM officer	20	30.3
	Total	66	100.00
Position of Tech officer			
	Chief Tech officer	11	16.7
	Assistant Tech officer	12	18.2
	Principal Tech officer	15	22.7
	Senior Tech officer	26	39.4
	Facilities Tech officer	2	3.0
	Total	66	100.0
Appellation of FM/Tech officer			
	Engineer	22	33.3
	Architect	10	15.2
	Estate surveyor and valuer	8	12.1

	Quantity surveyor	7	10.6
	Builder	4	6.1
	Other professionals	15	22.7
	Total	66	100.00
Academic Qualification of FM/Tech officer			
	Msc	8	12.1
	Bsc	24	36.4
	HND/PGD	26	39.4
	National Diploma	8	12.1
	Total	66	100.0
Years of work experience of FM/Tech officer			
	Above 30years	8	12.1
	20-30years	20	30.3
	10-20years	28	42.4
	Below 10years	10	15.2
	Total	66	100.0

Source: Field survey 2024

The facilities management system implemented at the Federal University of Technology has been evaluated over time. According to the results presented in Table II, the Facilities Management system at Federal University of Technology Minna was found to prioritize a 'reactive' approach, with a mean score of 3.95. Following closely was the 'reliability-centered' system, scoring 3.80 on average, while the 'predictive' and 'preventive' systems ranked third and fourth with mean scores of 3.42 and 3.39, respectively. Both the 'corrective' and 'proactive/planned' methods scored lower, with mean scores of 3.27 and 3.23. Regrettably, the longstanding FM system at Federal University of Technology Minna lacks a proactive or result-oriented nature. Similar to many other tertiary institutions in the country, actions are typically taken only after facilities have malfunctioned. This observation is underpinned by the dominance of the 'Reactive' approach, as indicated in Table II. This outcome contradicts the notion put forward by Price and Pitt (2011) that organizations have shifted from traditional to more proactive facilities management systems. This deficiency aligns with Lavy's (2008) assertion that businesses and institutions have yet to fully leverage facility management for enhanced performance and success. Despite the potential benefits of a proactive Facilities Management system, the Federal University of Technology Minna has not embraced this innovative facet of facilities management.

Table 11. Effectiveness of facilities management system in the study area

FM system	Mean score	SD	F	Significance	Ranking
Reactive	3.95	2.345667	5.704	0.001	1
Reliability centred	3.80	2.21117	5.601	0.002	2
Predictive	3.42	1.87759	4.738	0.004	3
Preventive	3.39	2.35486	3.760	0.0014	4
Corrective	3.27	1.98736	6.893	0.003	5
Proactive/planned	3.23	1.89768	2.609	0.012	6

Source: Field survey 2024

5. Conclusion and Recommendations

The exploration of facilities management system at Federal University of Technology Minna reveals that there is a higher proportion of technical staff compared to managerial staff in possession of the necessary skills, knowledge, and experience in the field of facilities management. It was observed that the individuals responsible for facilities management at the institution possess suitable academic qualifications. A majority of these technical and managerial staff members have accumulated more than a decade of work experience. The predominant facilities management approach at Federal University of Technology Minna was found to be 'Reactive', regardless of the age of the facility. Regrettably, the proactive facilities management strategy, which is more outcome-focused, is underutilized at the institution.

Drawing upon the findings from existing literature, this study posits that the facilities management system at Federal University of Technology Minna remains rudimentary, lacking in proactive and preventative measures as deemed necessary. Maintenance efforts are predominantly reactive, initiated only after facilities have malfunctioned

and require repairs. Tertiary institutions' facilities management systems encounter significant obstacles such as insufficient funding and inadequate policy enforcement by the governing bodies. Overall, the approach to facilities management in tertiary institutions tends to be haphazard.

Based on the findings, it recommends Federal University of Technology Minna should adopt a proactive and preventive measures deemed necessary. Maintenance efforts should be fixed on schedule base not predominantly reactive. Adequate funding should be allocated to proactive maintenance in order to curb breakdown of facilities before action is taken.

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Assessment Of Maintenance Management Practice for Office Buildings In Public Universities In Kebbi State

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Abstract

Maintenance management is the planning and control of construction resources to ensure necessary repairs and renewal are carried out with maximum efficiency and economy. This seems to be lacking in the Nigerian tertiary institutions because studies have established that office buildings in public tertiary institutions are in very poor and deplorable conditions of structural and decorative disrepairs. Meanwhile, substantial and quality education should take place in a conducive environment which will create an outstanding performance in the institution. Office buildings in the tertiary institution has an impact on the users in discharging their duties. Therefore, this study assessed the maintenance management practice of office buildings in public universities in Kebbi State, with a view to improving the overall institutional buildings maintenance culture. The study adopted the quantitative research approach using survey research design. Data were collected using questionnaire and condition survey from academic and non-academic staff within the public universities in Kebbi State. Analysis of data was undertaken with use of descriptive statistics such as such as Relative Importance Index and condition survey. Findings from the study revealed fourteen (14) major existing maintenance practices in office buildings within public universities in Kebbi State, among which are "Implementation of planned maintenance", "Implementation of preventive maintenance", and "Implementation of corrective maintenance". The study also identified eleven (11) challenges facing the maintenance management Practice of office buildings in public universities in Kebbi State among which are "Inadequate appreciation of condition of use", "Inadequate assessment of exposure", and "Poor maintenance funds". The study proposed effective strategies for enhancing the maintenance management of office buildings in public universities in Kebbi State, among which are "Buildings provided should be maintained properly to meet the prescribed standards" and "Use of integrated maintenance practices via a modular framework". The study therefore concludes that maintenance management practice for office buildings in public universities in Kebbi State is ineffective. Hence, there is a need for the management of the public universities in Kebbi State to develop an integrated digitalised framework to improve their maintenance practices.

Keywords: Maintenance management; Maintenance practice; Office buildings, public universities, Tertiary institutions.

1. Introduction

Globally, the maintenance management practice of buildings within educational institutions is recognized as a critical component of sustainable infrastructure development, hence, public universities around the world face similar challenges related to aging infrastructure, limited funding, and evolving maintenance needs (Gallo *et al.,* 2021). Buildings of Tertiary Institutions are any nation's asset. So therefore, university buildings are bound to become obsolete, but when the rate of building deterioration outstrips the rate of maintenance, then the components and fabrics of the buildings will fail and the buildings will not perform optimally any more (Roseline and Ebiwari, 2022; Ogunbayo *et al*., 2022).however, the issue of maintenances management practices should be addressed at all levels of the educational system in Nigeria, so that society at large can model after and benefit from, therefore, lack of an effective and efficient maintenance management practice at this level could have a negative effect on infrastructural maintenance operations in society at large(Lucky *et al.,* 2023). Maintenance is described as a set of a task carried out to maintain the structure and amenities of buildings to ensure it function as expected during its life cycle. Maintenance is defined as the amount of all specialized and managerial operations aimed at restoring or maintaining an element to its right position in other to function effectively, Maintenance management also is concerned about the condition of the structures and administrations to guarantee the necessary prerequisites for proper operation, (Innocent and Babajide., 2023). Meanwhile, the state of utilities and infrastructure within an academic institution plays a vital role in learning and the development of human capital. Hence, Universities need functional buildings and facilities to operate, and the buildings must achieve high functional performance standards (Lucky *et al.,* 2023) . Functional buildings in this context refer to the extent to which buildings allow users (i.e., both

students and staff alike) to carry out their intended functions (Odediran *et al*., 2012). However, budgetary constraints and competing priorities often limit the resources available for maintenance activities, leading to deferred maintenance and deterioration of university facilities (Nisar *et al.,* 2023). Despite these challenges, national initiatives such as the Tertiary Education Trust Fund (TETFund) and Public-Private Partnerships (PPP) offer opportunities for universities to access funding and expertise for infrastructure development and maintenance. Collaborative efforts between government agencies, academic institutions, and industry stakeholders are essential for addressing systemic issues and promoting sustainable maintenance practices nationwide (Nwokolo *et al.,*2023).

2. Literature Review

2.1 Concept of Maintenance Management

The concept of Maintenance Management practice is a set of interconnect processes that coordinated strategies adopted by an organization to ensure that their buildings continue to perform optimally without experiencing any form of downtime or degeneration due to defects (Ikenna *et al* 2022). In line with the contribution made by Shehu *et al.,* (2020) Maintenance management is the planning and control of construction resources to ensure necessary repairs and renewal are carried out with maximum efficiency and economy. This seems to be lacking in the Nigerian tertiary institutions because studies have established that office buildings in public tertiary institutions are in very poor and deplorable conditions of structural and decorative disrepairs. Meanwhile, substantial and quality education should take place in a conducive environment which will create an outstanding performance in the institution. Office buildings in the tertiary institution has an impact on the users in discharging their duties.Similarly, every academic institution must have school maintenance program which is a set of organizational processes undertaken to extend the lifespan of the educational buildings with its services (Tijanić *et al*, 2022).the purpose is to determine the optimal different maintenance methods by selecting the best maintenance approach for each structure component, by so doing, it increases the building life cycle and improves its longevity as well as ensures users safety, (Innocent and Babajide, 2023).Furthermore, the absence of standardized procedures and guidelines for maintenance activities leads to inconsistencies in maintenance practices across different university departments and campuses (Guarino *et al.,* 2023). The lack guideline at such may not only affects the quality and timeliness of maintenance work but also complicates resource allocation and decision-making processes (Ensafi *et al.*, 2023). Additionally, varying levels of expertise among maintenance staff further compound these challenges, as the effectiveness of maintenance efforts may be contingent upon individual skillsets and knowledge gaps. hence, It can be deduced from the literature that Nigerian universities generally have maintenance departments that care for their school facilities; however, studies clearly showed that gaps exist with negligence of building facilities which reflect a lack of definitive evidence of operations strategies, policy plan and qualified personnel to be able to keep buildings functional and well maintained (Olusegun and Guyimu 2015).

2.2 Existing Maintenance Practices in Office Buildings Within Public Universities in Nigeria

Maintenance management is concerned about the condition of the structures and administrations to guarantee the necessary prerequisites for proper operation (Zulkarnain, 2011). In other words, maintenance management's goal is to determine the optimal mix of building maintenance methods by selecting the best maintenance approach for each structure component (Innocent and Babajide, 2023). According to Adenuga *et al*. (2007), maintainability of building is one of the main areas in which the construction industry attains significant improvement. Omar *et al*. (2016) opined that maintenance of buildings is an important process in retaining the quality and value of building. The approach of maintenance management utilized should be checked on a regular basis to ensure high-quality facilities (Zulkarnain, 2011) and lack of effective maintenance management affects the financial performance of a building (Sinha, 2015). Hence, maintenance management is essential for building structures and construction business. The International Organization for Standardization of Building identified the following measures to help enhance maintenance management practices: (i) having maintenance personnel that is well-trained and experienced is important; (ii) having maintenance systems that provide requirements and response times; (iii) taking note of all site information, maintenance dates, service agreements, buildings, redecorating, technical services, and expenses; and (iv) using the most effective strategies for disseminating knowledge to aid in the reduction of costs and deficiencies that resulted from them (Fakhrudin *et al*., 2011) . Successful maintenance activities result in meeting and fulfilling the needs of building users as well as maintaining all building services. All maintenance work should be performed by the maintenance department, and all user reports should be taken seriously. Despite the importance of maintenance, buildings still suffer maintenance problems in the country. In Nigeria, according to Adenuga *et al*., (2007), public buildings including university buildings are in very terrible conditions. Besides, maintenance of university buildings is vital if sustainable and quality education is to be

delivered (Aghimien *et al.,* 2019; Olanrewaju, 2010)). However, previous studies have found a clear link between educational building performance and educational quality (Lateef *et al*., 2010).

2.3 Challenges Facing the Maintenance Management practice of Office Buildings in Public Universities in Nigeria

Public institutions have always been faced with ineffective maintenance of buildings due to bureaucratic constraints and poor maintenance culture denying that buildings are the most significant resource of tertiary institutions apart from the faculty members which offer much value to the general administration of the institutions, students, members of staff, parents and other users and stakeholders. Buildings may deteriorate and decay if maintenance strategy is not employ, because every building has a life span. The process of deterioration in both the physical and functional conditions of a building is complex, and is indicated by wears, tears and aging due to usage, degradation of equipment and construction material due to the environment, and the interaction of these mechanisms. However, in order to create conducive environment that supports and stimulates innovative research, teaching and learning, tertiary institution buildings require maintenance. In the same line of thought, Christian *et al.* (2021) asserted that the maintenance levels of these buildings are very crucial to educational effectiveness. Despite these challenges, national initiatives such as the Tertiary Education Trust Fund (TETFund) and Public-Private Partnerships (PPP) offer opportunities for universities to access funding and expertise for infrastructure development and maintenance. Collaborative efforts between government agencies, academic institutions, and industry stakeholders are essential for addressing systemic issues and promoting sustainable maintenance practices nationwide (Nwokolo *et al.,* 2023). Building maintenance management ensures that building facilities retain their structural, functional and aesthetic conditions throughout their lifespan and reduce unnecessary expenditures. It is evident that in Nigeria both public and private sector buildings face neglect due to lack of maintenance and as a result they are subjected to rapid deterioration. The study revealed lack of preventive maintenance for public residential buildings and this presents threats to the functional, structural and aesthetic conditions of such buildings. Users of the surveyed residential buildings perceived that faulty workmanship, design resolution that suits users' needs and the use of cheap and substandard materials also contribute to the maintenance problems. Another factor found to have a significant influence on the maintenance of residential buildings is the lack of fund for the maintenance of buildings (Baba and Vanduhe, 2013).

3. Methodology

The research methodology provides an approach into investigating the Existing Maintenance Practices in Office Buildings Within Public Universities in Kebbi State and Challenges Facing the Maintenance Management practice of Office Buildings in Public Universities in Kebbi State In achieving this research, the data collection instrument for this study will be questionnaire and condition survey. A well-structured questionnaire will be designed, and the data collected from the survey will be analysed using descriptive statistics. Descriptive statistics such as: frequencies, percentages, condition survey and Relative Importance Index (RII). Frequencies and percentages will be used to analyse the profile of respondents. In order to achieve the first objective of the study, RII will be used to rank the opinion of respondents on the existing maintenance practices in office buildings within public universities in Kebbi State. Secondly, to achieve the second objective of the study, RII will be used to rank the challenges facing the maintenance management practice of office buildings in these institutions. The analysis will be conducted with the aid of the Statistical Packages for the Social Sciences (SPSS version 23.0) software. RII is being ranked from 0.00 to 1.00 and the formula for calculating RII for data analysis is expressed in equation 3.1, while Table 1 gives the decision rule adopted for interpreting RII results. The decision rule for interpreting the outcome of the condition survey is presented in Table 1, the decision rule for interpreting the outcome of the post occupancy evaluation.

$$RII = \frac{\Sigma W}{A\ X\ N} \text{---------- (eq.1)}$$

Where: Σ = Summation, W = the weights of every one of the factors given by respondents and it was in the range of (1 - 5), (A=5) the largest value of weight (i.e., Highest factor) and finally N refers to the Total of number respondents.

Table.1: Decision Rule for Data Analysis

Scale	RII Cut-Off Point	Interpretation			
		Level of Importance	***Level of Severity***	***Level of Significance***	***Level of Effectiveness***
5	0.81 - 1.00	Extremely Important	Extremely Severe	Extremely Significant	Extremely Effective
4	0.61 - 0.80	Very Important	Very Severe	Very Significant	Very Effective

3	0.41 - 0.60	Important	Severe	Significant	Effective
2	0.21 - 0.40	Less Important	Less Severe	Less Significant	Less Effective
1	0.00 - 0.20	Least Important	Least Severe	Least Significant	Least Effective

Chapter 2 Source: Adapted and Modified from Shittu *et al*. (2022)

3.1 Data Analysis and Discussion of Results

Existing Maintenance Practices in Office Buildings Within Public Universities in Nigeria

Table 2 highlights the results of the MIS survey, which ranked respondents' opinions on the current maintenance practices in office buildings within public universities in Nigeria. Table 2 highlights that the most important existing maintenance practices in office buildings within public universities in Nigeria are "having maintenance systems that provide requirements and response times" (MIS = 4.30) and "implementation of predictable maintenance" (MIS = 4.30). The least important existing maintenance practices in office buildings within public universities in Nigeria are "Implementation of unplanned maintenance" (MIS = 3.87) and "Implementation of repair" (MIS = 3.85). In addition, it was shown that the existing maintenance practices that were important ranged from "having maintenance systems that provide requirements and response times" to "implementation of repair" (MIS = 4.30–3.85). On average, all of Nigeria's existing maintenance practices in office buildings within public universities were very important (MIS = 4.08).

Table 1: Existing Maintenance Practices in Office Buildings Within Public Universities in Nigeria

Code No.	Existing Maintenance Practices in Office Buildings Within Public Universities in Nigeria	MIS	Rank	Interpretation
1	Having maintenance systems that provide requirements and response times	4.30	1st	Very Important
2	Implementation of predictable maintenance	4.30	1st	Very Important
3	Implementation of avoidable maintenance	4.23	3rd	Very Important
4	Implementation of planned maintenance	4.18	4th	Very Important
5	Using the most effective strategies for disseminating knowledge to aid in the reduction of costs and deficiencies that resulted from them	4.18	4th	Very Important
6	Taking note of all site information, maintenance dates, service agreements, buildings, redecorating, technical services, and expenses	4.15	6th	Very Important
7	Having maintenance personnel that is well-trained and experienced is important	4.12	7th	Very Important
8	Implementation of preventive maintenance	4.11	8th	Very Important
9	Implementation of condition-based maintenance	4.04	9th	Very Important
10	Implementation of corrective maintenance	4.04	9th	Very Important
11	Implementation of scheduled maintenance	3.96	11th	Very Important
12	Implementation of emergency maintenance	3.89	12th	Very Important
13	Implementation of unplanned maintenance	3.87	13th	Very Important
14	Implementation of repair	3.85	14th	Very Important
	Average MIS	***4.08***		***Very Important***

3.2 Challenges Facing the Maintenance Management Practice of Office Buildings in Public Universities in Nigeria

Table 3 summarises the MIS results of respondents' ratings of the challenges facing the maintenance management practice of office buildings in public universities in Nigeria. The results summarised in Table 3 indicate that the extremely severe challenges facing the maintenance management practice of office buildings in public universities in Nigeria were "In Nigeria, both public and private sector buildings face neglect due to a lack of maintenance, and as a result, they are subjected to rapid deterioration (MIS = 4.73)" and "unsuitable materials" (MIS = 4.58). The least severe challenges facing the maintenance management practice of office buildings in public universities were "inadequate assessment of exposure and use of cheap and substandard materials" (MIS = 4.4.3 and 4.43, respectively) and "poor maintenance funds" (MIS = 4.42). Furthermore, the study revealed that the extreme challenges facing the maintenance management practice of office buildings in public universities in Nigeria, ranged from both public and private sector buildings face neglect due to a lack of maintenance, and as a result, they are subject to rapid deterioration" to "faulty workmanship" (MIS = 4.73–4.59), while the very severe challenges ranged

from "inadequate appreciation of condition of use" to "poor maintenance funds" (MIS = 4.48–4.42). On average, all of the challenges facing the maintenance management system of office buildings in Nigeria's public universities were extremely severe (MIS = 4.50).

Table 3: Challenges Facing the Maintenance Management Practice of Office Buildings in Public Universities in Nigeria

Code No.	Challenges Facing the Maintenance Management System of Office Buildings in Public Universities in Nigeria	MIS	Rank	Interpretation
1	In Nigeria, both public and private sector buildings face neglect due to lack of maintenance and as a result they are subjected to rapid deterioration	4.73	1st	Extremely Severe
2	Unsuitable materials	4.65	2nd	Extremely Severe
3	Faulty workmanship	4.59	3rd	Extremely Severe
4	Inadequate appreciation of condition of use	4.48	4th	Very Severe
5	Unrelated design decisions	4.48	4th	Very Severe
6	Incorrect assessment of loads	4.48	4th	Very Severe
7	Age of building	4.46	7th	Very Severe
8	Lack of preventive maintenance for public residential buildings which presents threats to the functional, structural and aesthetic conditions of such buildings	4.44	8th	Very Severe
9	Inadequate assessment of exposure	4.43	9th	Very Severe
10	The use of cheap and substandard materials	4.43	9th	Very Severe
11	Poor maintenance funds	4.42	11th	Very Severe
	Average MIS	***4.50***		Extremely Severe

4. Conclusion

This study assessed the maintenance management practices of office buildings in public universities in Kebbi State with a view to improving the overall institutional building maintenance culture. The study determined that the most crucial maintenance practices currently in place in office buildings within public universities in Nigeria include "having maintenance systems that provide requirements and response times, and implementing predictable maintenance." The study also highlighted the severe challenges that the maintenance management practice of office buildings in public universities in Nigeria faces: "In Nigeria, both public and private sector buildings face neglect due to a lack of maintenance, and as a result, they are subject to rapid deterioration" and "unsuitable materials."

5. Recommendation

Base on the findings from the above research, the study hereby recommended that;

1. Unplanned maintenance should be incorporated into the university's maintenance practices to enable parts of the buildings and/or their components to get repaired or fixed when they break down.
2. Running maintenance should be a crucial part of university maintenance practices, as it assists maintenance staff in restoring deteriorating surfaces or walls in university buildings, thereby enhancing their efficiency and performance.

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Impact of Urban Expansion on Agricultural Activities in Gidan Kwano Community, Niger State

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Abstract

This study evaluates the impact of urban expansion on agricultural activities in the Gidan Kwano community, Minna, Niger State, Nigeria. With agriculture as the community's economic mainstay, the research explores how rapid urbanization has transformed land use patterns, with implications for agricultural productivity and rural livelihoods. The study combines qualitative and quantitative data through Geographic Information Systems (GIS) and remote sensing to analyze 12 years of land-use change, while surveys capture local farmers' perspectives on socio-economic impacts. Findings reveal a 19% reduction in agricultural land, with 92% of surveyed farmers reporting productivity losses and displacement effects. Though infrastructural developments have enhanced connectivity, the adverse impacts on food security and rural income highlight a need for balanced urban planning.

Keywords: Urban expansion, agricultural impact, Gidan Kwano, socio-economic effects, land use change.

1. Introduction

Agriculture remains a foundational economic activity in rural Nigerian communities, contributing significantly to the GDP and sustaining livelihoods. Gidan Kwano, a community in Niger State, is emblematic of these rural areas where traditional agricultural practices shape socio-economic well-being. Recent physical development, including infrastructure, residential, and commercial expansion, has altered the agricultural landscape, presenting both opportunities and challenges. While urban infrastructure enhances access to markets, the displacement of farmland and environmental shifts pose risks to food security and rural resilience (FAO, 2017; World Bank, 2018). This study investigates these complex dynamics in Gidan Kwano, assessing the extent and socio-economic impact of urban expansion on local agriculture, with an emphasis on sustainable planning solutions that balance rural livelihoods and urban growth.

Urban expansion often drives significant land-use changes that affect agricultural productivity and rural stability. Previous studies highlight both positive and negative economic effects of infrastructure development on agriculture (Ellis & Biggs, 2001; Lambin & Meyfroidt, 2011). While improved access to markets can boost incomes, higher land values and competitive resource demands may displace smallholder farmers (Adjei-Nsiah *et al*., 2010; Chamberlin & Jayne, 2013). Studies indicate that rural communities facing rapid urbanization often experience a shift in economic priorities, risking long-term agricultural viability and food security (Pinto-Correia & Kristensen, 2013).

In Gidan Kwano, urban expansion brings forth similar challenges, with development activities transforming agricultural lands and prompting socio-economic shifts that affect traditional farming livelihoods.

2. Research Methodology

This study adopts a mixed-methods approach, combining spatial and survey data. Gidan Kwano, Niger State, known for substantial development following the establishment of the Federal University of Technology, Minna (Figure 1). A sample of 54 farmers was selected based on farming type (subsistence, commercial, intensive, and extensive) to capture diverse perspectives on urban expansion's impacts. Review of land use plans and development reports provides context for primary data. Land use changes were analyzed over 2012-2024, with data obtained from high-resolution satellite imagery processed in ArcGIS Pro. Field observations and surveys with GPS coordination mapped current land use. Spatial data for 2012, 2018, and 2024 helped identify trends in land conversion. Land cover classifications for agricultural, built-up, and other land uses.

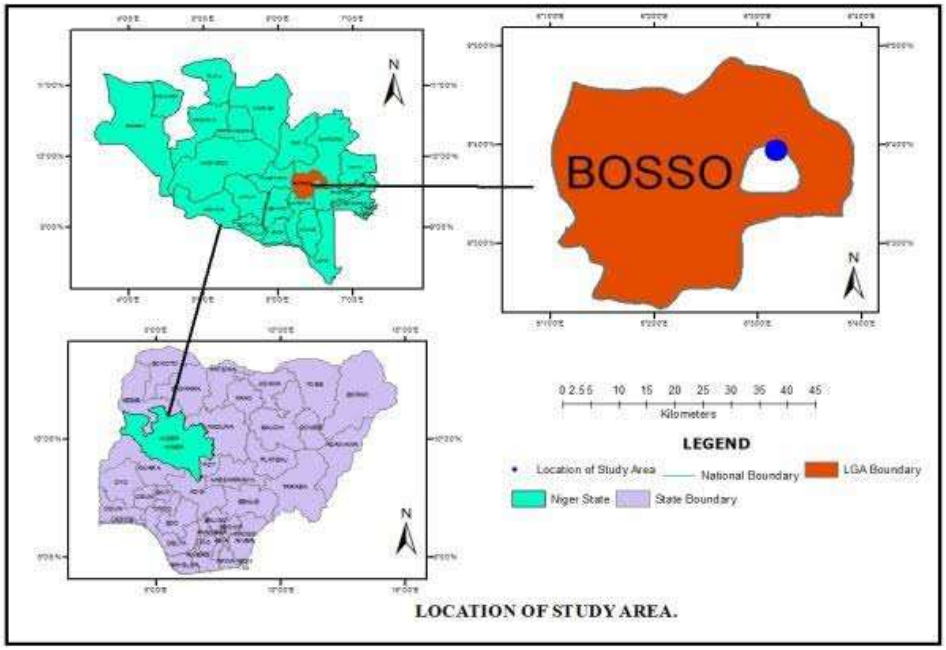

Figure 1: Showing the map of Bosso highlighting the Study area.

3. Result and Discussion

3.1 Spatial Analysis of Physical Development

The analysis of Land Use and Land Cover (LULC) maps (Figure 2,3 and 4) of Gidan Kwano, Minna for the years 2012, 2018, and 2024 reveals significant trends in the conversion of agricultural land into developed areas. The spatial analysis was carried out using remote sensing, GIS techniques, and satellite imagery, focusing on the reduction of agricultural land and the expansion of physical development. This shift has direct implications for agricultural activities and sustainability in the region.

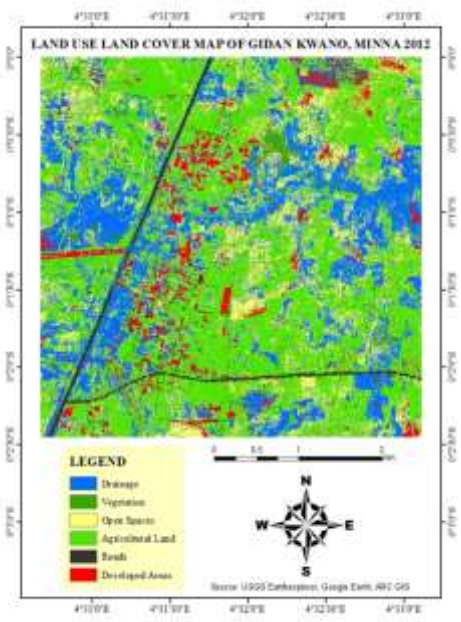

Figure 2: LULC Map of Gidan Kwano, Minna 2012.

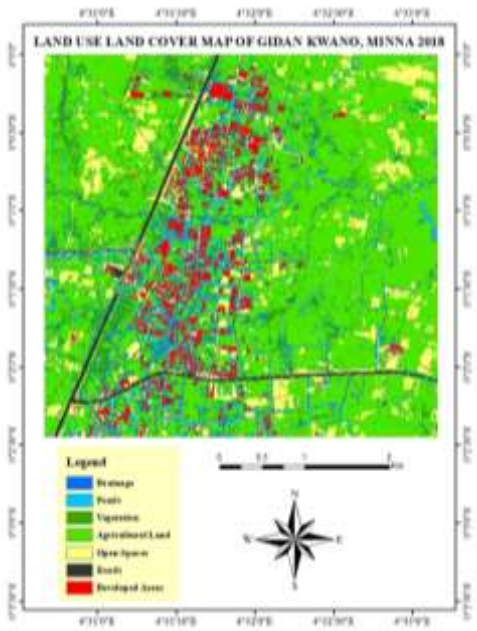

Figure 3: LULC Map of Gidan Kwano, Minna 2018.

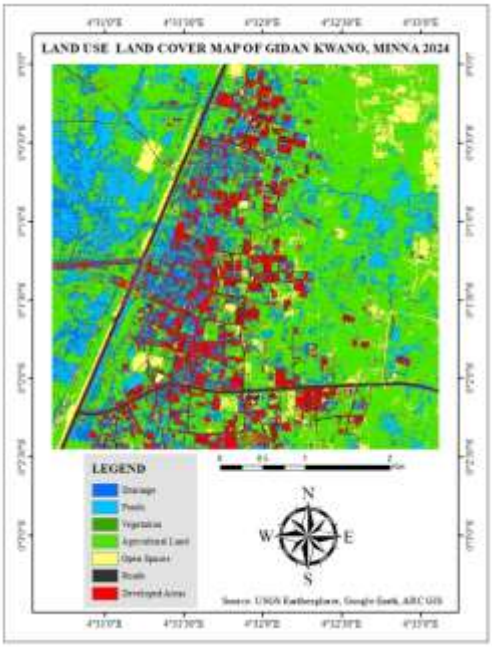

Figure 4: LULC Map of Gidan Kwano, Minna 2024.

3.2 Workflow Overview

The analysis followed a systematic workflow:

Site visits were conducted to observe the existing land uses, especially in areas undergoing physical development, and to gather geographic coordinates for key locations. The coordinates collected during field surveys were used to locate the study area on Google Earth and U.S.G.S. Earth Explorer. High-resolution satellite images for the years 2012, 2018, and 2024 were downloaded from these platforms. The downloaded satellite images were georeferenced using ArcGIS Pro 4.1to ensure spatial accuracy. This step involved aligning the satellite images to the correct geographic coordinates for further spatial analysis. Using ArcGIS Pro 4.1, the land cover for each year was digitized and classified into various categories, such as developed areas, agricultural land, drainage systems, and vegetation. This classification enabled the identification of spatial trends in land use changes over time.

3.6 Land Use Land Cover map indicating Changes Over Time

1. 2012 Spatial Map Analysis

The 2012 spatial map (Figure 2) specifically the land use land cover map serves as the baseline for understanding the initial state of land use in Gidan Kwano. In 2014, a significant portion of the land in Gidan Kwano was dedicated to agricultural activities. The map shows large expanses of farmland surrounding the residential and commercial areas. The built-up areas were relatively limited, concentrated primarily along major roads and near key infrastructure such as schools, churches, and small markets. Key infrastructure, including roads, schools, and healthcare facilities, were sparse but strategically located to serve the population. Agricultural land dominated, covering 59% of the area, while built-up areas were limited to key infrastructure near roads.

2. 2018 Spatial Map Analysis

By 2018, the physical landscape of Gidan Kwano had undergone significant transformation due to increasing urbanization and infrastructure development. The spatial map provides insights into the changes that occurred over the first Six years. By 2018, there was a noticeable expansion of built-up areas, particularly along the main roads. New residential and commercial buildings had been constructed, indicating increased development. The expansion of built-up areas led to a noticeable reduction in the extent of agricultural lands. Several parcels of farmland were converted into residential and commercial plots, especially in areas closer to the main roads and public facilities. This trend highlights the growing pressure on agricultural land as urbanization progresses. There was a marked improvement in infrastructure, with the development of new roads and the expansion of existing ones. This improved connectivity likely encouraged further development, making more remote areas accessible and attractive for construction. New residential zones began to emerge, particularly in the outskirts of the previously developed areas. This expansion suggests a growing population and the corresponding demand for housing. The spatial map shows an increase in commercial activities, with more shops, markets, and business centers emerging, particularly

along the main roads. This growth in commerce indicates a shift towards a more service-oriented local economy. Increased development led to a 12% reduction in agricultural land, correlating with new commercial and residential zones.

3. 2024 Spatial Map Analysis

The 2024 Land Use Land Cover Map spatial map represents the most recent phase of physical development in Gidan Kwano. The changes observed between 2018 and 2024 provide a comprehensive picture of the ongoing trends and their implications. By 2024, the built-up areas had expanded significantly. The urban sprawl extended into areas that were previously agricultural lands. This trend reflects the growing demand for land for residential and commercial purposes as the community continues to develop. The expansion of urban areas further encroached upon agricultural lands, reducing the space available for farming. In some areas, agricultural activities were pushed to the periphery of the community, where land is less accessible and often less fertile. Infrastructure development had become more extensive by 2024, with the construction of new roads, the establishment of more public facilities (e.g., schools, healthcare centers), and the expansion of existing infrastructure. This development likely supported the growing population and the increased economic activities within the community. The spatial map shows a diversification of land use, with the introduction of more mixed-use developments. Areas previously dominated by a single type of land use (e.g., agriculture) began to accommodate a combination of residential, commercial, and even industrial activities.

In Summary, Agricultural Land Loss has 19% decrease over 12 years and Farmer Impact has 91% of respondents report farmland conversion, with 92% noting a decline in productivity.

Table 1: Spatial distribution and changes in land use for Gidan Kwano between 2012 and 2024

Year	Developed Area (km^2)	Percentage of Developed Area	Total Agricultural Area (km^2)	Percentage of Total Agricultural Area
2012	1.09	5%	8.57	59%
2018	1.21	17%	12.38	48%
2024	2.32	22%	10.62	40%

4. Conclusion

The findings demonstrate significant negative impacts of urban expansion on agriculture in Gidan Kwano. As land previously used for farming transitions to urban development, local farmers face reduced productivity, displacement, and income challenges, highlighting concerns about food security. To mitigate these impacts, balanced urban planning is essential, including zoning policies that preserve agricultural land alongside urban growth.

5. Recommendations

Based on the findings, several actionable recommendations are proposed to mitigate the negative effects of physical development on agriculture:

1. Enforce Land-Use Regulations: Designate zones for agriculture to protect farmland from urban encroachment.
2. Support Sustainable Farming: Introduce practices such as vertical farming and crop rotation to maximize limited land.
3. Compensation for Displaced Farmers: Financial and training support for farmers affected by land conversion.
4. Community Engagement: Involve local farmers in decision-making to develop balanced land-use plans that meet both agricultural and urban needs.

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Impact of Stakeholder Management on Public-Private Partnership (PPP) Construction Projects Delivery in Niger State

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Abstract
Public-Private Partnership (PPP) construction projects have become a key approach for delivering public infrastructure in Niger State. Effective stakeholder management (SHM) is critical to the success of these projects, yet challenges persist in ensuring stakeholder involvement throughout the project life cycle. This study investigates the impact of stakeholder management on PPP construction project delivery in Niger State, with a focus on assessing SHM across the different stages of the PPP life cycle. The stages assessed include Pre-Feasibility, Feasibility, Project Preparation (Pre-Procurement), Procurement (Tendering), Contract Signing (Contracting), Implementation, Operation and Maintenance, and Closure and Evaluation.
A quantitative survey research design was adopted, targeting a population of 120 professionals involved in PPP projects, including project managers, contractors, engineers, and government representatives. Data was collected through structured questionnaires and analyzed using standard deviation to identify variability in stakeholder management practices across the project stages.
The results revealed that stakeholder management challenges are most severe during the Pre-Feasibility and Feasibility stages, with decreasing severity as projects move toward the Implementation and Closure stages. The study concludes that addressing these challenges, particularly in the early stages of the project life cycle, is crucial for the successful delivery of PPP construction projects.

Keywords: construction project, management in public-private partnership (ppp), Stakeholder,

1. Introduction

The Construction industry is one of the important sectors, which have a substantial contribution towards the fiscal expansion of any country. The industry stands as one of the largest sectors globally, contributing significantly to economic growth, job creation, and infrastructure development (Hassan, *et al*. 2024). There has been a significant increase in the private sector's involvement in financing and constructing public infrastructure in Nigeria, particularly in the North Central region, as a means to address the infrastructure gap (Leigland, 2018).
Public Private Partnership (PPP) have been utilized in Nigeria specifically in the North Central area, for the development of public infrastructure projects. Examples of such projects include the concession of the Nnamdi Azikiwe International Airport in Abuja, the housing project concession in Minna Airport City at Maikunkele and the construction of the Minna Five Star Hotel in Niger state (Gognaje *et al*,2023) others are construction of MI Wushishi Housing Estate, Talba Housing Estate, Sea mounting Estate all in Minna, Col Sani Bello Housing Estate in Kontagora and Aliyu makama Housing Estate in Bida, Niger state.
The poor management of stakeholder in Nigeria and some part of the world bemoan the challenges affecting the successful growth and development of PPP (Luqman*et al*.2018), as such the implementation of an effective stakeholder management strategy is crucial for ensuring that such projects will be successful and must be followed throughout the entire project lifecycle (not just in the delivery phase) (Jayasuriya *et al*.,2020).
Stakeholder management (SM) is a concept that describes an organization's resolve to manage relationships with its stakeholder groups in a proactive manner (Chinyio and Olomolaiye, 2010). However, as a result of characteristics such as enormous investment, long term contract periods, and multiple stakeholders with different objectives, PPPs face greater uncertainties than traditional projects (Mingzhu *et al*., 2020). Practical experiences of infrastructure PPP projects have revealed many problems. Many of such projects have encountered various crises and there are numerous cases of failed PPP projects. Example, the D47 Motorway in the Czech Republic and the M9 Motorway in Pakistan were ultimately canceled. Meanwhile, the failure of the Quanzhou Citong Bridge project in China provides a good example of a project being nationalized in advance (Soomro *et al*.,2016), Syntax Housing Estate opposite Zuma rock along Abuja

Road Suleja, Col Sani Bello Housing Estate Kontagora and Aliyu makama Housing Estate in Bida, all in Niger State were failure in that value for money was not achieved. Therefore, the complex long-term, systematic nature of PPP projects inevitably gives rise to various risks and challenges.
In addressing these challenges this research seeks to assess the impact of stakeholders on ppp construction project delivery in Niger State most especially on housing.

2. Literature Review

2.1 Concept of Construction Industry.

Construction industry is a dynamic system that encompasses a wide variety of technologies for the production of building and engineering facilities. The industry stands as one of the largest sectors globally, contributing significantly to economic growth, job creation, and infrastructure development (Hassan, *et al*., 2024).The industry especially in developing economies contributes as much as 10% to employment and GDP, about 50% to the Domestic Fixed Capital (DFC) Formation, aggregate demand and other sectors through backward and forward linkages, and strong multiplier effect on the economy (Odediran*et al*., 2012; Nawi *et al*., 2014 & ILO, 2019). Saka & Adegbembo (2022) stated that the construction sector involves only the firms and processes that construct and maintain physical infrastructure facilities. Thong and Hao (2019) further stated that construction investment is critical to growth, thus, it is reasonable to assume that the policy for the construction sector largely reflects the political, economic, social and technology values of a given nation. However, the Nigerian construction sector (NCS) is beset by a number of challenges including operating environment, low local content and poor project cost and time overruns (Saka and Adegbembo, 2022).
According to Akeem, O. (2021), construction projects are characterized by multiple stakeholders, including project owners, contractors, subcontractors, Architects, Engineers, and Government agencies, each with their own interests and agendas, project been executed in complex build Environment, where various factors such as weather, terrain, and existing infrastructure can impact project outcomes and uncertainty situations sometimes delivered risks such as delays, cost overruns, and quality issues posing significant challenges to project success.

2.2 The stakeholder management life cycle at each stage of a PPP project.

Any PPP project has different phases throughout its lifecycle, expanding over a long time span, sometimes reaching up to 40 years. There are several ways to describe the different stages any PPP projects goes through. Li and Zou (2012) identified the stages of PPP differently. Here's a detailed explanation of these benefits:
Pre-Feasibility Stage: According to Onugu, and Ugwu, (2014) and Ogunsanwo and Adewunmi, (2019), they Identify key stakeholders to including government agencies, private investors, local communities, and regulatory bodies. They analyzed stakeholder to understand their interests, concerns, and influence on the project through engagement Strategy, outlining communication channels and approaches. At this stage Project is Identifed , the duration is between 2-6 months, aimed to Identify the projects potential, conduct feasibility studies, define project scope and objectives, determine potential risks and benefits.
the Key Activities here are Literature review, Stakeholder engagement, Initial cost-benefit analysis and Risk assessment (Delmon etl, 2017) (Akintoye & Beck, 2008
Feasibility Stage: The Duration is between 6-18 months. At this stage stakeholder will to be consulted, risk assessed, and preliminary designs carried out, then feedback from stakeholders to be incorporate their inputs into the project planning process and then align stakeholder interests with project objectives and identify potential areas of conflict (Ushie, *et al*., 2020). The Key Activities Are Technical studies, Financial analysis, Stakeholder engagement and Market research.
Project Preparation (Pre-Procurement Stage): Duration is between 6-12 months aimed at Developing detailed project plans and specifications, conduct environmental and social impact assessments, prepare procurement documents and to Establish project governance structure (Delmon, 2017) (Akintoye & Beck, 2008
The Key Activities here are preparation of Detailed design and engineering, Environmental and social impact assessment, Procurement planning and Stakeholder engagement.
Procurement Stage (Tendering Stage): To ensure transparency in the procurement process to build trust among stakeholders and involve stakeholders in the procurement evaluation and selection process to enhance buy-in and legitimacy. Then to comply with regulatory requirements and procurement guidelines to mitigate risks and legal challenges (Aigbavboa, *et al*., 2019).
Procurement Duration is between: 3-6 months, and the Key Activities Are Bid evaluation, Negotiations with bidders and contract drafting.
Contract Signing (Contracting Stage) Duration 1-3 months, the Objectives are to Sign concession agreement or contract, establish project timeline and milestones, define roles and responsibilities and to Establish dispute resolution mechanisms (Delmon, 2017) (World Bank, 2014) (Hodge & Greve, 2007).
The Key Activities here are Contract signing, Project kickoff meeting and Stakeholder engagement

Implementation Stage: To establish regular communication channels to keep stakeholders informed about project progress, milestones, and any changes and to maintain ongoing engagement with stakeholders in order to address emerging issues, concerns, and challenges. Then to implement mechanisms for resolving conflicts and disputes among stakeholders in a fair and timely manner (Ezeah and Ocholi, 2019). The duration is between 12-60 months Key Activities here are Design and engineering, Procurement, Construction, Testing and commissioning
Operation and Maintenance Stage: To ensure long-term sustainability 5-30 years by engaging stakeholders in ongoing maintenance and operational activities, to establish feedback mechanisms and to solicit input from stakeholders regarding service quality, performance, and improvements (Ogunsemi*et al*., 2015).
Key Activities at this stage are Operations and maintenance, Performance monitoring and Maintenance planning.
Closure and Evaluation Stage (End-of-Project Stage): To document lessons learned from stakeholder management thro ughout the project life cycle for future improvement and to valuate stakeholder engagement performance against predefined metrics and objectives. Finally share insights and best practices with relevant stakeholders to promote learning and continuous improvement (Okoye& Manu, 2018) and (Ajide& Raheem, 2019).
it took 1-6 months aimed at Transfer project ownership to public sector, Complete final inspections and testing and to Resolve any outstanding issues (Hodge & Greve, 2007) (World Bank, 2014) (Delmon, 2017).

3. Methodology

This research adopts a structured approach to investigating the impact of stakeholder management (SHM) on Public-Private Partnership (PPP) construction projects delivery in Niger State. A quantitative survey research design was employed, utilizing structured questionnaires to gather information on the stakeholder management practices across the various stages of the PPP life cycle. The target population consisted of 120 professionals, including Project Managers, Engineers, Quantity Surveyors, Public Sector Representatives, Private Sector Partners, and Contractors, all of whom are actively engaged in PPP construction projects within Niger State.
The questionnaire used in this study was well-structured and divided into two sections. Part A focused on gathering general information about the characteristics of the respondents, while Part B provided insights into the stakeholder management processes at the eight identified stages of PPP projects, namely: Pre-Feasibility Stage, Feasibility Stage, Project Preparation (Pre-Procurement Stage), Procurement Stage (Tendering Stage), Contract Signing (Contracting Stage), Implementation Stage, Operation and Maintenance Stage, and Closure and Evaluation Stage (End-of-Project Stage).
The data was analyzed using descriptive statistics, including standard deviation to measure the variability in stakeholder management practices across the project life cycle stages. The analysis was conducted using SPSS software, version 16. Standard deviation values were used to rank the stages based on the severity of challenges encountered during stakeholder management. The decision rule for ranking was based on the following scale: 0.00-0.20: Least Severe, 0.21-0.40: Less Severe, 0.41-0.60: Severe, 0.61-0.80: Very Severe, 0.81-1.00: Extremely Severe.

4. Data Analysis and Discussion of Results

4.1 Background to the study

The composition of respondents in this study included Project Managers (30 respondents, 25%), Engineers (28 respondents, 23.3%), Public Sector Representatives (25 respondents, 20.8%), Private Sector Partners (20 respondents, 16.7%), and Contractors (17 respondents, 14.2%). These professionals represent key stakeholders involved in Public-Private Partnership (PPP) construction projects in Niger State.
The professional affiliations of the respondents revealed that 31 respondents (25.8%) were Members of the Nigerian Institute of Management (MNIM), 28 respondents (23.3%) were Members of the Nigerian Society of Engineers (MNSE), 26 respondents (21.7%) were affiliated with the Nigerian Institute of Quantity Surveyors (NIQS), 18 respondents (15%) were Members of the Nigerian Institute of Building (MNIOB), and 17 respondents (14.2%) were affiliated with other professional associations related to project management and construction.
Regarding their academic qualifications, 47 respondents (39.2%) held a Bachelor's Degree, 32 respondents (26.7%) had a Higher National Diploma (HND), 22 respondents (18.3%) held a Master's Degree, 11 respondents (9.2%) had a National Diploma (ND), and 8 respondents (6.7%) held a Doctor of Philosophy (PhD).

Standard deviation was used to analyze the variability in responses concerning stakeholder management (SHM) practices across the life cycle stages of PPP construction projects. The analysis provided insights into the consistency of stakeholder involvement throughout the PPP delivery process.

4.2 Shm Stages

The study identified eight (8) key stages of the Stakeholder Management (SHM) life cycle in Public-Private Partnership (PPP) construction projects in Niger State, as shown in Table 4.1. The study revealed that the Pre-Feasibility Stage was

the most critical stage for stakeholder management, with a standard deviation (SD) of 0.85, indicating high variability in responses and the need for significant attention at this stage. The Feasibility Stage followed, with a standard deviation of 0.82, also reflecting high stakeholder management challenges. The Project Preparation Stage (Pre-Procurement Stage) and Procurement Stage (Tendering Stage) were both ranked 3rd with an SD of 0.78, emphasizing the importance of thorough stakeholder involvement during the early planning and bidding phases.

The Contract Signing Stage (Contracting Stage) ranked 4th with an SD of 0.75, indicating the challenges faced in finalizing agreements with key stakeholders. The Implementation Stage and Operation and Maintenance Stage were ranked 5th with an SD of 0.70, showing moderate variability in stakeholder management challenges. Finally, the Closure and Evaluation Stage (End-of-Project Stage) ranked 6th with an SD of 0.65, suggesting that while the challenges here are less severe, attention is still needed to ensure effective project closure.

On average, the variability in stakeholder management practices across the PPP life cycle stages had a standard deviation of 0.76, highlighting the need for a structured and consistent approach to managing stakeholders throughout the project stages.

The severity of the study agrees with other studies, such as that by Daniel *et al*. (2018), which also highlighted significant challenges in stakeholder management during PPP construction projects, particularly during the early stages.

Table 4.1 Respondents' profile.

Code	SHM STAGES	SD	Rank	Decision
S1	Pre-Feasibility Stage	0.85	1st	Very Severe
S2	Feasibility Stage	0.82	2nd	Very Severe
S3	Project preparation (pre-procurement)	0.78	2nd	Very Severe
S4	Procurement Stage (Tendering Stage)	0.78	3rd	Very Severe
S5	Contract Signing (Contracting Stage)	0.75	4rd	Very Severe
S6	Implementation Stage	0.70	5th	Severe
S7	Operation and Maintenance Stage	0.70	5th	Severe
S8	Closure and evaluation Stage (End-of-Project)	0.65	6th	Severe
Average SD		**0.76**		**Very Severe**

Source: Researcher's Field Survey (2024)

5. Conclusion

This study has examined the impact of stakeholder management (SHM) on the delivery of Public-Private Partnership (PPP) construction projects in Niger State, with a focus on assessing the SHM life cycle across the various stages of the PPP process. The findings revealed that effective stakeholder management plays a crucial role in the successful execution of PPP projects, particularly during the early stages such as Pre-Feasibility, Feasibility, and Project Preparation, where stakeholder engagement and alignment of interests are critical. However, challenges persist throughout the PPP life cycle, particularly in the Procurement, Implementation, and Operation stages, where misalignment between public and private stakeholders can hinder project success.

Overall, the study concludes that the implementation of robust SHM strategies is essential for improving communication, decision-making, and collaboration among key stakeholders. Addressing these challenges at each stage of the PPP life cycle can significantly enhance project performance, reduce delays, and ensure that project objectives are achieved.

6. Recommendations

Based on best practices in stakeholder management, the following recommendation are proposed to ensure effective stakeholder engagement and project success :

1. Engage stakeholders early in the Pre-Feasibility and Feasibility stages.
2. Establish regular communication and feedback mechanisms throughout the project life cycle.
3. Provide capacity-building programs for stakeholders involved in the PPP process.
4. Implement a monitoring and evaluation system to assess stakeholder participation at each stage.

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Impact OF Human Resource Management Techniques on the Performance of Construction Workers in Abuja, Nigeria

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Abstract

The success of the building project depends on identifying the issue with human resource management and developing measures to address it. This study assessed the impact of human resource management techniques on the performance of construction workers in Abuja, Nigeria, with establishing view to identify strategies for enhance the management of construction workers to ensure optimal performance. Data was collected from 117 professional construction companies listed in the Abuja business directory using a structured questionnaire. The analysis of the data was carried out with the use of percentage and mean item score. The study revealed that the most used human resource management techniques are hiring labour, staffing, selection, and recruitment (MIS = 3.73), while the least used human resource management technique is job security (MIS = 3.54). The regression model is a good fit for the data. Accordingly, findings shows that the p-value is <0.00. Thus, it is found that the model is statistically significant (R2 =.658, F (5, 111) = 4.163, p <.000). Therefore, this study concludes that human resource management techniques have a significant impact on the performance of construction projects in Abuja, Nigeria. Therefore, the study recommends that construction firms and all other relevant stakeholders to develop a mechanism that will include all the strategic measures for enhancing labour performance through effective human resource management on construction sites, as identified in this study Provision of appropriate/modern working tools and equipment and Communication of workers and information.

Keywords: Construction workers, Impact, Human resource, management, Performance,

1. Introduction

Construction projects have increased due to the high demand for infrastructure development. The fast-changing environment of the present day imposes financial, legal ethical, environmental, and logical constraints (Abhishek *et al.*, 2017). Construction activities constitute important components of the global economy. They interact in several ways, such as technically, economically, and socially, within the environment as well as with other organizations, structures, and systems. Construction projects adopt many resources that have difficulties and risks in using them to achieve the project goals (Raja and Murali, 2020). Daily, construction projects encounter several challenges. Human resource management in construction projects is a problem that has been considered in this research. Even though construction uses more manpower in its business activities compared to other projects, its human resource management is still inadequate and insufficient (Ghattas *et al.*, 2022).

The success of the building project depends on identifying the issue with human resource management and developing measures to address it. According to Berawi (2018), unlike other industries, the construction industry is mainly project-based or matrix-structured. The construction projects have the general characteristics of a limited budget, schedule, and quality standards with a series of complex and interrelated activities. Collaboration between the project's stakeholders' clients, directors, designers, contractors, builders, project managers, team members, and consultants is essential.

There are many human resource issues that will lead to poor performance on construction projects, such as poor project design and structure, shortages of qualified skilled employees, changing workforce demography, a high rate of employee turnover, and a high rate of burnout. Poor project design and structure is a typical problem in the construction companies.

Ratajczak *et al*. (2019) state that as people are in charge of managing and carrying out the project, it is crucial to create an organizational structure that may favourably impact the team's building project, the duties involved, and each individual's demands.

The shortage of qualified, skilled employees is also one of the most common issues among construction firms. The scarcity of both skilled trades personnel and experienced managers will place more emphasis on the need to increase the quality and quantity of training in order to produce more effective and productive workers" (Neyestani and Juanzon, 2016). Therefore,

a lack of proper screening processes, selection methods, and recruitment procedures will badly affect the success rate of construction projects and therefore lead to low productivity and growth for the construction firm.
In the construction industry, human resource management practices play a crucial role in determining the success or failure of construction projects. However, there is a gap in understanding the specific ways in which human resource management practices influence project performance. Therefore, this paper explores and analyses the impact of human resource management techniques on the performance of construction workers, with a focus on identifying the most appropriate strategies to manage construction workers.

2. Literature review

2.1 Concept of Human Resource Management in Construction Projects

Human resource management considers people's dimension in management since every organization constitutes people, acquiring their services, fine-tuning their skills, motivating them to higher levels of performance, and ensuring that they continue to maintain their commitment to the organization are prerequisites to achieving organizational objectives (Chukwuka and Nwakoby, 2016). Human resource management has a key role in today's competitive work environment. The style and management of human resource systems are based on employment policy, comprising a set of policies designed to maximize organizational integration, employee commitment, elasticity, and quality of work (Alagaraja, 2013).
HRM is defined as a strategic and compatible approach to the management of an organization's most approached assets the people working there who one by one jointly contribute to the accomplishment of its objectives. According to Armstrong, the main aim of human resource management is to ensure that the organization can achieve success through people (Neyestani and Juanzon, 2016).
Human Resource Management is the performance of all managerial functions involved in planning, recruiting, selecting, developing, utilizing, rewarding, and maximizing the potential of human resources for the achievement of the objectives of an organization. Human Resource (HR) management deals with the design of formal systems in an organization to ensure the effective and efficient use of human talent to accomplish organizational goals. HR practices are the most important tools in order to contribute to increasing project performance for companies. Companies can take the leading position with an effective use of human resources to increase productivity and performance under competitive market conditions. The human resource is the most important factor affecting project performance (Goshu and Kitaw, 2017).

3. Research method

The quantitative research approach was adopted for this study. In view of this, this study adopted a structured questionnaire to collect data. The unit of analysis is made up of human resource managers in charge of employment who are also professionals from the identified firms in the built environment. According to the data used in this research, there are 230 registered construction enterprises in Abuja (Abuja Business Directory, 2023). The unit of analysis is made up of human resource managers in charge of employment who are also professionals from the identified firms in the built environment (architects, engineers, quantity surveyors, builders, and estate surveyors).

A sample is a small proportion of a population selected for observation and analysis. The sample size of the respondents was calculated using a simplified formula proportion as illustrated by Glenn (2013).

$$n = \frac{N}{1 + N\,(e)2}$$

Where;
n = Sample size
N = Population size in the sample unit
e = Level of precision which is + 5% (0.05)

$$n = \frac{230}{1 + 230\,(0.05)2 = 146}$$

To arrive at a sample size that served as a representative of the entire population in the study area. The 230 construction companies listed in the Abuja business directory were substituted in equation (1) and an estimated sample size of 146 respondents was arrived at a respondent from a firm. Therefore, the sample size for the study was 146. One hundred and seventeen (117) questionnaires were retrieved from 146 administered. The analysis of the data

was carried out with the use of multiple regression analysis to determine the impact of human resource management on the performance of construction projects.

4. Result and Discussions

4.1 Existing Human Resource Management Techniques on Construction Sites

Table 1 presents the results of the MIS analysis. The MIS values of 3.73, 3.72, 3.58, 3.55, and 3.51, respectively, indicate that the frequently utilized human resource management techniques include hiring labor, staffing, selection, and recruitment; supervision, checks, and inspections; information sharing; training; and appraisal, compensation, and rewards. The MIS values of 3.55 and 3.55, respectively, indicate the relatively frequent use of mobility and job security. On average, all of the human resource management techniques were used frequently (average MIS = 3.54). In summary, the results in Table 1 reveal that the most used human resource management techniques are hiring labor, staffing, selection, and recruitment (MIS = 3.73), while the least used human resource management technique is job security (MIS = 3.54). The results of this study agree with those of Mason *et al.* (2012). Staffing and recruitment are important practices for organizations to attract qualified applicants, ensure that the desired applicants accept the job offers, and ensure that they continue in the firm's employment. (Communication)/Employment Relationship Practices Because of the changing working environment and characteristics of multitasking, role transitions, and involvement, employees need to solve conflicts and collaborate with their colleagues. Employee relations practices concern stable and cooperative relationships, commitment achievement, and mutuality development (Armstrong 2012).

Table 1: Human Resource Management Techniques

Human Resource Management Techniques	Mean Score	Rank	Frequency of usage
Hiring labor/staff (staffing) / Selection/recruitment:	3.73	1st	Often
Supervision/Checks/Inspections	3.72	2nd	Often
Sharing of information	3.58	3rd	Often
Training	3.55	4th	Often
Appraisal/Compensation/Rewards	3.51	5th	Often
Mobility	3.35	6th	Fairly often
Job Security	3.35	7th	Fairly often
Average MIS	***3.54***		***Often***

Source: Author's fieldwork (2024)

4.2 Result on the impact of human resource management on the performance of construction projects.

The composites of the important variables served as the basis for the regression analysis. The data was inputted into the SPSS software. Tables 2 and 3 show the results. The study's explanatory variables explain the proportion of variance in the dependent variable, as indicated by the coefficient of determination. Table 4.4 demonstrates that the combined effect of the predictor variables could account for 65.8% of the changes in impact factors.

Table 2: model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.397[a]	.658	.120	1.08519

a. Predictors: (Constant), Impact of performance management on project performance, Impact of work design on project performance, Impact of compensation system on project performance, Impact of training on project performance, Impact of selective recruitment on project performance

A significant test is performed to determine whether independent variables influence the dependent variable. If the p-value is below 0.05, the results have a significant effect. Table 3 displays the results of the significance test.

Table 3: Regression of Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.346	.474		4.951	.000
	Selective recruitment	-.333	.137	-.348	-2.440	.016
	Work design	.227	.163	.189	1.389	.168

Training	.465	.146	.428	3.185	.002
Compensation system	-.195	.156	-.163	-1.249	.214
Performance management	.156	.137	.131	1.139	.257

a. Dependent Variable: Kindly rate the impact of human resource management on the performance of construction projects

Were

Y = project performance

X_1= selective recruitment

X_2= work design

X_3= training

X_4= compensation system

X_5= performance management

$Y= 2.346+ -0.333X_1 + 0.465X_3+ \varepsilon$

Table 3 regression coefficient results show that selective recruitment has a significant positive impact on project performance (β = -0.333, t = -2.440, p =.016). Work design has an insignificant impact on project performance (β = 0.227, t = 1.389, p =0.168). Training has a positive significant impact on project performance (β = 0.465, t = 3.185, p = 0.002). The compensation system has an insignificant impact on project performance (β = -0.195, t = -1.249, p =0.214). Performance management has an insignificant impact on project performance (β = 0.156, t = 1.139, p = 0.257).

According to Subramaniam *et al.* (2016), an effective recruiting process facilitates the hiring of qualified employees who can meet the company's work requirements, thereby enhancing product quality and generating economic profit. Competent project managers enhance the firm's project performance through effective recruitment and selection. Furthermore, Tzabbar *et al.* (2017) stated that selective recruitment and selection will help an organization's sales grow. Therefore, it is believed that the practice of selective recruitment will have a positive effect on the company's project performance. Raineri (2016) explained that work design such as teamwork and decentralization of decision-making will be able to encourage and promote employee commitment, participation, and a sense of attachment, thereby affecting the organization's project performance. The employees in the organization are more likely to be motivated and committed to the organization if they are satisfied, easily adapt to the work design and management styles of the organization, and produce effective work in handling projects.

5. Conclusion

The findings revealed that the most commonly used human resource management techniques are hiring labor, staffing, selection, and recruitment, whereas job security is the least commonly used. The findings revealed that the most significant impact of human resource management on the performance of construction projects is the impact of the compensation system on project performance, while the least significant impact of the compensation system on project performance is the impact of selective recruitment on project performance. The study therefore concludes that human resource management has a significant impact on the performance of construction projects in Abuja, Nigeria. Based on the study's conclusions, the following recommendations were made: The human resource manager should make sure that construction sites are using and periodically reviewing the existing human resource management techniques identified in this study such as hiring labor/staff (staffing) / selection/recruitment, supervision/checks/inspections, and sharing of information.

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The imperatives of accessibility and inclusivity of healthcare in infrastructure: A Literature Exploration

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Abstract

The subject of inclusivity for people living with disability (PLWD) in their quest to access health infrastructure. The challenges faced by individuals with disabilities in accessing healthcare services, with a focus on global and African contexts is the major pivot of this literature exploration. The research undertakes a careful desktop review of literature resources targeted at understanding the challenges of inclusivity within the healthcare infrastructure for PLWDs. The study identifies three main categories of barrier: physical, attitudinal, and financial. Physical barriers include inaccessible healthcare facilities and equipment. Attitudinal barriers stem from stigma, discrimination, and lack of disability awareness among healthcare providers. Financial barriers relate to the high costs of healthcare services and assistive devices, particularly burdensome for individuals with disabilities who often face economic disadvantages. The key strategies include implementing accessibility standards, enhancing disability awareness training for healthcare professionals, expanding universal health coverage, and engaging the disability community in healthcare design and evaluation. The study concludes with the target of improving healthcare inclusivity and accessibility, emphasizing the need for comprehensive infrastructure upgrades, enhanced professional training, expanded health coverage schemes, and collaborative partnerships with the PLWD community. By adopting these multifaceted approaches, healthcare systems can work towards ensuring equitable access and quality care for individuals with disabilities, ultimately realizing the fundamental human right to health for all.

Keywords: Accessibility, Community, Equity, Healthcare Services, Inclusivity, PLWD,

1. Introduction

The right to health is a fundamental human right, recognized by international conventions such as the United Nations Convention on the Rights of Persons with Disabilities (CRPD). Despite this, people with disabilities face significant challenges in accessing healthcare services. These challenges are multifaceted and pervasive, spanning physical, attitudinal, and systemic barriers. Globally, healthcare systems often fail to meet the needs of disabled individuals, leading to health disparities and poorer health outcomes.

Globally, an estimated 15% of the population lives with some form of disability, translating to over one billion people (WHO, 2023). This demographic is disproportionately affected by health inequities, experiencing higher rates of chronic illnesses, secondary health conditions, and premature mortality compared to the general population. The barriers they face in accessing healthcare are diverse and include physical obstacles, such as inaccessible buildings and medical equipment attitudinal barriers and financial barriers.

In Africa, these challenges are compounded by additional factors such as infrastructure deficits, economic constraints, and cultural attitudes towards disability. Many African countries grapple with inadequate healthcare facilities, a shortage of healthcare professionals, and limited availability of specialized services.

2. Methodology

The methodology utilized is a desktop research approach, which relies on a comprehensive literature review of existing studies and reports. This method is particularly suitable for the study, as it allows for the collection and consolidation of information from a diverse array of scholarly sources, including academic journals, reports from international organizations, and policy documents. Through this approach, a deeper understanding of the complex and multifaceted barriers that individuals with disabilities face in accessing healthcare services.

Review of the available literature was conducted to explore these challenges, with a focus on both global and African contexts. This desktop research method is well-suited for the content presented, as it enables the synthesis and analysis of current knowledge and evidence on this critical issue. The desktop research has allowed for the identification and

discussion of key barriers to healthcare access for people with disabilities. These barriers can be broadly categorized into physical, attitudinal, and financial challenges. The literature review also draws insights from various geographical regions, including Europe, Asia, America, and other African countries, to provide a comprehensive understanding of the challenges and potential lessons for Nigeria.

3. Challenges of inclusivity of healthcare infrastructure from a global space

From a global environment, the barrier to inclusivity and accessibility for individuals with disability can be broadly narrowed into three which is discussed below:

3.1.1 Physical Barriers

The issue of physical barriers in healthcare access for individuals with disabilities is a significant concern that has been extensively explored in the literature. According to a study by Shakespeare *et al*. (2022), a substantial proportion of healthcare facilities in low- and middle-income countries lack basic accessibility features, such as ramps, accessible toilets, and elevators, which are essential for individuals with mobility impairments. The research surveyed healthcare facilities across multiple countries and found that these physical barriers were a major obstacle preventing people with disabilities from accessing necessary healthcare services. For instance, people facing significant challenges in entering and navigating healthcare facilities, limiting their ability to receive timely and appropriate medical care (WHO, 2021).

3.1.2. Attitudinal Barriers

Attitudinal barriers, including stigma and discrimination, have a significant impact on the healthcare experiences of people with disabilities. The World Health Organization (WHO, 2023) reports that negative attitudes from healthcare professionals, stemming from a lack of disability awareness and training, are a major deterrent for individuals with disabilities seeking medical care, ultimately affecting their overall health outcomes. These biased attitudes and inadequate care can lead to suboptimal treatment and poorer health outcomes for people with disabilities (Iezzoni *et al*., 2020). Healthcare providers may hold misconceptions about the capabilities and needs of individuals with disabilities, leading to assumptions about their health status, treatment preferences, and quality of life (WHO, 2023).

3.1.3 Financial Barriers

Financial constraints play a critical role in limiting access to healthcare for people with disabilities. Imagine a family struggling to make ends meet, having to choose between paying for their child's life-saving medications or putting food on the table. This is the reality for many individuals with disabilities and their families, especially in countries without comprehensive health insurance schemes. The International Disability Alliance (IDA, 2023) highlights that out-of-pocket expenses for healthcare can be prohibitively high for individuals with disabilities. This financial burden is exacerbated by the need for specialized services and assistive devices, which often come at a significant cost (Mitra *et al*., 2017). Individuals with disabilities may face higher healthcare expenditures due to the need for specialized treatments, rehabilitation services, and assistive technologies (Mitra *et al*., 2017).

Governments and policymakers can also implement targeted financial assistance programs, such as disability-specific insurance schemes, subsidies, or voucher systems, to help offset the high out-of-pocket expenses faced by individuals with disabilities (Mitra *et al*., 2017). The development of innovative financing models, such as community-based insurance schemes or microfinance programs, can help expand the availability of affordable healthcare options for individuals with disabilities (Kuper *et al*., 2018).

3.2. Challenges in the African Context: Barriers to Healthcare Access for People with Disabilities

3.2.1 Infrastructure Deficits

In Africa, the challenges of healthcare infrastructure accessibility for people with disabilities are exacerbated by significant infrastructure deficits. Many healthcare facilities are outdated and not equipped to meet the needs of disabled patients. The African Development Bank (AfDB, 2022) notes that in many African countries, healthcare facilities lack basic accessibility features, such as ramps, wide doorways, and adapted restrooms, which severely limits the ability of people with disabilities to receive adequate care. A study by Maart and Jelsma (2014), in South Africa found that the lack of accessible facilities was a significant barrier to healthcare access, with many participants reporting difficulties in entering and navigating healthcare settings. This can lead to delayed diagnoses, interrupted treatment, and suboptimal care, ultimately contributing to poorer health outcomes for people with disabilities.

3.2.2 Limited Availability of Specialized Services

The availability of specialized healthcare services for people with disabilities is limited in many African countries. There is often a shortage of rehabilitation centers, specialized clinics, and trained healthcare professionals who can address the specific needs of disabled individuals. According to a study by Mji *et al*. (2022), only a small fraction of African countries has established comprehensive rehabilitation services, leading to significant gaps in care.

The lack of specialized services can have far-reaching consequences for the health and well-being of people with disabilities. Without access to specialized treatments, rehabilitation programs, and assistive technology services, individuals may experience delayed recovery, reduced functional independence, and an overall poorer quality of life (Maart & Jelsma, 2014). Moreover, the shortage of healthcare professionals with expertise in disability-related care can further exacerbate the challenges faced by people with disabilities. Many healthcare providers in Africa may lack the necessary training and knowledge to effectively address the unique needs of their disabled patients, leading to suboptimal care and poor health outcomes (Nduku *et al*., 2023).

3.2.3 Socioeconomic Factors

Socioeconomic factors, including poverty and lack of education, further hinder access to healthcare for people with disabilities in Africa. Many disabled individuals live in poverty and cannot afford healthcare services or transportation to healthcare facilities. The United Nations Economic Commission for Africa (UNECA, 2023) emphasizes that socioeconomic disparities are a major barrier to healthcare access, with people with disabilities often being among the most economically disadvantaged groups. The financial burden associated with healthcare expenses, such as the cost of specialized treatments, assistive devices, and transportation, can be overwhelming for individuals with disabilities and their families, especially in the absence of comprehensive social protection or health insurance schemes (Mitra *et al*., 2017).

Governments and policymakers should prioritize the development and expansion of Universal Health Coverage (UHC) schemes that include comprehensive coverage for individuals with disabilities (World Bank, 2021). UHC can help ensure that essential healthcare services, including specialized treatments and assistive technologies, are accessible and affordable for all, regardless of an individual's socioeconomic status or disability

3.2.4 Cultural and Social Barriers

Cultural and social barriers also play a significant role in limiting healthcare access for people with disabilities in Africa. Traditional beliefs and societal attitudes towards disability can lead to discrimination and exclusion from healthcare services. A study by Nduku *et al*. (2023) found that in many African communities, disability is stigmatized, leading to neglect and poor health outcomes for disabled individuals. The stigma and discrimination experienced by people with disabilities can manifest in various ways, including negative attitudes from healthcare providers, social isolation, and barriers to participation in community life (Maart & Jelsma, 2014). These cultural and social barriers can deter individuals with disabilities from seeking necessary medical care, as they may fear being subjected to discrimination or receiving substandard treatment.

4. Achieving Global Healthcare Inclusivity and Accessibility for People with Disabilities

4.1 Introduction

Ensuring that people with disabilities have equitable access to quality healthcare is a global imperative. Across different regions and economic contexts, countries have undertaken various initiatives to address the multifaceted barriers that have traditionally prevented individuals with disabilities from receiving the medical care and support they require. From infrastructure improvements to policy reforms and community-based approaches, these efforts have sought to create more inclusive and accessible healthcare systems that cater to the unique needs of people with diverse abilities.

4.1.1 Europe: Advancing Accessibility and Inclusion

Several European nations have taken a leading role in developing inclusive and accessible healthcare systems for people with disabilities. Through a combination of policy initiatives, infrastructure improvements, and active stakeholder engagement, these countries have been instrumental in driving significant progress and fostering meaningful change in healthcare accessibility and inclusivity.

4.1.2 Policy and Regulatory Frameworks

The European Union (EU) has played a pivotal role in establishing comprehensive policy and regulatory frameworks to promote healthcare accessibility for individuals with disabilities. The EU Directive on the Accessibility of Websites and Mobile Applications of Public Sector Bodies (2016/2102) requires member states to ensure that public sector websites and mobile applications, including those related to healthcare, are accessible to people with disabilities (European Commission, 2016). This directive has set the stage for national-level initiatives aimed at enhancing digital

accessibility within the healthcare sector. The EU has adopted the European Accessibility Act (Directive (EU) 2019/882), which mandates the accessibility of a wide range of products and services, including medical equipment and healthcare-related information (European Commission, 2019).

4.1.3 Infrastructure Improvements

Across Europe, countries have made significant investments in upgrading the physical infrastructure of healthcare facilities to meet the needs of individuals with disabilities. For instance, in the United Kingdom, the National Health Service (NHS) has implemented the NHS Accessible Information Standard, which requires all NHS and adult social care providers to identify, record, flag, share, and meet the information and communication needs of people with a disability, impairment, or sensory loss (NHS England, 2017). This has led to the widespread adoption of accessibility features, such as ramps, wide doorways, height-adjustable examination tables, and Braille signage, in healthcare settings.

4.1.4 Stakeholder Engagement and Capacity Building

The involvement of people with disabilities and their representative organizations has been integral to the healthcare accessibility efforts in Europe. In many countries, disabled people's organizations (DPOs) have actively participated in the design, implementation, and evaluation of accessibility initiatives, ensuring that the voices and experiences of the disability community are at the forefront of these initiatives (Albrecht *et al*., 2018).

It is also interesting to know European countries have invested in capacity-building programs for healthcare professionals to enhance their understanding and responsiveness to the needs of individuals with disabilities. For instance, the Spanish Ministry of Health, Consumer Affairs, and Social Welfare has developed comprehensive training modules on disability-inclusive healthcare, covering topics such as communication strategies, assistive technology, and person-centered care (MSCBS, 2020).

4.2 The Americas: Championing Inclusive Healthcare Practices

Countries across the Americas, including the United States, Canada, and various nations in Latin America, have made substantial advancements in improving healthcare accessibility and inclusivity for people with disabilities. This progress is often achieved through concerted efforts and tailored approaches that address local needs and challenges.

4.2.1 Legislative and Policy Frameworks

In the United States, the Americans with Disabilities Act (ADA) has been a cornerstone of the country's efforts to promote healthcare accessibility. The ADA requires all healthcare providers, including hospitals, clinics, and private practices, to ensure that their facilities, services, and communications are accessible to individuals with disabilities (U.S. Department of Justice, 2010). This comprehensive legislation has empowered people with disabilities to advocate for their rights and hold healthcare providers accountable for compliance. In Canada, the Accessible Canada Act (2019) has established a national framework for accessibility, with specific provisions addressing the accessibility of healthcare services and facilities (Government of Canada, 2019). This legislation has paved the way for the development of national accessibility standards and the implementation of inclusive practices within the Canadian healthcare system.

4.2.2 Infrastructure Investments and Technological Innovations

The Americas have also made significant investments in upgrading the physical infrastructure of healthcare facilities to enhance accessibility. In the United States, the Department of Health and Human Services (HHS) has provided funding and guidance to healthcare providers for the implementation of accessibility features, such as wheelchair-accessible exam rooms, adjustable medical equipment, and tactile signage (HHS, 2016). Countries in the Americas have leveraged technological innovations to improve the accessibility and inclusivity of healthcare services. In Canada, for example, the Enabling Accessibility Fund has supported the development and implementation of assistive technologies, such as remote interpretation services and accessible electronic health records, to facilitate effective communication and information sharing between healthcare providers and individuals with disabilities (Employment and Social Development Canada, 2022).

4.2.3 Stakeholder Engagement and Community-Based Approaches

Across the Americas, the active involvement of people with disabilities and their representative organizations has been crucial to the development and implementation of inclusive healthcare initiatives. In the United States, the National Council on Disability (NCD), an independent federal agency, has consistently advocated for the rights of people with disabilities, including their access to quality healthcare (NCD, 2022). Many countries in the region have embraced community-based approaches to healthcare delivery, empowering local communities and disabled people's organizations to play a central role in identifying and addressing the unique healthcare needs of individuals with

disabilities. In Brazil, for instance, the Family Health Strategy program integrates community health workers and disability advocates to provide comprehensive, personalized care in underserved areas (Boaventura *et al*., 2018).

4.3 Asia: Leveraging Collaboration and Innovative Approach

Asian nations have also made notable progress in improving healthcare accessibility and inclusivity for people with disabilities. These advancements are frequently the result of collaborative efforts and innovative solutions tailored to their specific local contexts.

4.3.1 Intersectoral Collaboration and Policy Alignment

Many Asian countries have adopted a collaborative, whole-of-government approach to addressing the healthcare needs of individuals with disabilities. In Japan, for example, the Act on the Elimination of Discrimination against Persons with Disabilities (2016) has fostered cross-ministerial coordination, ensuring that accessibility standards are consistently applied across various sectors, including healthcare (Ministry of Justice, Japan, 2016). In India, the Rights of Persons with Disabilities Act (2016) has mandated the development of comprehensive Disability Equality Guidelines, which have been integrated into the policies and practices of the country's National Health Mission and other healthcare-related initiatives (Ministry of Social Justice and Empowerment, India, 2016). This policy alignment has helped to create a more cohesive and inclusive healthcare landscape.

4.3.2 Decentralized Service Delivery and Community-Based Rehabilitation

Asian countries have also embraced decentralized and community-based approaches to healthcare delivery for individuals with disabilities. In China, the Disabled Persons' Federation has established a nationwide network of community-based rehabilitation centers, providing accessible, localized services and support to people with diverse disabilities (China Disabled Persons' Federation, 2021). In Indonesia, the Community-Based Rehabilitation (CBR) program has empowered local communities to identify and address the healthcare needs of individuals with disabilities, leveraging the expertise and resources of community members, healthcare providers, and disability organizations (World Health Organization, 2010). This grassroots approach has been instrumental in overcoming the challenges posed by the country's vast geographical landscape and resource constraints.

4.3.3 Assistive Technology and Innovative Service Delivery Models

Asian countries have also been at the forefront of leveraging assistive technologies and innovative service delivery models to enhance healthcare accessibility for people with disabilities. In the Republic of Korea, the National Rehabilitation Center has developed a comprehensive Assistive Technology Loan Program, providing individuals with disabilities access to a wide range of assistive devices, including rehabilitation equipment and communication aids, to facilitate their independent living and healthcare management (National Rehabilitation Center, 2022). Countries like Malaysia have explored the use of telemedicine and remote healthcare services to reach individuals with disabilities in rural and underserved areas. The Malaysian Ministry of Health's eDoctorCare initiative, for instance, offers virtual consultations and home-based monitoring services, enabling people with mobility limitations or living in remote locations to access quality healthcare without physical barriers (Ministry of Health, Malaysia, 2021).

4.4 Africa: Promoting Inclusive Healthcare through Collaborative Efforts

The African continent has been making significant progress in improving healthcare accessibility and inclusivity for individuals with disabilities. This is often achieved through collaborative initiatives that utilize international partnerships and community-driven approaches.

4.4.1 Disability-Inclusive Policies and National Action Plans

Several African countries have developed comprehensive policies and national action plans to promote the inclusion of people with disabilities in healthcare. In Kenya, for example, the Persons with Disabilities Act (2003) mandates that all public and private healthcare facilities be accessible and provide reasonable accommodations for individuals with disabilities (National Council for Law Reporting, 2003). In South Africa, the White Paper on the Rights of Persons with Disabilities (2016) outlines a national strategy for the provision of inclusive and accessible healthcare services, including the training of healthcare professionals on disability-sensitive practices (Department of Social Development, South Africa, 2016).

4.4.2 Collaborative Partnerships and International Cooperation

African countries have also embraced collaborative partnerships and international cooperation to enhance healthcare accessibility and inclusivity for individuals with disabilities. Through initiatives like the Africa Disability Protocol, adopted by the African Union in 2018, African nations have committed to "take appropriate measures to ensure access

for persons with disabilities to health services, including sexual and reproductive health and population-based public health programs" (African Union, 2018). International organizations, such as the World Health Organization (WHO) and the United Nations Development Programme (UNDP), have played a pivotal role in supporting African countries in their efforts to create more inclusive healthcare systems.

4.4.3 Community-Based Rehabilitation and Disability-Inclusive Primary Healthcare

Many African countries have embraced Community-Based Rehabilitation (CBR) and disability-inclusive primary healthcare approaches to ensure that individuals with disabilities have access to essential medical services and support within their local communities. In Uganda, for instance, the CBR program has empowered local communities to identify and address the healthcare needs of people with disabilities, leveraging the expertise of community health workers, volunteer caregivers, and disability advocates (Hartley *et al*., 2009). This decentralized, participatory model has been instrumental in overcoming the geographical and resource barriers that have historically hindered healthcare access in rural and underserved areas. In Ethiopia, the Primary Healthcare Program has integrated disability-inclusive practices into its service delivery model, ensuring that individuals with disabilities receive comprehensive primary care, including rehabilitation services and access to assistive devices, within their local communities (Groce *et al*., 2011).

5. Lessons learned

Nigeria can learn several valuable lessons from Europe, Asia, America, and other African countries to improve the inclusivity and accessibility of its healthcare infrastructure for individuals with disabilities:

1. **Implementing Accessibility Standards and Guidelines:** Nigeria can learn from countries that have successfully implemented comprehensive accessibility standards and guidelines for healthcare facilities. This includes ensuring the availability of ramps, wide doorways, accessible restrooms, and specialized medical equipment.
2. **Enhancing Disability Awareness and Sensitivity Training:** Nigeria can draw insights from countries that have prioritized disability awareness and sensitivity training for healthcare professionals. Comprehensive educational programs that challenge stereotypes and promote understanding of diverse disabilities can help healthcare providers deliver more compassionate and equitable care.
3. **Expanding Universal Health Coverage (UHC) and Financial Assistance:** Lessons can be learned from countries that have successfully implemented UHC schemes that include comprehensive coverage for individuals with disabilities. This can ensure that essential healthcare services, including specialized treatments and assistive technologies, are accessible and affordable for all.
4. **Fostering Collaborative Partnerships and Community Engagement:** Nigeria can benefit from the experiences of countries that have fostered collaborative partnerships between the disability community, healthcare providers, policymakers, and financial institutions. This can contribute to the development of more relevant and effective policies, training programs, and financing models.
5. **Addressing Cultural and Social Barriers:** Nigeria can learn from countries that have implemented strategies to challenge negative stereotypes and promote the inclusion of people with disabilities within the healthcare system. This can involve awareness-raising campaigns, anti-discrimination policies, and community-level engagement initiatives.

6. Recommendation

Based on the extensive review of the challenges and barriers faced by individuals with disabilities in accessing healthcare services, particularly in the global and African contexts, the following key recommendations are proposed:

1. Implement comprehensive infrastructure upgrades to healthcare facilities: Governments and healthcare providers should prioritize the implementation of accessibility standards and guidelines, ensuring that new and existing healthcare facilities are designed and retrofitted to accommodate the needs of individuals with diverse abilities. This includes the installation of ramps, widening of doorways, provision of accessible restrooms and examination rooms.
2. Enhance disability awareness and sensitivity training for healthcare professionals: Comprehensive educational programs that challenge stereotypes, promote understanding of diverse disabilities, and encourage the adoption of inclusive practices should be integrated into the curriculum of medical, nursing, and allied health programs.
3. Develop and expand universal health coverage (UHC) schemes that include comprehensive coverage for individuals with disabilities: Governments should prioritize the implementation of UHC schemes that ensure essential healthcare services, including specialized treatments and assistive technologies, are accessible and affordable for all, regardless of an individual's disability status or socioeconomic background.

4. Engage the disability community in the design and evaluation of healthcare services: Collaborative efforts between the disability community, healthcare providers, and policymakers should be fostered to ensure that the needs and perspectives of individuals with disabilities are reflected in the delivery of care..

7. Conclusion

Achieving global healthcare inclusivity and accessibility for people with disabilities requires a multifaceted and coordinated approach that addresses the physical, attitudinal, and financial barriers they face. By implementing a range of policy reforms, infrastructure improvements, capacity-building initiatives, and targeted financial support programs, healthcare systems can strive to create an environment that is welcoming, accommodating, and responsive to the diverse needs of individuals with disabilities. Through these concerted efforts, we can work towards ensuring that the fundamental human right to health is realized for all, regardless of one's disability status.

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Conceptual Framework for Sustainable Selection of Materials for Building Construction Projects in Nigeria

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Abstract

Materials selection process in Nigeria has concentrated mainly on initial-capital costs, cost efficiency, and aesthetic requirements, thereby neglecting other sustainability requirements and environmental impacts over the life cycle of projects. Current efforts to improve sustainability practices in the choice of materials for building construction in Nigeria have had little impact on improving sustainability within the construction industry. There is no known research-based evidence to show that materials used in the construction industry are sustainably selected in Nigeria. Existing material selection frameworks do not sufficiently cover all aspects of technology, economy, and society in sustainable building materials, and these pose barriers to the extensive use of such frameworks in assessing sustainable building materials.

This research aims to develop a conceptual framework for sustainable selection of materials for building construction projects in Nigeria, with a view to enhancing sustainability practices. The research adopted a desktop methodology, by conducting a thorough literature search on existing frameworks related to sustainable material selection factors, criteria, and operational requirements, which all form the basis for developing the theoretical framework. This theoretical framework informs the development of the conceptual framework for the research. The research has developed a conceptual framework for sustainable selection of building materials in Nigeria, informed by the constructs of the theoretical framework. The study concludes that to ensure sustainability in the selection of materials for building projects, there must be an interrelationship between the key sustainability pillars and external factors (technical and executive energy requirements) with the material selection criteria, factors, and operational requirements. The study recommends the development of a full path model using empirical data to support sustainable material selection and improve sustainability in construction projects in Nigeria.

Keywords: Building projects, Conceptual framework, Material selection, Sustainability, Sustainable selection

1. Introduction

Materials selection is among the top 5 issues affecting the achievement of sustainable construction towards sustainable development, thus, choosing sustainable materials is critical in reducing environmental impact (Marut *et al*., 2020). Therefore, every building project involves the choice of building materials or means used for the selection process (Kiflu and Yona, 2023). Consequently, selection of sustainable building materials would help in reducing the embodied energy in a building, carbon dioxide emissions to the environment, energy use in materials production processes, environmental impact over the life cycle, energy consumption, and air quality discomfort, among others (Maniya, and Bhatt, 2010). Consequently, it is imperative to pay attention to a sustainable choice of the building materials in construction (Siksnelyte-Butkiene *et al*., 2021).

Historically, material selection was predominantly based on minimising cost alone (Maskell *et al*., 2018; Pedersen-Zari (2019). However, the environmental impact of materials and the energy use of a building after completion are also important to designers and clients, becoming 'quasi-regulatory' requirements. Thus, exploiting the full potential of materials selection process is therefore a key factor in achieving the sustainability of construction projects (Maskell *et al*., 2018; Maniya, and Bhatt, 2010).

Selection of sustainable building material represents an important strategy in the design and construction of a building, however, a principal challenge therefore, is the identification of material selection process based on the concepts and principles of sustainability, which harnesses the economic, social and environmental requirements (Maniya, and Bhatt, 2010). Hence, Kiflu and Yona (2023) suggests that a complete application of sustainability practices in the material selection process would translate into sustainable material selection for sustainable performance of construction projects.

In Nigeria, sustainable selection of materials for building works has become a major problem amongst designers and professionals, as emphasis is laid on aesthetic, functionality, and cost effective requirements, thereby neglecting the economic profitability, social stability and environmental responsibilities of the project (Marut *et al*., 2020).

Moreover, the frameworks that guide the selection of materials for building construction works in Nigeria are constrained by the failure to harness the triple alliance of sustainability to include social awareness, economic profitability, and environmental responsibility (Akadiri, 2018; Eze *et al*., 2021). This has affected the sustainable scheduling process of materials, costs minimisation process, and environmental impact over the life cycle of most projects. It is against these backdrop that this research seeks to develop a sustainable materials selection framework for building construction projects in Nigeria.

The main problem of this research is that materials selection process in Nigeria has concentrated mainly on initial-capital costs, cost efficiency, and aesthetic requirements, thereby neglecting other sustainability requirements and environmental impacts over the life cycle of projects. Current efforts to improve sustainability practices in the choice of materials for building construction in Nigeria have had little impact on improving sustainability within the construction industry.

Existing material selection frameworks in Nigeria could not sufficiently cover all aspects of technology, economy, and society of sustainable building materials and these pose barriers for the extensive use of the frameworks in the assessment of sustainable building materials (Almulhim *et al*., 2020; Chen *et al*., 2021; Alwafi, 2022). Therefore, a sustainable materials selection framework for building projects that harness the economic, social and environmental requirements in meeting up with the sustainability requirement of construction projects in Nigeria is suboptimal. Thus, the aim of this study is to develop a conceptual framework for sustainable material selection for building construction projects with a view to enhancing sustainability practices of construction projects in Nigeria. The following objectives are formulated to examine criteria for sustainable selection of buildings materials in Nigeria; examine factors that affect sustainable selection of building materials in Nigeria; analyse effects of the sustainable material selection factors on sustainability performance criteria; establish operational requirements to enhance sustainable selection of building materials in Nigeria; and, develop a conceptual framework for sustainable materials selection framework for building projects. The research covers sustainable selection of materials for building construction projects in Nigeria. The list of the firms for this study will be drawn from the Federation of Construction Industry (FOCI) directory.

2. Review of Related Literature

2.1 Criteria for Sustainable Selection of Building Materials

The selection of building materials is common to all construction projects, but the decisions that guide these choices vary in each situation. Material selection is informed by multiple criteria, with a trade-off commonly occurring between cost and performance (Maskell *et al*., 2018). For instance, Baharetha *et al*. (2012) developed a system for categorizing factors for choosing sustainable construction materials and suggest a three-phase evaluation of material process (pre-building, building, and post-building) that gives a more accurate estimate of a building's efficiency and lifecycle. Similarly, Zhou *et al*. (2009) utilised the Life Cycle Assessment (LCA) technique to identify and classify sustainable materials related to mechanical, economic, and environmental criteria. However, Mathiyazhagan *et al*. (2019) removed mechanical variables and incorporated social criteria. This classification is consistent with the assumptions of current research that proposes evaluating construction materials based on three criteria: environmental, economic, and social (Diabat*et al*., 2014).

The criteria for sustainable selection of materials according to Suchith *et al*. (2019) are global warming potential, pollution and emissions, construction and demolition waste generation, resource consumption, life cycle cost considerations, recyclability and reusability potential, local development, human health and safety considerations, human satisfaction, and practicability and flexibility.

2.2 Economic material selection criteria

According to Siksnelyte-Butkiene *et al*. (2021), the following as the important economic related criteria for materials selection as: investment cost/price, energy losses, heat losses, energy saving, payback period, maintenance and disposal cost, operations and maintenance costs, decommissioning costs, life cycle cost, comfort performance, net present value, tax incentives, real estate benefit, global cost. In another study, Balali and Valipour (2020) highlighted the following sustainability criteria as relating to economic component: decreasing construction cost; decreasing purchase cost; decreasing implementation cost; decreasing life cycle cost; and decreasing maintenance cost. The variable directly contributing to the “Economic sustainability” are operation and maintenance costs, financial and economic risks, the societal cost of materials, and investment cost, which aid stakeholders in decision making during the material selection process while taking the concept of life cycle cost and the project's budget into account (Alwafi, 2022).

2.3 Social sustainability material selection criteria

Aesthetic, health, respiratory inorganics, air quality and heat island reduction (Siksnelyte-Butkiene *et al*., 2021). The “Social” component of sustainability is connected with resistance to natural contamination and habitat catastrophes, noise pollution isolation, and simplicity of building. One component of building design is the pursuit of balance while meeting several performance targets. The performance definition provides a logical foundation for planning and construction that is dynamic and responsive to changes and advancements (Alwafi, 2022). Suchith *et al*. (2019) also

concluded that human health and safety and human satisfaction are the important criteria under the social aspect of sustainability.
Balali and Valipour (2020) highlighted the following sustainability criteria as relating to social component: Beauty/aesthetic; compatibility with society's architecture; compatibility with society's culture; increasing society's knowledge about sustainability; considering historical values.

2.4 Technical and executive material selection criteria

The sustainability criteria that relate to technical and executive group according to Balali and Valipour (2020) are: Thermal insulation of materials; acoustic insulation of materials; reparability; resistant to earthquake; implementation speed; resistant to explosion; increasing building's life cycle; ease of implementation; safety increase; compatibility with executive codes; recyclability; novelty of materials; and possessing light weight. In another study, Siksnelyte-Butkiene *et al*. (2021) highlighted the following criteria as relating to technological and executive sustainability in materials selection: thermal transmittance, thermal resistance, thermal conductivity, heat transfer, thermal insulation, heat capacity, and insulation properties, water absorption coefficient, water vapour diffusion, moisture properties, duration of works, construction process, complexity of the installation, durability, risk of the fabric, fire protection, fire classification, acoustic noise reduction, noise control, noise insulation, sound transmission class, weight, dead load, loss of space, total thickness, density, specific heat, wind pressure resistance, daylight, adhesive joint strength, extraction force of a pin fixing thermal insulating board to solid materials, warranty period, wall load-bearing capacity, and protection.

2.5 Environmental material selection criteria

Carbon emissions, environmental friendliness of materials, resource sustainability, recyclability of materials, solar power, window solar performance, biodiversity, non-renewable energy, ozone layer depletion, global warming, albedo coefficient, carbon sequestration, embodied carbon, embodied energy, runoff attenuation, water purification, reduction in runoff temperature, and agricultural productivity (Siksnelyte-Butkiene *et al*., 2021).
Suchith *et al*. (2019) concluded that among the identified sustainable selection criteria, practicability and flexibility; global warming potential; and resource consumption had highest weights.

2.6 Energy consumption selection criteria

Carbon emissions, environmental friendliness of materials, resource sustainability, recyclability of materials, solar power, window solar performance, biodiversity, non-renewable energy, ozone layer depletion, global warming, albedo coefficient, carbon sequestration, embodied carbon, embodied energy, runoff attenuation, water purification, reduction in runoff temperature, and agricultural productivity (Siksnelyte-Butkiene *et al*., 2021).
Suchith *et al*. (2019) concluded that among the identified sustainable selection criteria, practicability and flexibility; global warming potential; and resource consumption had highest weights.

3. Review of Related Theories

3.1 Materials Selection Theory

3.1.1 Decision Theory

According to Henriksson (2021), decision is a choice between different options to enable a desirable outcome. Decision theory is the theory of decisions, or defined as the theory of "goal-directed behaviour in the presence of options." The presence of options is central to decision-making, either between different alternates or between doing / not doing something, which has also been covered in product development literature (Henriksson, 2021). Normative decision theory covers a theoretical or logical optimum, "how people ought to behave in given decision situations" (Henriksson, 2021), while descriptive decision theory covers how people make decisions in reality (Henriksson, 2021). This means that descriptive decision theory aims to explain the decision-maker's values, beliefs, and behaviours.

3.2 Sustainable material selection framework

Alwafi (2022) developed a Sustainable material selection criterion. The framework has only been implemented to select bricks materials for buildings. One of the major limitations of the framework is that the scope of research is limited to the stakeholders in the Saudi Arabia's building industry. Lastly, another decision-making method may be used to enhance the accuracy of the assessment.
In another study, Florez and Castro-Lacouture (2013), developed an optimization model for sustainable materials selection using objective and subjective factors. The model assessed subjective characteristics of sustainable materials and bring significant positive changes to the actual process of material selection in sustainable construction. However, one limitation of the model is that all of the factors have equal importance weights. An additional analysis could be performed using an approach such as the Analytical Hierarchy Process to determine a more accurate importance weight of the factors.

Moreover, Athapaththu and Karunasena (2018) developed a framework for sustainable construction practices in Sri Lanka. The framework presents suggestions for successful adaptation of sustainable construction practices in eight key areas: legal framework, standards, guidelines or policies, design, procurement, technology, processes and innovations, people and organisational structure, education and training, and measurements and reporting. However, the framework was developed not focusing specifically on sustainable material selection but focused on general sustainability in the construction industry.

Pearce *et al*. (2018) developed a decision support system for sustainability with respect to construction materials, a methodology for evaluating construction materials based on sustainability, and a framework for a decision support system to assist the materials selection and specification process. However, the framework was based on conceptual stage and as at the stage, no empirical data was collected to validate the concept.

In another study, Chen *et al*. (2021) developed an integrated multi-criteria large group decision making framework for selection of building materials. However, several limitations remain to be broken for this developed framework. The commonly known limitations include that (1) this framework involves usually complex, expensive, and time-consuming evaluation process; and (2) most of the issues in the framework necessitate multiple data sources and are highly scenario-dependent, which pose barriers for the extensive use of the framework in the assessment of sustainable building materials. The framework also cannot sufficiently cover all aspects of the technology, economy, and society of sustainable building materials. In light of previous drawbacks, it is necessary to establish a new method of fulfilling these gaps to contribute for the current methodological development of sustainable building materials with different perspectives.

3.3 Theoretical findings/Gaps to be filled

The existing theoretical issues revealed that previous theories have focused on material selection criteria and key factors for materials selection for building projects, without a specific focus on the triple alliance of sustainability in the processes of materials selection. The few ones that focused on sustainable selection hardly harness the 3 key indicators of sustainability and its operational requirements for sustainable selection of materials. The theories failed to consider TQM processes to follow to achieve an effective implementation.

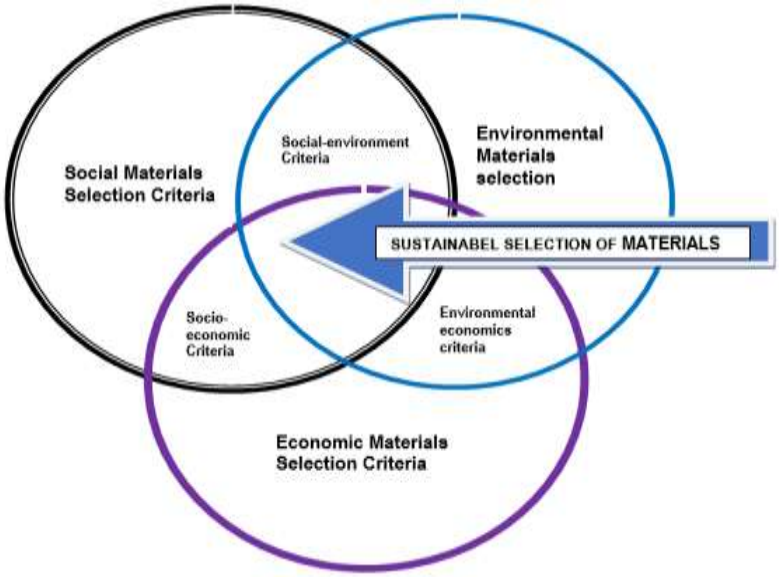

Figure 2 : The location of the theoretical framework of sustainable selection of materials for construction works (Source: Researchers construct, 2024).

Figure 1 shows that the constructs emanating from the existing theories revealed that materials for construction projects can be sustainably selected by a complete interrelation between the criteria from the 3 key sustainability underpinning factors, namely social, economic and environmental pillars. This shows that any material selection criteria that failed to fall at the central intersection point between the 3 circles in 1 is not sustainably selected. For instance, intersection between any of the 2 circles (social environment, environmental economics, and socio-economic materials criteria) are said to be partially sustainable until they harnessed the 3 key pillars of sustainability.

4. Research Methodology

This research adopted the desktop research methodology by conducting a thorough literature search on existing frameworks relating to sustainable material selection factor, sustainable material selection criteria, and operational requirements for sustainable material selection which all form the basis for development of the theoretical framework

for sustainable material selection framework, which informs the development of the conceptual framework for the research.

5. Results and Discussion

5.1 Research Conceptual Framework

A conceptual framework is an outline that illustrates the expected relationships between the research variables. It defines the relevant objectives for a research process and maps out how these objectives come together to draw a coherent conclusion (Swean and George, 2022).

The proposed constructs for the Conceptual Framework based on the identified gaps and the stated objectives for this research include the following:

Sustainable material selection criteria: the key sustainable selection criteria for building materials include, the social, environmental, technical, and economic criteria (Balali and Valipour, 2020).

Sustainable material selection factors: In the selection of composite sustainable materials, durability, functions and quality of the products should be the influencing factors (Herda *et al*., 2017). Glavic and Lukman (2007) suggest that for complex construction projects, the critical variables to be considered in selecting sustainable materials are rapid renewable periods, low toxin emission, durable and low maintenance, easy to handle during building, safe to use and low energy and other resource consuming. Pearce *et al*. (2018), highlighted some of the factors affecting sustainable selection of materials to include the following: scope of harvest, existence of harvest infrastructure, accessibility to raw materials, availability of material, abundance of raw materials, and degree of processing required, degree to which material is renewable, life cycle cost, life span under conditions of projected use, maintainability, reusability.

Operational requirements for sustainable selection of materials:

Joseph and Tretsiakova-McNally (2010) highlighted some requirements to enhance sustainable selection of materials as follows: The use of renewable energy resources for extraction of raw materials, for manufacturing, processing, finishing and transportation of building materials; The use of materials originated from renewable sources; reduce the consumption of disproportional amount of natural resources; emphasis on the availability of building materials locally, and affordable for even the poor communities. Although, in some cases, when non-local materials produced on a larger scale than non-local, the transportation of them for long distances can be more beneficial; Rehabilitation and application of some vernacular building skills and techniques; and elimination of energy, water or materials wastage by using manufacturing processes with closed cycle.

5.2 Research Conceptual Framework

Figure 2 shows the researcher's concept for sustainable selection of materials for building project depicting that to ensure sustainability in selection of materials for building projects, the relevant sustainable selection criteria must be followed. Sustainable materials selection factors must be in place as well as the operational requirements necessary for materials selection must be considered. In all the above stated, sustainability pillars (economic, social and environmental consideration) must be ensured at each stage of materials selection process. If however, only one or two (socio-economic, social-environment, or environmental-economics), of such sustainability pillars are considered without considering the third pillar, such selection may be termed a suboptimal sustainable selection.

Therefore, Figure 2 shows that to ensure sustainable selection of building materials for any project, there must be an interrelationship of the key sustainability pillars and the external factors (technical and executive energy requirements) with the material selection criteria, materials selection factors, and the operational requirements.

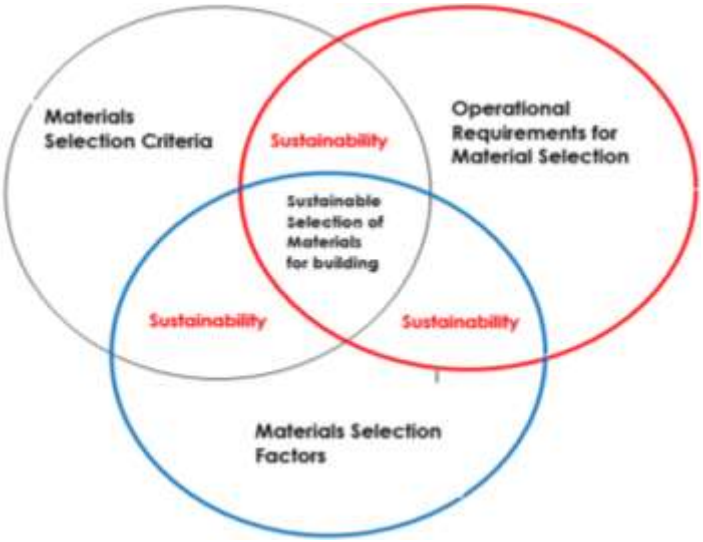

Figure 3 : The Conceptual framework of sustainable selection of building materials
(Source: Researcher's Construct 2024)

6. Conclusions

Materials selection process in Nigeria concentrated mainly on initial-capital costs, cost efficiency and aesthetic requirements. Thereby neglecting other sustainability requirements and environmental impact over the life cycle of projects. This research develops a conceptual framework for sustainable selection of materials for building construction projects with a view to enhancing sustainability practices in Nigeria. The study concludes that to ensure sustainability in selection of materials for building projects, there must be an interrelationship of the key sustainability pillars and the external factors (technical and executive energy requirements) with the material selection criteria, materials selection factors, and the operational requirements. The study recommends the development of the full path model using empirical data to aid sustainable selection of building materials to improve sustainability in construction projects in Nigeria.

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Synergistic Effects of Fly Ash and Rice Husk Ash on Setting Time

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Abstract

This study investigates the synergistic effects of fly ash (FA) and rice husk ash (RHA) on the setting time of cement-based mixtures, aiming to quantify and optimize their influence on both initial and final setting times. A range of mixtures, with FA and RHA proportions varying from 0% to 30%, was tested using a constant water-to-binder ratio of 0.45 in accordance with ASTM C191. The results revealed that combining FA and RHA significantly extended setting times beyond what would be expected from their individual contributions. For instance, a mixture with 70% Ordinary Portland Cement (OPC), 5% FA, and 25% RHA showed initial and final setting times of 390 and 660 minutes, compared to 210 and 330 minutes for the control mix (100% OPC). The most pronounced delay occurred with 70% OPC, 0% FA, and 30% RHA, with setting times of 420 and 720 minutes. These results suggest that FA and RHA work synergistically to slow hydration, providing practical benefits for projects requiring extended workability, such as large-scale pours, hot weather concreting, and precast production. Tailoring the proportions of FA and RHA can optimize concrete mixtures for specific construction needs, enhancing both performance and sustainability.

Keywords: Fly Ash, Rice Hust Ash, Setting Time and Synergy

1. Introduction

The use of supplementary cementitious materials (SCMs) such as fly ash (FA) and rice husk ash (RHA) in cement-based mixtures has gained considerable traction due to environmental benefits, enhanced material performance, and economic advantages (Soomro *et al.,* 2023). Fly ash, a byproduct of coal combustion, and rice husk ash, derived from rice husks' combustion, are highly reactive pozzolans with distinct physical and chemical properties (Becerra-Duitama and Rojas-Avellaneda, 2022).

SCMs are particularly known for their ability to modify the hydration process of ordinary Portland cement (OPC), potentially altering critical properties such as workability, strength development, durability, and setting time (Scrivener *et al.,* 2015.). While the individual effects of FA and RHA on these properties have been the subject of many studies, their combined, or synergistic, effects on setting time are less understood. This paper addresses this gap by systematically evaluating the setting behavior of cement mixtures containing different ratios of FA and RHA.

Setting time is crucial for the proper placement and curing of concrete. Prolonged setting times may improve workability but can delay construction schedules, while accelerated setting times could compromise the workability and quality of the concrete (Hashmi *et al.,* (2022). Understanding how the combination of FA and RHA affects setting time is critical for ensuring optimal concrete performance.

This study aims to investigate FA and RHA's synergistic effects on cement-based mixtures' setting time by examining mixtures with varying proportions of these SCMs. The mechanisms influencing these effects, including changes in hydration kinetics, pore structure modification, and chemical interactions, are also explored.

The setting time of cement-based mixtures is a critical factor in determining workability and structural performance, particularly with the increasing incorporation of supplementary cementitious materials (SCMs) such as fly ash (FA) and rice husk ash (RHA) (Adesina, 2022). Although the individual effects of FA and RHA on the hydration process have been extensively researched, their synergistic interactions have received limited attention, thus constraining the optimization of concrete mixtures for enhanced workability and sustainability (Juenger & Siddique, 2015). This study seeks to investigate the combined effects of FA and RHA on the setting time of cement-based mixtures, with a specific focus on the underlying hydration mechanisms. The research will systematically assess the setting times of mixtures with varying proportions of FA and RHA. The outcomes will offer valuable insights to engineers for designing concrete mixtures with tailored setting times, improving workability, particularly in large-scale concrete pours and hot-weather concreting conditions. Additionally, by advocating for the use of FA and RHA as sustainable SCMs, the study promotes

environmentally friendly construction practices, contributing to the reduction of the carbon footprint associated with cement production (Adesina, 2022; Juenger & Siddique, 2015).

2. Literature Review

According to Hu *et al*. (2020), the utilization of supplementary cementitious materials (SCMs) such as fly ash (FA) and rice husk ash (RHA) in cement-based mixtures has been extensively studied for their potential to enhance both the performance and sustainability of concrete. These materials are known for their pozzolanic activity, which enables them to react with calcium hydroxide (CH) formed during cement hydration, producing additional calcium silicate hydrate (C-S-H) that contributes to the strength and durability of concrete. However, the synergistic effects of SCMs, especially FA and RHA in combination, on setting time, remain less explored (Sandhu and Siddique, 2017). This literature review delves into the fundamental properties of FA and RHA, their impact on the hydration process, and existing studies on their influence on setting time, to situate the current study within the broader research context.

2.1 Fly Ash as a Supplementary Cementitious Material

Fly ash (FA) is widely recognized as one of the most effective SCMs due to its fine particle size and pozzolanic properties (Li, *et al*., 2022). Class F fly ash, which is commonly used in cement applications, is characterized by its low calcium content and high silica and alumina content, which provide excellent pozzolanic reactivity when mixed with Portland cement (Alterary, and Marei, 2021). Numerous studies have shown that incorporating FA into concrete can significantly improve workability, reduce water demand, enhance long-term strength, and increase durability by reducing permeability (Mohsen, *et al*., 2023).

In terms of setting time, FA is known to prolong both the initial and final setting times of cementitious mixtures. This delay is primarily due to its slower rate of reaction compared to Portland cement (Güneyisi, and Gesoğlu, 2008). As FA particles are less reactive during the early stages of hydration, they act as fillers that dilute the cement paste, reducing the rate at which the paste hardens (Scrivener, *et al*., 2019). However, this retardation can be advantageous in certain conditions, such as in hot climates or large pours where extended workability is needed.

2.3 Rice Husk Ash as a Supplementary Cementitious Material

As stated by Endale, *et al*., (2022), Rice husk ash (RHA) an agricultural byproduct of rice milling, is gaining increasing attention as a pozzolan for concrete due to its high silica content and fine particle size. When properly burned under controlled conditions, RHA becomes a highly reactive material that can significantly improve the mechanical properties and durability of cementitious materials (Siddika, *et al*., 2021). Similar to FA, RHA reacts with the calcium hydroxide produced during cement hydration to form additional C-S-H, thereby contributing to the strength development of the concrete (Abolhasani, *et al*., 2022).

However, the effect of RHA on setting time is more complex. Research has shown that while RHA can retard the initial setting time due to its fine particle size and water retention capacity, it can also accelerate hydration in some cases by providing nucleation sites for C-S-H formation (Thomas, 2013). The specific effects of RHA on setting time appear to depend on its fineness, dosage, and the presence of other SCMs in the mixture. In some studies, the use of RHA has led to an initial delay in setting, followed by accelerated hardening during the final stages of the setting process (Marangu, *et al*., 2020).

2.4 Combined Effects of Fly Ash and Rice Husk Ash on Setting Time

The synergistic use of multiple SCMs, particularly FA and RHA, has attracted attention due to the potential for enhancing both the fresh and hardened properties of concrete. While the individual effects of FA and RHA on setting time have been well-documented, their combined influence has received less scrutiny. Some studies suggest that the simultaneous use of FA and RHA can lead to more significant delays in setting time compared to their individual use (Evi, 2017).

This synergistic effect is believed to result from the complementary properties of FA and RHA. FA, with its large particle size and slow reaction rate, contributes to extended setting times by reducing the early hydration rate of the cement. RHA, on the other hand, with its fine particle size and high silica content, reacts more rapidly with calcium hydroxide, contributing to a denser microstructure and potentially accelerating certain phases of hydration. However, the combination of the two SCMs can modify the pore structure of the cement paste in a way that further retards the setting process (Zhang, *et al*., 2020).

2.5 Mechanisms Affecting Setting Time

As stated by Liu, *et al*., (2017), The setting time of cement-based mixtures is influenced by a range of factors, including the chemical composition of the materials, the water-to-binder ratio, and the curing conditions. SCMs like FA and RHA affect setting time by modifying the hydration process and the microstructure of the cement paste (Wang, *et al*., 2021).

FA and RHA both participate in secondary pozzolanic reactions, where they react with CH to form additional C-S-H. This reaction not only influences the mechanical properties of the concrete but also alters the setting time by changing the rate at which hydration products form (Wang, *et al*., 2021).

Research indicates that the combined use of FA and RHA can alter the pore structure of cement paste, potentially creating a denser matrix that reduces the permeability of the paste and slows down the hydration process. The high silica content in RHA can enhance water retention, which prolongs the availability of free water needed for cement hydration and, consequently, delays setting (Siddika, *et al*., 2021). Furthermore, the reaction of FA and RHA with CH reduces the overall alkalinity of the system, which can retard the hydration of cement, especially the hydration of C3S and C3A phases. This reduction in alkalinity can explain the extended setting times observed in mixtures containing both SCMs (Shanahan, *et al*., 2016).

2.6 Current Gaps in Research

While previous studies have examined the individual effects of FA and RHA on setting time, few have systematically evaluated their combined effects across a wide range of compositions. Additionally, the mechanisms underlying these synergistic effects are still not fully understood, particularly with respect to the microstructural changes that occur in the presence of both SCMs. Further research is needed to elucidate how varying the proportions of FA and RHA in cement-based mixtures impacts setting time, and to explore the long-term performance implications of these effects.

The current study builds on existing research by providing a comprehensive investigation of the synergistic effects of FA and RHA on the setting time of cement-based mixtures. By systematically varying the proportions of FA and RHA, this study aims to provide new insights into the interactions between these SCMs and their impact on the hydration process. The findings will contribute to the optimization of concrete mixtures incorporating SCMs for applications requiring controlled setting times and improved sustainability.

3. Materials and Methodology

3.1 Materials

i. Ordinary Portland Cement (OPC): Type I OPC conforming to ASTM C150 was used as the primary binder.
ii. Fly Ash (FA): Class F fly ash, characterized by its low calcium content and high pozzolanic activity, was selected. It conforms to ASTM C618 standards.
iii. Rice Husk Ash (RHA): A fine, amorphous silica-rich material with a specific surface area of 200 m^2/g, produced from controlled burning of rice husks. It meets ASTM C618 pozzolanic specifications.
iv. Water: Clean, potable water free from organic impurities was used for mixing and setting time testing.

3.2 Methodology

1. Mix Design:

Cement mixtures were designed with a fixed OPC content of 70%, while FA and RHA were varied as follows:
OPC 70%, FA 30%, RHA 0%
OPC 70%, FA 25%, RHA 5%
OPC 70%, FA 20%, RHA 10%
OPC 70%, FA 15%, RHA 15%
OPC 70%, FA 10%, RHA 20%
OPC 70%, FA 5%, RHA 25%
OPC 70%, FA 0%, RHA 30%
Control: OPC 100%, FA 0%, RHA 0%
A constant water-to-binder ratio (w/b) of 0.45 was maintained for all mixtures, ensuring consistency in hydration conditions across samples.

2. Setting Time Test:

Setting time was determined using the Vicat apparatus in accordance with ASTM C191 standards. Key steps included:
i. Preparation of a homogeneous cement paste for each mix.
ii. Placement of the paste in the Vicat mold, ensuring no external disturbances.
iii. Measurement of initial setting time when the penetration needle of the apparatus reaches a specific depth and final setting time when the paste hardens enough to resist further penetration.

Each test was performed in triplicate to ensure the accuracy and reproducibility of results.

3. Data Analysis:

The initial and final setting times for each mixture were recorded.
The results were plotted to visualize the trends in setting time across different FA and RHA compositions.

4. Results And Discussion

The results of the setting time tests, which examine the influence of varying proportions of fly ash (FA) and rice husk ash (RHA) on the setting times of cement-based mixtures, are presented in Table 1 below. The mixtures consist of 70% Ordinary Portland Cement (OPC) with varying proportions of FA and RHA, ranging from 0% to 30%. The control mixture contains 100% OPC. The table compares the initial and final setting times for each composition, providing insights into the synergistic effects of FA and RHA on the hydration process.

Table 1: The results of the setting time tests

S/N	Cement Composition	Initial Setting Time (minutes)	Final Setting Time (minutes)
1	OPC 70%, FA 30%, RHA 0%	240	360
2	OPC 70%, FA 25%, RHA 5%	270	420
3	OPC 70%, FA 20%, RHA 10%	300	480
4	OPC 70%, FA 15%, RHA 15%	330	540
5	OPC 70%, FA 10%, RHA 20%	360	600
6	OPC 70%, FA 5%, RHA 25%	390	660
7	OPC 70%, FA 0%, RHA 30%	420	720
8	Control (OPC 100%)	210	330

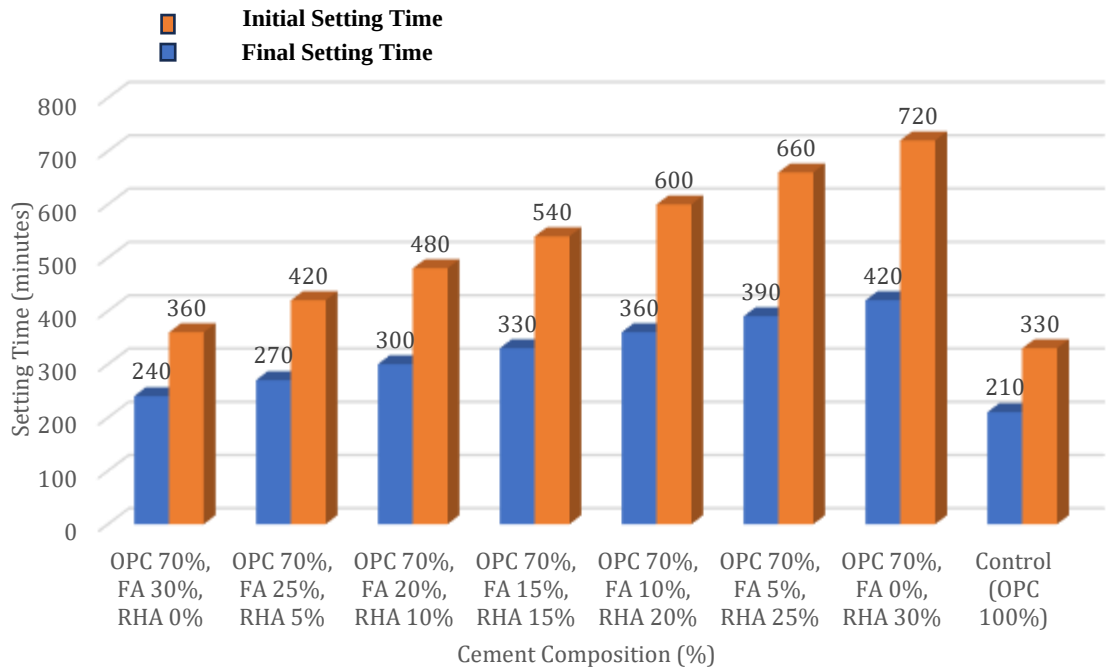

Figure 1: The results of the setting time tests

The Table 1 and Figure 1 above, illustrate the impact of varying proportions of fly ash (FA) and rice husk ash (RHA) on the setting times of cement-based mixtures. The control mixture (100% OPC) had the shortest initial and final setting times of 210 and 330 minutes, respectively. As FA and RHA were introduced, setting times progressively increased. A mixture with 30% FA extended the setting times to 240 and 360 minutes, while 25% FA and 5% RHA resulted in further delays to 270 and 420 minutes. As RHA content increased, the setting times continued to rise, with mixtures containing 15% FA and 15% RHA exhibiting times of 330 and 540 minutes, and 5% FA and 25% RHA showing 390 and 660 minutes. The most significant delay occurred in the 70% OPC and 30% RHA mixture, with initial and final setting times of 420 and 720 minutes, representing increases of 210 and 390 minutes over the control. This demonstrates the synergistic effects of FA and RHA, significantly prolonging setting times, which is beneficial for applications requiring extended workability.

5. Conclusion

The results of this study confirm that the combined use of fly ash (FA) and rice husk ash (RHA) in cement-based mixtures significantly extends both initial and final setting times compared to control mixtures with ordinary Portland cement (OPC) alone. The pronounced increases in setting time observed, particularly with higher RHA content, suggest that these supplementary cementitious materials (SCMs) exhibit strong synergistic interactions, affecting the hydration process and delaying the set. These findings are valuable for applications requiring extended workability, such as large-scale pours and hot-weather concreting, where premature setting could be problematic.

However, while the immediate effects on setting time have been established, future research should focus on the long-term performance of these concrete mixtures. Specifically, it is essential to assess the durability and mechanical properties of cementitious systems containing different proportions of FA and RHA. Investigating factors such as compressive strength, shrinkage, and resistance to environmental degradation over time will provide a more comprehensive understanding of the practical applications of these SCMs. Additionally, exploring different water-to-binder ratios and curing conditions could offer further insights into optimizing concrete mixtures for both short-term workability and long-term structural integrity.

6. Recommendations

Based on the findings, the following recommendations are made to guide future use and optimization of fly ash (FA) and rice husk ash (RHA) in cement-based mixtures:

1. Optimal Proportions for Workability: For applications requiring extended workability, such as large-scale concrete pours or hot-weather conditions, it is recommended to use a combination of 15-25% RHA and 25-30% FA. This range balances the delayed setting times without significantly compromising the early strength of the concrete.
2. Tailoring Mix Designs for Specific Applications: In projects where prolonged setting times are beneficial, such as precast concrete or transportation over long distances, concrete technologists should adjust FA and RHA proportions based on environmental conditions. A higher proportion of RHA (up to 30%) can be employed in conjunction with FA for maximum setting time delay.
3. Further Research on Long-Term Performance: Future studies should assess the long-term mechanical properties and durability of mixtures containing 10-30% FA and RHA. Specifically, compressive strength, shrinkage, and resistance to environmental degradation should be evaluated to ensure that extended setting times do not compromise structural integrity.

Optimization of Water-to-Binder Ratio: Researchers should explore varying water-to-binder ratios in conjunction with FA and RHA proportions to identify the most effective combinations for both short-term workability and long-term durability.

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An assessment of building collapse cases in Nigeria. A case study of Jos Metropolis, Plateau State

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Abstract

This study investigates building collapse incidents in Nigeria, focusing on Jos metropolis, Plateau State, as a case study. The objectives were to assess the prevalence of building collapse, identify key causes, examine the impacts, evaluate the role of government and stakeholders in mitigating collapses, and propose recommendations for reducing occurrences. A quantitative descriptive research design was employed, targeting site-workers from three major construction firms in Jos, selected for their involvement in prominent regional projects. Purposive sampling ensured a focus on companies with substantial experience in structural engineering, representing industry standards. A sample of 93 respondents was initially chosen using convenience sampling, with 85 valid responses obtained. Data collection involved structured questionnaires analyzed through frequency tables and mean scores. Hypothesis testing using Chi-square analysis revealed a statistically significant variation in building collapse incidents across different periods, with a calculated Chi-square value (20.9) exceeding the critical threshold (5.991), thereby rejecting the null hypothesis. Key findings indicate that building collapse in Jos is primarily driven by poor design, construction faults, substandard materials, inadequate construction methods, foundation issues, insufficient supervision, and lack of maintenance. The study recommends that the Nigerian Institute of Building (NIOB) and the Nigerian Institute of Structural Engineers (NISE) collaborate with the government on building materials awareness initiatives. Additionally, it is advised that developers assign Material Engineers to large-scale projects to ensure compliance with quality standards.

Key words: Building collapse, Building materials, Building construction, Site supervision

1. Introduction

In developed nations, strict adherence to building codes and professional standards has kept the rate of building collapses relatively low, even in the face of severe natural hazards such as earthquakes (Berrisford, 2016). However, in contrast, Nigeria has witnessed numerous building collapses largely due to human factors rather than natural causes. Unlike regions prone to seismic activity, Nigeria's geographical setting rarely subjects its buildings to extreme natural forces, aside from localized incidents such as erosion and flooding, which primarily affect low-rise structures. Nonetheless, building collapses remain a frequent and deadly issue in urban centers across Nigeria, with Jos, Plateau State, exemplifying the challenges associated with substandard construction practices and weak regulatory oversight. In Jos, recent cases highlight the severity of this issue. For example, a two-story building in Bukuru, Jos South, collapsed without casualties but drew attention to widespread safety concerns. In 2020, a storey building collapse in the Yanshanu suburb of Jos, housing eight households, narrowly avoided tragedy after a heavy rainstorm led to its failure. Despite such incidents, little research has focused specifically on the unique factors contributing to building collapses in Plateau State. According to Dimuna (2018), while Nigeria's structural failures often result from poor construction materials, insufficient regulatory compliance, and design flaws, studies directly examining Plateau State's construction challenges remain scarce. This study aims to address this gap by providing a comprehensive analysis of building collapse cases within Jos Metropolis. Key areas of investigation include: 1. Identification of Contributing Factors: This research will examine the root causes of structural failures in Jos, focusing on aspects such as substandard materials, poor workmanship, regulatory gaps, and design issues, all of which are critical for understanding and mitigating collapse risks. 2. Evaluation of Regulatory Frameworks: The study will assess the effectiveness of existing building regulations and their enforcement within Jos. It will explore whether current policies sufficiently address the challenges of construction safety and regulatory compliance in this rapidly urbanizing region. 3. Impact Analysis: The research will consider the socio-economic impacts of building collapses on affected communities in Jos, including

financial losses, displacement, and the strain on emergency services. Understanding these effects is essential for comprehending the full scope of consequences that extend beyond physical damage. 4. Recommendations for Improvement: Based on findings, the study will propose actionable strategies for improving construction practices, strengthening regulatory frameworks, and increasing public awareness around building safety. This investigation seeks to uncover the patterns and causes of building collapses in Jos, Plateau State, using statistical tests to validate two key hypotheses: (1) There is no significant difference in the frequency of building collapses across different times and locations, and (2) There is no significant association between specific factors and the occurrence of building collapses. These hypotheses will be evaluated using chi-square analysis, with univariate data providing insights into the frequency and influencing factors of collapses over time and across various areas within Jos. Through these analyses, this study aims to contribute valuable insights into reducing the incidence of building collapses in Jos and, by extension, support the development of safer urban environments across Nigeria.

2. Literature Review

Introduction to Building Standards and Safety in Construction

Buildings serve as essential structures that provide shelter for individuals and accommodate various activities. A well-constructed building enhances users' satisfaction and safety, with quality dependent on aspects like structural durability, resistance to environmental factors, and resilience against fire and other hazards (Bala, 2017). The durability of a building, a crucial factor in structural integrity, is influenced by advancements in materials and architectural practices. The process of designing and constructing buildings involves selecting materials and structures that align economically with the desired standards and aesthetics. Codes of practice govern building design, construction, and safety measures, aiming to establish guidelines for structural integrity, yet enforcement and adherence to these codes vary across regions. The role of buildings as safe, enduring structures is universally acknowledged. Key elements of building safety include structural integrity, material quality, and adherence to regulatory standards, which together influence a building's durability and resilience. Globally, standards such as the International Building Code (ICC, 2021) serve to enhance safety and quality by establishing guidelines for material use, design, and construction practices. However, in Nigeria, weak enforcement of such standards frequently results in inconsistencies in building safety and quality (Ahmad *et al*., 2021). This gap underscores the objective of the current study, which seeks to address why Nigerian buildings fail to meet international durability and safety benchmarks despite the existence of regulatory frameworks.

Regulatory Inadequacies and Building Standards in Nigeria

The Nigerian construction industry is complex, involving various stakeholders and relying on both local and imported materials and equipment. However, regulatory inadequacies remain a significant concern. According to Davies *et al*. (2011), the industry's openness to participation by individuals with varying levels of skill often results in subpar workmanship and quality issues. The absence of stringent certification and enforcement mechanisms allows inadequately trained personnel to undertake critical roles, contributing to substandard building practices. Chinwokwu (2020) highlights that while there are standards meant to ensure quality, these are frequently undermined by poor regulatory enforcement and oversight, leading to persistent building quality issues. This gap in regulatory rigor, coupled with inadequate monitoring, creates an environment where building codes are often disregarded, resulting in structures that fail to meet safety standards. Couto *et al*. (2020) demonstrate that effective regulatory oversight in other countries is associated with lower building failure rates, underscoring the importance of stringent enforcement and skilled labor certification.

Structural Integrity as a Foundation for Building Safety

The structural integrity of a building is paramount, as it must withstand loads from occupants, furnishings, wind, and its own weight. Structural failure, a common cause of building collapse, indicates an inability of a building to bear these loads safely. Structural failures can be divided into two types: cosmetic failures, which impact appearance, and structural failures, which compromise stability (Ayuba *et al*., 2015). Fakere *et al*. (2020) define a structure as a system capable of bearing loads without deformation, but when a building's framework is compromised, it risks collapse. Research by Xie *et al*. (2021) suggests that incorporating risk assessments for structural elements can minimize failure risks, a practice that is often overlooked in Nigeria's construction projects. Studies within Nigeria (e.g., Olajumoke *et al*., 2019) attribute over 30% of building collapses to structural inadequacies stemming from both poor design and faulty construction practices. This failure to ensure structural integrity highlights the need for industry reform to prioritize both load-bearing capabilities and resilience to local environmental conditions. Addressing this within the study links directly to understanding how improved structural practices could reduce collapse incidents in Nigeria.

Material Quality and the Challenge of Consistency

Material quality significantly impacts building safety and longevity, particularly in regions where environmental conditions place additional stress on construction materials. Studies indicate that high-quality, standardized materials are essential to avoid structural failures, especially in high-risk climates (Alam *et al*., 2019). Unfortunately, the Nigerian market is flooded with substandard materials, and quality control measures are inconsistently applied. Ogunsemi (2022) emphasizes that reliance on low-grade materials is a significant contributor to building collapses, as they are unable to withstand the stresses required for durability. The current study aims to bridge this gap by evaluating the role that enhanced quality standards for materials could play in achieving safer building practices. Kaminetzy (2019) describes building failure as a failure in performance due to inadequate materials, non-performance, or loss of structural strength. In the Nigerian context, imported materials and local production often lack standardized quality assessments, leaving buildings vulnerable to collapse due to compromised materials.

While previous studies in both Nigeria and internationally underscore the importance of regulatory standards, structural integrity, and material quality, there is limited integration of these factors into a unified approach for preventing building collapses. Existing research lacks a critical examination of how these elements collectively contribute to building failures in the Nigerian context. This study fills that gap by not only analyzing each component individually but also examining their interdependence to propose a holistic framework for improving construction practices in Nigeria. This framework is particularly crucial given the country's economic and environmental challenges, which exacerbate the impacts of poor-quality materials and weak regulatory enforcement.

Study Area

Jos, the capital of Plateau State, Nigeria, offers a significant context for studying building collapses due to its unique geographic, economic, and regulatory factors:

Geographic and Demographic Context

Jos is located on the Jos Plateau, characterised by rocky terrain and stable soil, which affects construction practices. The city's growing population and increased construction activity have strained regulatory frameworks.

Economic and Urban Development

Rapid economic growth and urbanization in Jos have increased demand for buildings, often leading to rushed projects that may not meet building standards. Economic pressures can lead to cost-cutting that compromises safety.

Building Regulations and Enforcement

Building regulations in Jos are sometimes poorly enforced due to corruption, resource limitations, and lack of technical expertise. Effective regulation is crucial to preventing building collapses.

Case Studies and Historical Data

Analyzing past building collapses in Jos helps identify common causes and patterns related to construction practices and material quality. This data is key to understanding failures and improving safety measures. Jos provides a valuable case study for understanding building collapses in Nigeria, highlighting the need for improved regulatory and safety strategies in similar urban environments.

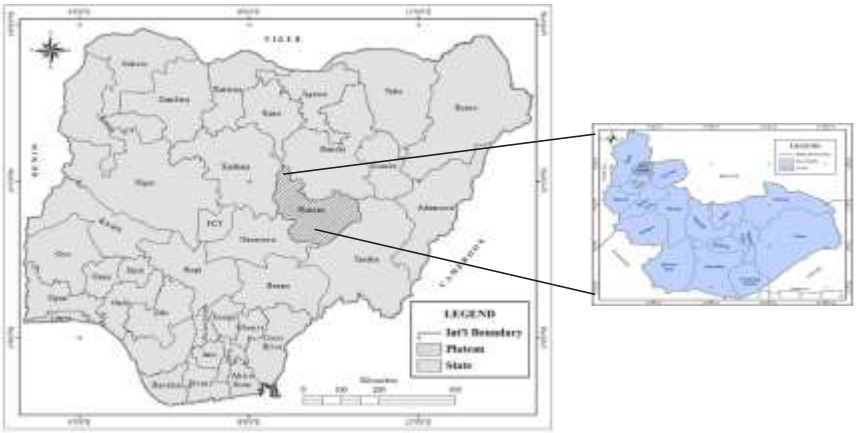

Figure 1: Map of Nigeria Showing Plateau State and Study Area
Source: University of Jos GIS Laboratory (Accessed 15/09/2023).

3. Methodology

Research Design

This study employs a survey research design to effectively address the research problem by collecting opinions and views from a selected group of individuals. Survey research can utilize quantitative methods (such as questionnaires with numerical items), qualitative methods (such as open-ended questions), or a mixed-methods approach (Singleton & Straits, 2009). Given the nature of this research, a structured questionnaire was utilized to gather quantitative data from site-workers involved in construction projects in Jos metropolis, Plateau State.

Population

A study population is defined as a group of individuals sharing similar characteristics (Udoyen, 2019). This study focuses on site-workers from selected construction companies in Jos metropolis, Plateau State, who have been involved in high-profile construction projects. The companies were chosen based on their substantial experience and involvement in structural engineering projects. The selected companies are:

Ritek Concept Nigeria Ltd

Chibok Gifted Hands Construction Limited

Nganjis Design Construction Limited

Sampling Strategy: Sample Size and Technique

According to Nwana (2005), sampling techniques are procedures adopted to systematically select the chosen sample in a specified away under controls. This research work adopted the convenience sampling technique in selecting the respondents from the total population. According to Torty (2021), a sample of convenience is the terminology used to describe a sample in which elements have been selected from the target population on the basis of their accessibility or convenience to the researcher.

The sample for this study was determined using a convenience sampling method, which entails selecting participants based on their accessibility to the researcher. Convenience sampling allows for the efficient collection of data but may impact the generalizability of the findings, as the sample may not represent the broader population.

In this study, a total of 93 site-workers were selected, comprising 31 participants from each of the three construction companies. This sample size was deemed adequate based on practical considerations, including time and resource constraints, while still being sufficient to derive meaningful insights into the opinions of construction workers in Jos. However, it is important to acknowledge that the convenience sampling method may limit the ability to generalize the findings to all site-workers in Nigeria, as it does not account for the full diversity of experiences and opinions present in the wider population.

A total of 93 site-workers were selected from three construction companies, with 31 participants from each company. This sample size was determined based on several considerations:

1. **Contextual Comparison:** Previous studies in construction safety and building collapses have utilized sample sizes ranging from 80 to 100 participants. Thus, a sample size of 93 is consistent with existing research standards in the field, ensuring that the findings are comparable and relevant.
2. **Statistical Power Considerations:** The chosen sample size allows for adequate statistical power for the analysis, specifically for chi-square tests. A sample size of 93 was calculated to achieve a power level of 0.80, enabling the detection of medium effect sizes. This level of power ensures that the study can identify significant relationships or differences among the responses.
3. **Population Size and Characteristics:** The total population of site-workers in the three selected construction companies is estimated at approximately 300. Thus, a sample of 93 represents nearly 31% of this population, providing a substantial representation of worker perspectives regarding building collapses.
4. **Feasibility and Practical Constraints:** The sample size was also influenced by practical considerations such as time and resource availability, as well as the urgency of addressing the issue of building collapses in Jos metropolis. The sample size strikes a balance between methodological rigor and the practical realities of data collection.

Method of Data Collection

Data was collected through a combination of primary and secondary sources. The primary data collection method involved administering structured questionnaires, while secondary sources included literature such as textbooks, journal articles, and government publications. This comprehensive approach facilitated an in-depth understanding of the prevalence, causes, effects, and contributing factors of building collapses in Jos metropolis, encompassing:

Prevalence Assessment

Impact Analysi

Cause Identification

Casualty Analysis

Research Instrument

The primary research instrument was a structured questionnaire, divided into two sections. The first section collected demographic information, while the second focused on questions aligned with the study objectives. Participants indicated their responses using a five-point Likert scale, ranging from "Strongly Agree" to "Strongly Disagree." The questionnaire was personally administered to ensure clarity and encourage participation.

Method of Data Presentation and Analysis

Responses were analyzed using frequency tables to address the research questions. The data was evaluated using a five-point rating scale with assigned values as follows:

Strongly Agree (SA) = 5
Agree (A) = 4
Neutral (N) = 1
Disagree (D) = 3
Strongly Disagree (SD) = 2

Decision Rule:

To ascertain the decision rule; this formula was used

$$\frac{5+4+3+2+1 = 15}{5 \quad 5} = \mathbf{3.0}$$

The decision rule was based on calculating the mean score, with a cut-off mean of 3.0. Any score equal to or above 3.0 was accepted, while scores below 3.0 were rejected. The hypotheses were tested using the Chi-square statistical tool.

Validity of the Study

The validity of the study was ensured through careful construction of the questionnaire, which was then critically reviewed by the project supervisor. Their expertise helped confirm that the instrument accurately measured the intended research objectives.

Reliability of the Study

The reliability of the research instrument was assessed using the Pearson Correlation Coefficient, yielding a coefficient value of 0.68, indicating reasonable reliability. According to Taber (2017), this falls within an acceptable range for research instruments, which is typically between 0.67 and 0.87.

Any score that was 3.0 and above was accepted, while any score that was below 3.0 was rejected. Therefore, 3.0 was the cut-off mean score for decision taken. While the hypotheses will be tested using Chi-square statistical tool.

Plate 1 shows Scene of a collapsed building in Jos by James Abraham (3rd October 2020)

Plate 2 shows Three-storey building collapse in Dilimi Community of Jos North Local Government Area of Plateau. Confirmed by NEMA (2019).

Type of Building Structure: Three – Storey Building
Location of Building: Dilimi Community of Jos North Local Government Area of Plateau.
Date of Collapse: 16th July, 2019
Suspected Cause(s): Use of Substandard materials, weak Structure
Remarks (lives lost): 3 deaths, 7 injured
Remedies: the design of the building prepared by the structural engineer appointed by the developer/builder must be proof checked by the municipal authorities, well standard building materials should be used, and thorough supervisions recommended.

Plate 3 shows a recent reported case of Collapsed Buildings in Jos Metropolis, plateau State

4. Presentation and Discussion of Results

The purpose of this study was to examine building collapse cases in Nigeria using Jos metropolis, Plateau State as a case study. Hence, corresponding results are properly reviewed through presentation, analysis, and interpretation of data gathered through the use of a questionnaire distributed to the respondents.

The study answered the following research questions:

i. What is the prevalence of building collapse in Jos Metropolis, Plateau State?
ii. What are the main causes of building collapse in Jos metropolis, Plateau State?
iii. What are the supervisions rated factors which has contributed to building collapse in Jos metropolis, Plateau State?
iv. What are the recommendations on how building collapse can be reduced or totally stopped?

Table 1 shows the summary of the survey. A sample of 93 was calculated for this study. A total of 89 responses were received, while a total of 85 were validated. This was due to irregular, incomplete and inappropriate responses to some questionnaire. For this study a total of 85 was validated for the analysis.

Table 1: Distribution of Questionnaires

Questionnaire	Frequency	Percentage
Sample size	91	100
Received	89	98
Validated	85	93

Source: Field Survey, 2023

Table 2 shows the Demographic profile of the respondents. This demographic profile reveals the characteristics of the survey respondents, providing insight into their gender distribution, age range, educational background, and marital status.

Gender: the majority of respondents are male (88%), with a smaller proportion being female (12%). This indicates a significant gender imbalance in the sample.

Age: most respondents are between 36 and 45 years old (49%), suggesting that this age group is the most represented in the survey. Younger individuals (18-25 years) make up the smallest percentage (12%).

Education: the educational background of respondents is diverse. The majority have a BSC/HND (45%), indicating a higher level of education among most respondents. Only a small fraction holds advanced degrees like Masters (9%) or PHD (4%).

Marital Status: the marital status of respondents is varied. The largest group is married individual (45%), while single respondents are a smaller group (16%). There are also notable percentages of separated (19%) and divorced (11%) respondent.

Table 2: Demographic profile of the respondents

Demographic Information	Frequency	Percent
Gender		
Male	75	88%
Female	10	12%
Age		
18-25	10	12%
26-35	17	20%
36-45	42	49%
46+	16	19%
Education		
SSCE	13	15%
OND	26	31%
BSC/HND	38	45%
MASTERS	08	9%
PHD	03	4%
Marital Status		
Married	38	45%
Separated	16	19%
Single	14	16%
Divorced	09	11%
Widowed	08	13%

Source: Field Survey, 2023

Answering Research Questions:

Question 1: What is the prevalence of building collapse in Jos metropolis, Plateau State?

From Table 3, 41% of the respondents said high, followed by 32% of the respondents said low, and 15% of the respondents were undecided, while the remaining 12% of the respondents were neutral.

Table 3: Respondents on question 1

Options	Frequency	Percentages
High	35	41
Low	27	32
Undecided	13	15
Neutral	10	12
Total	85	100

Source: Field Survey, 2023

Question 2: What are the main causes of building collapse in Jos metropolis, Plateau State?

Table 4 shows the Mean Responses on the main causes of building collapse in Jos metropolis, Plateau State. This table presents the mean responses on the causes of building collapse in Jos metropolis, Plateau State. Here is a breakdown of each column:

1. ITEM STATEMENT: Lists different potential causes of building collapse.
2. X: Represents the mean score (average response) for each cause. It is a measure of how frequently each cause is considered important.
3. S.D: Stands for Standard Deviation, which indicates how much variation there is from the average response. A higher S.D. suggests more variation in responses.
4. N: Number of respondents who provided feedback on each item.
5. DECISION: Indicates whether the cause is generally accepted as a significant factor in building collapse.

How Values Were Obtained:

1. Mean Score (X): Calculated by averaging the responses from all respondents for each item. For example, if several respondents rated "Poor design" as 3, 4, and 3, the mean score would be (3+4+3)/3 = 3.33.
2. Standard Deviation (S.D.): Computed to show how much individual responses deviate from the mean. It reflects the level of agreement among respondents.
3. N: The number of respondents surveyed for each cause. In this case, each item had 85 respondents.
4. Decision: Based on the mean score, if it meets a pre-determined threshold, it is accepted as a significant cause of building collapse.

Each listed cause of building collapse (e.g., poor design, faulty construction) was rated by 85 respondents. The mean score and standard deviation for each cause are provided, indicating how strongly each cause is perceived and how consistent the responses were. All causes listed are accepted as significant factors contributing to building collapse in the studied area.

Table 4: Mean Responses on the main causes of building collapse in Jos metropolis, Plateau State

S/N	ITEM STATEMENT	X	S. D	N	DECISION
1	Poor design	3.5	4.5	85	Accepted
2	Fault at construction	3.3	4.2	85	Accepted
3	Poor material quality	3.5	4.4	85	Accepted
4	Method of construction	3.6	4.6	85	Accepted
5	Foundation failure	3.4	4.3	85	Accepted
6	Inadequate maintenance	3.8	4.8	85	Accepted

Source: Field Survey, 2023

Figure 1 shows the main causes of building collapse in Jos metropolis, Plateau State. From the responses derived as described in table 4 on the main causes of building collapse in Jos metropolis, Plateau State, the table shows that all the items(item1-item6): stating; poor design, fault at construction, poor material quality, method of construction, foundation failure, and inadequate maintenance, all with mean score of 3.5, 3.3, 3.5, 3.6, 3.4, and 3.8 were accepted. This indicates that respondents accepted the main causes of building collapse in Jos metropolis, Plateau State. This is proven as the respective items (item1-item6) had mean scores of 3.0, and above.

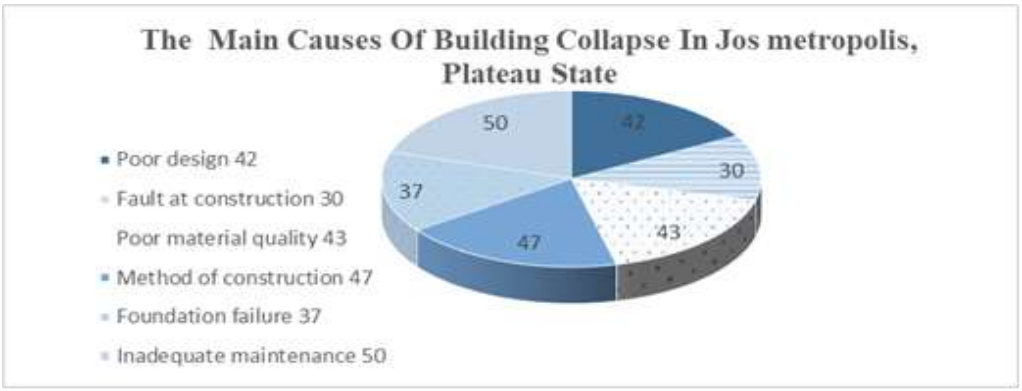

Figure 1: The main causes of building collapse in Jos metropolis, Plateau State

Question 3: What are the supervisions rated factors which has contributed to building collapse in Jos metropolis, Plateau State?

Table 5 shows the Mean Responses on the supervision rated factors which has contributed to building collapse in Jos metropolis, Plateau State. From the responses derived as described in table 5 on the supervision rated factors which has contributed to building collapse in Jos metropolis, Plateau State, the table shows that all the items(item1-item5): stating; construction of unapproved building pattern, improper compliance to building codes and regulations, lack of proper supervision of building drawings, lack of effective supervision of building materials provided, and lack of thorough supervision of site from the inception to the final stage of the project, all with mean score of 3.8, 3.3, 3.2, 3.6, and 3.4 were accepted. This indicates that respondents accepted the supervision rated factors which has contributed to building collapse in Jos metropolis, Plateau State. This is proven as the respective items (item1-item5) had mean scores of 3.0 and above.

Table 5: Mean Responses on the supervision rated factors which has contributed to building collapse in Jos metropolis, Plateau State.

S/N	ITEM STATEMENT	X	S. D	N	DECISION
1	Construction of unapproved building pattern	3.8	4.7	85	Accepted
2	Improper compliance to building codes and regulations	3.3	4.2	85	Accepted
3	Lack of proper supervision of building drawings	3.2	4.1	85	Accepted
4	Lack of effective supervision of building materials provided	3.6	4.5	85	Accepted
5	Lack of thorough supervision of site from the inception to the final stage of the project	3.4	4.4	85	Accepted

Source: Field Survey, 2023

Question 4: What are the recommendations on how building collapse can be reduced or totally stopped?

Table 6 shows the Mean Responses on the recommendation on how building collapse can be reduced or totally stopped. From the responses derived as described in table 6 on the recommendation on how building collapse can be reduced or totally stopped, the table shows that all the items(item1-item5): stating; adequately monitoring the imported building materials, exclusive supervision of building activities in the state, issuing license to qualified contractors, enforcing accountability by all licensed contractors, and punishing contractors and sub-contractors found guilty, all with mean score of 4.7, 4.3, 4.5, 4.1, and 4.6 were accepted. This indicates that respondents accepted the recommendation on how building collapse can be reduced or totally stopped. This is proven as the respective items (item1-item5) had mean scores of 3.0, and above.

Table 6: Mean Responses on the recommendation on how building collapse can be reduced or totally stopped

S/N	ITEM STATEMENT	X	SD	N	DECISION
1	Adequately monitoring the imported building materials	3.8	4.7	85	Accepted
2	Exclusive supervision of building activities in the state	3.4	4.3	85	Accepted
3	Issuing license to qualified contractors	3.5	4.5	85	Accepted
4	Enforcing accountability by all licensed contractors	3.2	4.1	85	Accepted
5	Punishing contractors and sub-contractors found guilty	3.6	4.6	85	Accepted

Source: Field Survey, 2023

Testing of Hypotheses

Ho1: There is no significant difference in the frequency of building collapses across different times in Jos metropolis, Plateau State.

Ho2: There is no significant association between various factors and the occurrence of building collapses in Jos metropolis, Plateau State.

Hypothesis One

Table 7: Chi-Square test showing whether there is a significant difference in the frequency of building collapses across different times in Jos metropolis, Plateau State

Variables	Fo - Fe	(Fo - Fe)2	(Fo--Fe)2/Fe
Yes	5.75	33.06	1.2
No	13.75	189.06	6.7
Undecided	-19.5	380.25	13.0
Total			20.9

Source: Field Survey, 2023

Degrees of freedom = (r-1) (c-1) = (3-1) (2-1) = 2
At 0.05 significance level, the critical table value is 5.991.
Findings: The calculated Chi-square value (20.9) is greater than the table value (5.991).
Decision: The null hypothesis is rejected. The alternative hypothesis, stating that there is a significant difference in the frequency of building collapses across different times in Jos metropolis, is accepted.

Hypothesis Two

Table 8: Chi-Square test showing whether there is a significant association between various factors and the occurrence of building collapses in Jos metropolis, Plateau State

Variables	Fo - Fe	(Fo - Fe)2	(Fo--Fe)2/Fe
Yes	-8.25	68.06	2.4
No	-4.0	16.0	0.6
Undecided	11.75	138.06	4.9
Total			7.9

Source: Field Survey, 2023

Degrees of freedom = (r-1) (c-1) = (3-1) (2-1) = (2)
At 0.05 significance level, the critical table value is 5.991.
Findings: The calculated Chi-square value (7.9) is greater than the table value (5.991).
Decision: The null hypothesis is rejected. The alternative hypothesis, stating that there is a significant association between various factors and the occurrence of building collapses in Jos metropolis, is accepted.
Univariate data of the variables used in the hypothesis tests, stating the frequency of building collapses across different times in Jos metropolis, Plateau state and the frequency of occurrence of building collapse is shown in the table.

1. Frequency of Building Collapses Across Different Times in Jos metropolis, plateau State

Table 9: Frequency of Building Collapses Over Time in Jos metropolis, plateau State

Month/Year	Frequency of collapses
January 2020	2
February 2020	3
March 2020	1
April 2020	4
May 2020	2
June 2020	5
July 2020	3
August 2020	6
September 2020	1
October 2020	4
November 2020	2
December 2020	3

Source: Field Survey, 2020

Summary Statistics:

Total collapses: 40
Most frequent Month: August 2020 (6 collapses)
Least frequent month: March 2020 and September 2020 (1 collapse each)

2. Frequency of Occurrence of Building Collapses by Type

Table 10: Frequency of Building Collapses by type

Type of Building	Frequency of Collapses
Residential Buildings	18
Commercial Buildings	10
Educational Institutions	5
Industrial Structures	2
Religious Buildings	3

Source: Field Survey, 2020

Summary Statistics:

Total Collapses by Type: 38

Most Common Type: Residential Buildings (18 occurrences)

Least Common Type: Industrial Structures (2 occurrences)

5. Discussion

The findings of this study reveal a troubling pattern of building collapses in the Jos metropolis, Plateau State, with a multitude of contributing factors underscoring the need for urgent regulatory reforms and enhanced construction practices. The descriptive analysis indicated a high prevalence of building failures, primarily attributed to poor design, construction faults, substandard material quality, and inadequate supervision. These issues are not isolated; they reflect broader regulatory and environmental challenges endemic to the Nigerian construction industry.

Poor Design and Construction Faults

One of the predominant causes identified was poor design, which can often be traced back to a lack of qualified professionals involved in the planning stages. Many structures in Jos are designed without adequate engineering assessment, leading to insufficient load-bearing capabilities and vulnerability to environmental stresses. Additionally, construction faults, such as improper foundation work and lack of compliance with architectural plans, exacerbate these issues. To address these concerns, it is critical to enforce strict licensing requirements for architects and engineers, ensuring that only qualified individuals participate in the design and oversight of construction projects.

Poor Material Quality

The use of substandard materials was another significant factor contributing to building collapses. In Jos, there is a prevalent practice of sourcing low-quality materials due to cost-cutting measures or unregulated suppliers. This compromises the structural integrity of buildings and significantly increases the risk of failure. To combat this issue, regulatory bodies must implement stringent quality control measures for construction materials, including mandatory testing and certification processes for all suppliers. Increased public awareness campaigns could also encourage builders to prioritize quality over cost.

Inadequate Supervision

Supervision challenges were prominently highlighted, particularly concerning unapproved building patterns and a lack of adherence to established codes. Many construction projects proceed without the necessary approvals or oversight from regulatory authorities, leading to violations of safety standards. The Chi-square tests conducted in this study confirmed significant associations between inadequate supervision and the prevalence of building collapses. To mitigate these risks, it is imperative to enhance the capacity and authority of local building inspectors and regulatory agencies. Implementing a robust system of checks and balances that includes regular inspections and a transparent reporting mechanism for non-compliance will help ensure adherence to safety standards.

The relationship between these causes and the high incidence of building collapses in Jos underscores a critical need for policy improvements. Key recommendations include:

1. Strengthening Regulatory Frameworks: Revise and enforce building codes that mandate strict compliance with design and material specifications, alongside the establishment of a centralized database for approved contractors and materials.
2. Capacity Building for Inspectors: Invest in training programs for building inspectors to equip them with the necessary skills and knowledge to effectively evaluate construction practices and materials.
3. Public Awareness and Engagement: Foster community involvement in building safety initiatives to promote vigilance and reporting of unapproved constructions, thereby enhancing accountability within the construction sector.
4. Monitoring and Evaluation: Establish a comprehensive monitoring system that tracks compliance with safety standards, providing data for ongoing improvements in regulatory practices.

In conclusion, addressing the multifaceted causes of building collapses in Jos requires a holistic approach that integrates policy reforms, regulatory enforcement, and community engagement. By implementing these recommendations, it is possible to significantly reduce the incidence of building failures, ultimately safeguarding lives and investments in the region.

6. Conclusion

This study highlights the alarmingly high prevalence of building collapses in the Jos metropolis, Plateau State, identifying critical factors such as poor design, construction faults, low-quality materials, inadequate construction methods, foundation failures, and insufficient maintenance as the primary contributors. The repercussions of these collapses are dire, leading to loss of lives, property destruction, injuries, financial setbacks, and wastage of resources. Addressing the challenges of building collapses requires a collaborative approach among various stakeholders, including government bodies and professional organizations. It is imperative for these entities to develop and implement robust policies, enforce regulations in the construction industry, monitor the quality of imported materials, and conduct regular assessments of existing structures to ensure timely maintenance.

To effectively mitigate the risk of future building collapses, the following actionable recommendations are proposed:

1. Enhanced Monitoring and Regulation: Establish stringent monitoring protocols for imported building materials to ensure compliance with quality standards. This should include regular inspections and certifications to prevent the entry of substandard materials.
2. Supervised Construction Practices: Implement strict supervision of construction activities within the state. This entails requiring that all construction sites have licensed professionals overseeing the work to ensure adherence to design specifications and safety standards.
3. Licensing Qualified Contractors: Revise the licensing process to ensure that only qualified and experienced contractors are permitted to undertake construction projects. This should be accompanied by a system of accountability that holds contractors responsible for negligence.
4. Penalties for Non-compliance: Introduce and enforce penalties for contractors and stakeholders found guilty of violating construction regulations or for engaging in substandard practices.
5. Interdisciplinary Collaboration: Encourage collaboration among professional bodies such as the Nigerian Institute of Architects (NIA), Architects Registration Council of Nigeria (ARCON), Nigerian Society of Engineers (NSE), and others. This joint effort should focus on establishing clear roles and responsibilities during the design and construction phases to ensure a comprehensive approach to safety.

The findings of this study also prompt further investigation into specific areas that could provide a more holistic solution to building collapses in Jos. Future research should explore the following:

The impact of community awareness and education on building safety practices.

The effectiveness of existing regulatory frameworks in preventing building collapses.

Comparative studies of building regulations and enforcement in other regions to identify best practices that can be adapted to Jos.

Overall, this study's findings and recommendations serve as a crucial foundation for stakeholders to collaboratively address the pressing issue of building collapses in Jos, ultimately safeguarding lives and properties while promoting sustainable construction practices.

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Optimizing HVAC Systems for Sustainable Lecture Rooms: Harnessing Environmental and Occupancy Data for Comfort and Energy Efficiency through Data-Driven Insights

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Abstract

The escalating energy consumption in campus infrastructure, especially in lecture halls with heating, ventilation, and air conditioning (HVAC) systems, necessitates data-driven optimization strategies. This research demonstrates the integration of Internet of Things (IoT) sensors with cloud-based predictive analytics to develop intelligent lecture room policies aimed at enhancing efficiency and sustainability. A Raspberry Pi-based IoT device, equipped with a BME680 sensor for monitoring temperature, humidity, and air quality, and a passive infrared sensor for occupancy detection, was installed in a university lecture room for real-time data acquisition. Data collected was routed through MySQL for storage and Node-RED for preprocessing. Time series forecasting models, including ARIMA and Prophet, along with machine learning models like XGBoost, achieved over 90% forecast accuracy for temperature and occupancy levels, enabling proactive control of environmental conditions. The optimized HVAC scheduling, based on forecasted occupancy patterns, resulted in a 20% reduction in energy consumption over an 8-week deployment, ensuring thermal comfort by maintaining temperatures within the recommended range of 21-23°C during occupancy. Enhanced occupant comfort was also achieved by maintaining humidity levels between 40-60%, improving indoor air quality through proactive ventilation control. Key recommendations include dynamic HVAC scheduling based on occupancy forecasts, thermostat setpoint adjustments to prevent temperature peaks, and expanding IoT sensor deployments across campus facilities to generate deeper insights. This integrated IoT and predictive analytics approach enabled a sustainable and responsive built environment, providing a scalable framework for optimizing other infrastructure types such as laboratories and offices.

Keywords: Building energy management, HVAC optimization system, Sustainable lecture rooms, Occupant comfort, Data-driven insights

1. Introduction

Lecture rooms within educational institutions present distinct energy challenges due to irregular occupancy patterns and high comfort expectations (Wadud *et al.,* 2019; Guelpa & Verda, 2019). Unlike residential or office spaces, lecture rooms experience fluctuating usage, with some periods of high occupancy followed by long stretches of vacancy. Managing these spaces with traditional HVAC systems, which operate on fixed schedules, results in inefficient energy consumption. These systems often run unnecessarily, cooling or heating rooms even when unoccupied, which leads to wasted energy and increased operational costs (Chung & Yeung, 2020). Additionally, maintaining a comfortable environment is crucial to occupant well-being and productivity. Poor indoor conditions—such as high temperatures, humidity, or poor air quality—can negatively affect student concentration and learning outcomes (Krukowski *et al.,* 2020). Therefore, there is a pressing need for more efficient HVAC strategies that align energy use with actual room conditions without compromising comfort. A data-driven approach to HVAC management addresses these challenges by using real-time environmental and motion data to optimize operations. Sensors measuring temperature, humidity, air quality, and occupancy can provide actionable insights to dynamically control HVAC systems. For instance, when motion detectors indicate vacancy, cooling and heating can be reduced or turned off, minimizing unnecessary energy usage (Kim & Cho, 2019; Huang *et al.,* 2018). Conversely, when sensors detect high occupancy, the system can adjust to maintain thermal comfort. Predictive algorithms based on historical usage data can also help schedule HVAC operations proactively, reducing dependence on reactive measures (Bhuiyan *et al.,* 2017; Al Hadi *et al.,* 2020). Despite the benefits, implementing such solutions poses challenges, including the cost of deploying sensors across multiple spaces and the complexity of managing the data generated. Additionally, intuitive dashboards are needed to translate the data into insights accessible to building operators and decision-makers (Habib *et al.,* 2021; Li *et al.,* 2020). This research aims to overcome these challenges by installing environmental sensors and motion detectors in a lecture room to gather real-time data. The collected data will inform predictive HVAC models that align energy consumption with occupancy patterns and environmental conditions. This approach will demonstrate how smart systems can

enhance both comfort and energy efficiency while reducing the institution's environmental footprint. Ultimately, the study offers a scalable framework for sustainable infrastructure management in educational institutions, bridging the gap between dynamic room usage and efficient energy use (Schwartz *et al.,* 2021).

2. Literature Review

2.1 Energy Utilisation and its Environmental Effect

2.2.1 Machine Learning and IoT Applications in Lecture Room

Educational lecture rooms present unique energy challenges, particularly because of varying occupancy patterns, intermittent usage, and high comfort demands during teaching hours. Traditional HVAC systems, which operate on rigid schedules, are often unable to respond dynamically to real-time fluctuations in occupancy, leading to energy waste or discomfort. Machine learning and IoT technologies offer promising solutions by providing adaptive control mechanisms to manage these complex patterns. Machine learning models, such as Temporal Convolutional Networks (TCN) and Long-Short Term Memory (LSTM), can analyze historical and real-time data to forecast occupancy trends, adjust HVAC schedules, and optimize comfort levels with minimal human intervention (Lum *et al.,* 2021; Jamwal *et al.,* 2021). For example, by predicting when lecture rooms will be occupied, HVAC systems can pre-cool or heat rooms just in time for classes, minimizing energy use during vacant periods. Similarly, data from environmental IoT sensors monitoring air quality, temperature, and humidity allows ML algorithms to fine-tune HVAC operations in response to changing environmental conditions (Yaïci *et al.,* 2021; Chen *et al.,* 2021). By integrating IoT and ML, educational institutions can move towards predictive and occupancy-based control systems. Wireless sensors such as PIR (Passive Infrared), WiFi, and computer vision technologies detect real-time room occupancy and usage patterns, triggering HVAC adjustments only when necessary (Goyal, 2022; Shafqat *et al.,* 2022). This not only reduces energy consumption but also ensures optimal thermal comfort, crucial for students' focus and well-being (Shang *et al.,* 2021).

2.2 HVAC Optimization Studies in Educational Settings

Several studies have demonstrated the value of optimizing HVAC systems in educational environments to balance energy conservation with occupant comfort. Esrafilian-Najafabadi & Haghighat (2020) explored the benefits of smart occupancy sensors in reducing energy consumption by adjusting HVAC settings in real-time based on lecture room utilization. Similarly, Javaid *et al.* (2021) showed how IoT-based HVAC solutions can align operational schedules with real-time occupancy data, leading to significant energy savings. Other research emphasizes the importance of environmental quality in educational spaces. Temperature, lighting, and indoor air quality all directly impact student performance and health (Coggins *et al.,* 2022; Krukowski *et al.,* 2020). IoT-based HVAC systems address these concerns by maintaining optimal indoor conditions through continuous environmental monitoring and data-driven interventions (Smith *et al.,* 2021). To overcome the challenge of inefficient manual control, Romano *et al.* (2021) demonstrated how data analytics and ML models could yield up to 15% energy savings by dynamically managing HVAC loads based on occupancy forecasts. Moreover, adaptive strategies such as passive cooling and demand-response control systems enhance sustainability while maintaining comfort levels (Atallah *et al.,* 2021; Perez-Lombard *et al.,* 2022). These approaches are especially relevant in lecture rooms, where both the timing and intensity of HVAC operation must match varying teaching schedules to avoid energy waste.

2.3 Energy Efficiency and Conservation in Buildings

To overcome the challenge of inefficient manual control, Romano *et al.* (2021) demonstrated how data analytics and ML models could yield up to 15% energy savings by dynamically managing HVAC loads based on occupancy forecasts. Moreover, adaptive strategies such as passive cooling and demand-response control systems enhance sustainability while maintaining comfort levels (Atallah *et al.,* 2021; Perez-Lombard *et al.,* 2022). These approaches are especially relevant in lecture rooms, where both the timing and intensity of HVAC operation must match varying teaching schedules to avoid energy waste.

3. Materials and Methods

3.1 Hardware Design and Components Selection

The IoT sensor device uses a Raspberry Pi Pico W microcontroller with a dual-core ARM Cortex-M0+ processor, supporting Wi-Fi communication. With its ARM Cortex-M0+ processor, this board consumes minimal power, allowing continuous operation without overwhelming the lab's power infrastructure. Its Wi-Fi capability eliminates the need for power-hungry communication modules. Programmed in Micro-Python, it connects sensors and peripherals via GPIO pins, storing firmware in onboard flash memory. This microcontroller offers low cost (around $6) compared to alternatives such as Arduino boards with Wi-Fi modules. It balances functionality and affordability, reducing the financial burden on large-scale deployments across campus lecture rooms.. The BME680 sensor measures temperature, humidity, and VOCs, communicating via I2C interface at 3.3V or 5V. The HC-SR501 PIR sensor detects

motion within 5 meters. A 0.96-inch SSD1306 OLED display shows sensor values and notifications. These components were selected for their low energy consumption during continuous operation. The OLED display consumes only about 20-30 mA during data updates, making it energy-efficient for local display needs. The device, powered by a USB connection, is housed in a 3D-printed enclosure with ventilation slots for the BME680. With a 5-meter detection range, this sensor meets the spatial needs for detecting human presence in lecture rooms. The low cost (less than $3 per unit) of this sensor makes it ideal for multiple deployments across rooms, minimizing budget constraints while maintaining acceptable detection performance. It ensures occupancy-based HVAC adjustments by reliably detecting movement events. The choice of BME680 ensures reliable environmental measurements. Its temperature accuracy (±1°C) and humidity accuracy (±3%) are well-suited for monitoring thermal comfort in indoor spaces, aligning with ASHRAE standards. It also measures VOCs, which are crucial for assessing indoor air quality and occupant health. This sensor provides all-in-one measurement capabilities, reducing system complexity and ensuring consistent data collection.

Figure 3.1: IoT devices

3.2 IoT System Architecture and Connectivity

The IoT architecture captures environmental data and occupancy activities, transmitting them using the MQTT protocol. The HiveMQ Cloud provides managed MQTT brokering, ensuring secure and scalable communication. Node-RED on an AWS EC2 server processes the data, routing it to a MySQL Cloud database for storage. Grafana Cloud visualizes the data, offering insights into indoor environmental parameters. This setup supports reliable data capture and delivery for building performance insights.

Figure 3.2: IoT System Architecture and Connectivity

3.3 Dataset

Three IoT devices in lecture rooms collect temperature, humidity, air quality, and occupancy data every 30 seconds. The final dataset includes:

- Temperature (°C)
- Relative Humidity (%)
- VOC gas (ppm)
- Motion (binary 0/1)
- Timestamps
- Sensor ID

The data, covering a 7-week period, is structured as a time series, enabling detailed analysis for building energy optimization.

3.4 Exploratory Data Pre-Processing Methods

The exploratory data analysis (EDA) involved dynamic handling of missing values, statistical verification, and feature scaling to prepare sensor data for predictive modeling. Network delays occasionally caused missing data, which was imputed using a sliding window method, replacing missing values with the average of adjacent readings to maintain contextual relevance. This adaptive approach minimized bias compared to static techniques like forward or backward filling. Outliers were identified using the Z-score method, with flagged values beyond three standard deviations

reviewed to distinguish between noise and legitimate environmental events, such as sudden VOC spikes. Min-Max scaling normalized variables to a range of 0 to 1, ensuring balanced model input. The data, originally collected at 30-second intervals, was aggregated into minute-level and hourly resolutions to smooth fluctuations and improve interpretability. Linear interpolation addressed irregular time gaps from network disruptions, maintaining temporal continuity. Statistical tests, such as ADF and KPSS, found temperature and humidity to be stationary, while VOCs exhibited non-stationarity. ACF and PACF plots revealed seasonal cycles, and correlation matrices identified strong relationships between temperature and humidity. This pre-processing framework enhanced data quality and ensured model robustness, enabling accurate predictions even amidst occasional delays or outliers.

4. Results and Discussion

4.1 Statistical Tests on Sensor Variables

Statistical analysis was conducted on the sensor data to assess stationarity and determine suitable time series modeling techniques. The Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests were used to evaluate stationarity from different angles.

4.1.1 Augmented Dickey-Fuller (ADF) Test

The ADF test examines the null hypothesis that a time series contains a unit root, indicating non-stationarity. The test statistic and p-value indicate whether to reject the null hypothesis.

i. Temperature
- ADF Statistic: -1.6169892942522364
- p-value: 0.47430804438075813

With a p-value above 0.05, we cannot reject the null hypothesis, indicating that the temperature data is non-stationary.

ii. Humidity
- ADF Statistic: -3.084740548948205
- p-value: 0.02770326024739388

A p-value below 0.05 allows rejecting the null hypothesis, indicating that the humidity data is stationary.

iii. Gas (VOC)
- ADF Statistic: -3.889058383738723
- p-value: 0.0021168633903055553

The low p-value suggests rejecting the null hypothesis, indicating that the gas data is stationary.

4.1.2 KPSS Test

The KPSS test evaluates whether a time series is stationary around a deterministic trend using the test statistic and p-value.

i. Temperature
- KPSS Statistic: 1.007035937822467
- p-value: 0.01
- Lags Used: 19
- Critical Values: {'10%': 0.347, '5%': 0.463, '2.5%': 0.574, '1%': 0.739}

The high test statistic indicates rejecting the null hypothesis, suggesting non-stationarity.

ii. Humidity
- KPSS Statistic: 0.7015766707060473
- p-value: 0.013402120844904785
- Lags Used: 18
- Critical Values: {'10%': 0.347, '5%': 0.463, '2.5%': 0.574, '1%': 0.739}

The low test statistic does not reject the null hypothesis, indicating that the humidity data is stationary.

iii. Gas (VOC)
- KPSS Statistic: 0.974637892435634
- p-value: 0.01
- Lags Used: 18
- Critical Values: {'10%': 0.347, '5%': 0.463, '2.5%': 0.574, '1%': 0.739}

The high test statistic indicates rejecting the null hypothesis, suggesting non-stationarity.

In summary, these tests provided insights into the stationarity of each sensor variable, guiding the selection of appropriate time series modelling techniques.

4.13 Auto ARIMA

1. Auto ARIMA, a Python library, automatically identifies the optimal p, d, q parameters for modeling time series, tailoring ARIMA models to each sensor variable.
2. Temperature: Auto ARIMA identified an ARIMA (2,1,1) model as the best fit with an AIC of -1651.278. This aligns with the ADF test results indicating potential non-stationarity in the temperature data, addressed by the differencing (1) term. The AR and MA terms capture daily/weekly cycles.
3. Humidity: An ARIMA (3,1,0) model was selected, with an AIC of 1452.244. The inclusion of 3 AR terms to model seasonality corroborates the KPSS test results confirming stationarity in the humidity data.
4. Gas (VOC): A simple ARIMA (0,1,0) model was chosen, with an AIC of 20931.832, indicating short-term randomness. This matches the statistical test outcomes suggesting non-stationarity in the VOC gas readings.

In summary, the automated ARIMA parameter selection accounted for the uniqueness of each time series revealed through statistical testing, including stationarity considerations, providing tailored modeling approaches for accurate forecasting.

4.2 Results and Performance Metrics

A comprehensive comparative analysis of the performance metrics across all machine learning models was applied to individual sensor variables. The primary objective was to identify the most effective model for predicting each sensor variable.

4.2.1 Facebook Prophet Results

- Temperature: MAE of 0.2, MSE of 0.0558, and EVS of -1.3812.
- Humidity: MAE of 6.3833, MSE of 44.7758, and EVS of -0.6546.
- Gas concentration: MAE of 41681.9792, MSE of 2165157870.8729, and EVS of -1.543.

4.2.2 ARIMA Results

- Temperature: MAE of 0.1075, MSE of 0.0185, and EVS of -0.2544.
- Humidity: MAE of 1.2917, MSE of 2.5183, and EVS of 0.065.
- Gas concentration: MAE of 14669.7417, MSE of 368164062.6825, and EVS of -0.0.

4.2.3 XGBoost Results

- Temperature: MAE of 0.0685, MSE of 0.0064, and EVS of 0.1683.
- Humidity: MAE of 0.403, MSE of 0.2925, and EVS of 0.8836.
- Gas concentration: MAE of 5122.0635, MSE of 47365911.9604, and EVS of 0.8694.

4.2.4 Random Forest Results

- Temperature: MAE of 0.0749, MSE of 0.0079, and EVS of 0.0572.
- Humidity: MAE of 0.4192, MSE of 0.3149, and EVS of 0.8771.
- Gas concentration: MAE of 3499.8563, MSE of 22313004.7697, and EVS of 0.9386.

4.2.5 Linear Regression Results

- Temperature: MAE of 0.0273, MSE of 0.0018, and EVS of 0.7395.
- Humidity: MAE of 0.2753, MSE of 0.1896, and EVS of 0.9222.
- Gas concentration: MAE of 4483.4628, MSE of 44483342.364, and EVS of 0.8827.

4.2.6 LSTM Results

- Temperature: MAE of 0.6917, MSE of 0.5592, and EVS of -11.1462.
- Humidity: MAE of 4.1875, MSE of 32.9721, and EVS of -0.8222.
- Gas concentration: MAE of 14644.341, MSE of 572986247.67, and EVS of -0.2669.

4.3 Comparative Analysis of Model Performance

A comparative analysis of performance metrics was conducted to identify the optimal machine learning model for each sensor variable. The models evaluated include ARIMA, LSTM, Prophet, Linear Regression, Random Forest (RF), and XGBoost (XGB). The key metrics considered are Mean Absolute Error (MAE), Mean Squared Error (MSE), and Explained Variance Score (EVS), with lower MAE and MSE and higher EVS preferred. The evaluation of machine learning models for predicting temperature, humidity, and gas concentration demonstrated varying levels of effectiveness, with Random Forest and XGBoost standing out as top performers. These models outperformed others by balancing

predictive power, computational efficiency, and the ability to handle the non-linear patterns in the sensor data. For temperature prediction, Random Forest and XGBoost excelled due to their ability to capture complex, non-linear relationships. Random Forest aggregates predictions from multiple decision trees, which reduces the risk of overfitting while improving accuracy. This makes it particularly suitable for datasets with temperature fluctuations that follow daily or weekly cycles. On the other hand, XGBoost's gradient boosting approach sequentially improves predictions by correcting errors from previous iterations. This incremental learning process helps capture subtle patterns in temperature changes, explaining its low Mean Absolute Error (MAE) and Mean Squared Error (MSE). The high Explained Variance Score (EVS) of both models confirms that they effectively captured the variance in temperature over time. In predicting humidity, Random Forest again performed well, showing an ability to model the rapid changes driven by environmental factors like HVAC systems, room occupancy, or weather conditions. XGBoost also delivered competitive results, thanks to its advanced boosting technique, which adjusts the model to capture intricate dependencies. Models such as Prophet performed poorly for humidity due to its focus on seasonality and trend detection, which may not align with the sporadic variations typical of indoor environments. For gas concentration (VOC) predictions, although Random Forest and XGBoost provided reasonable forecasts, the inherent randomness in VOC readings resulted in higher prediction errors compared to temperature and humidity. This reflects the challenge of modeling gas concentration accurately, given its sensitivity to transient activities like cleaning or chemical usage, which are harder to predict. The LSTM model did not perform well for any of the variables, as it requires larger datasets with long-term dependencies to realize its full potential. Since the sensor data in this study was more suitable for short-term forecasting, LSTM produced higher errors, indicating that it is not the ideal model for such real-time IoT applications.

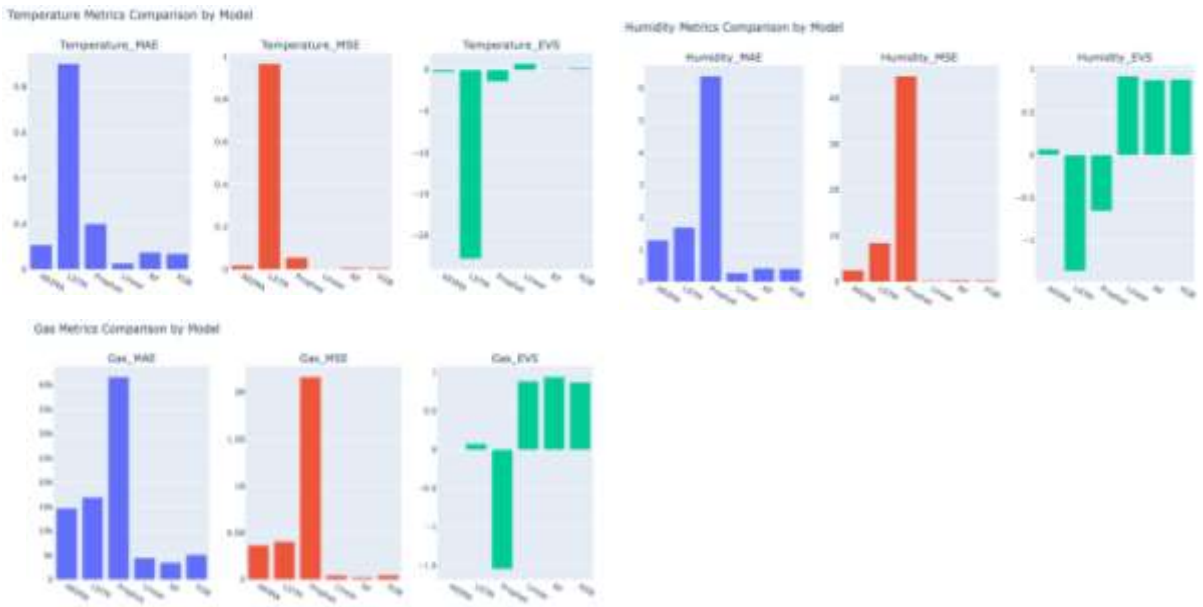

Figure 4.1: Model comparison

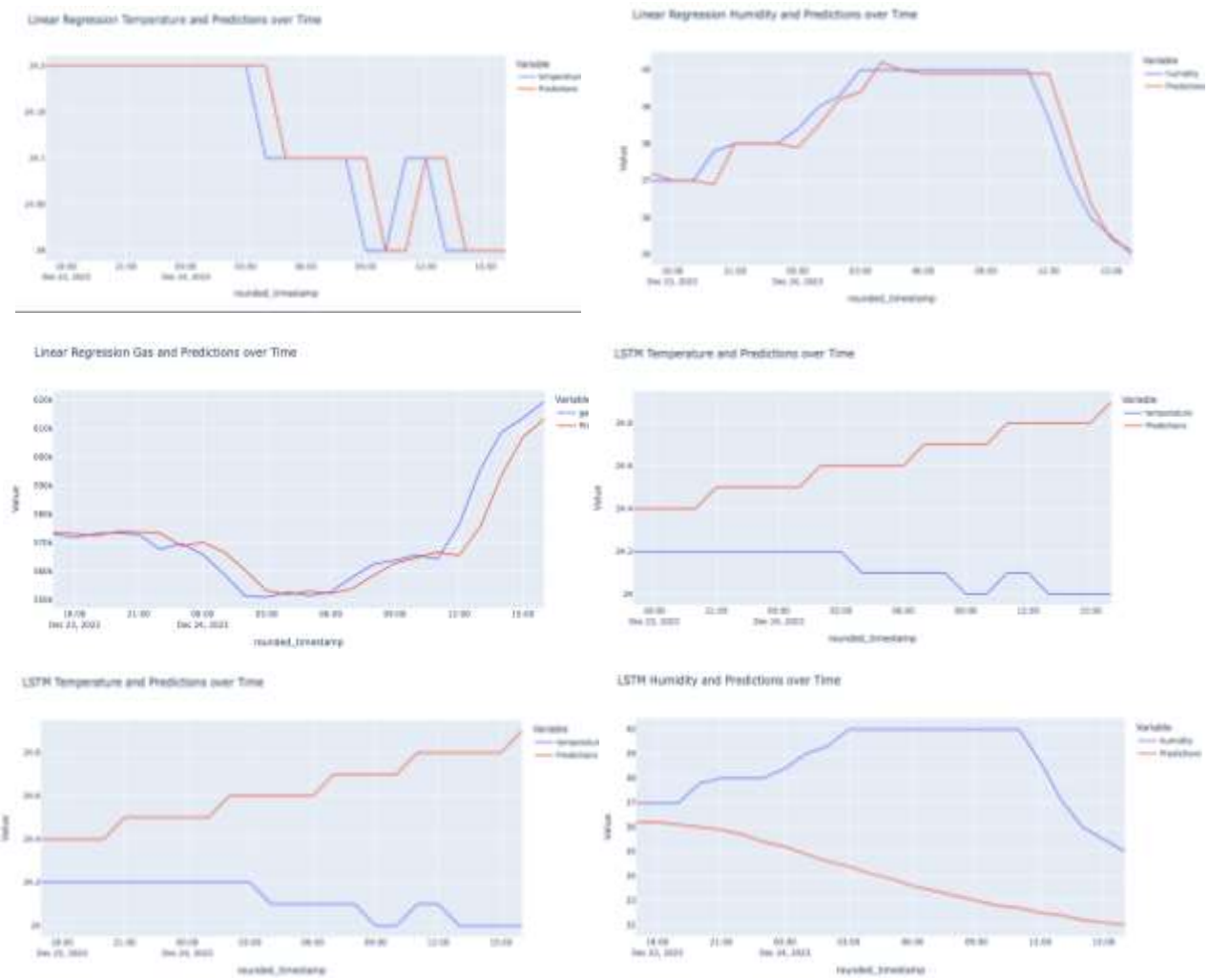

Figure 4.2: Timeseries plot for the actual parameter verses prediction of the models

4.4 Dashboard Visualizations

The developed Grafana monitoring dashboard proved to be an effective tool for real-time visualization of IoT sensor data and predictive model outputs. Key features of the dashboard include interactive line graphs that track temperature, humidity, and VOC gas concentration over time. These charts provide a comprehensive view of environmental conditions, allowing users to monitor changes and trends efficiently.

5. Conclusions and Recommendations

This research demonstrates the feasibility of integrating IoT-based analytics with predictive models to optimize academic infrastructure. Although primarily adopting established methodologies, such as ARIMA and Random Forests, the study validates the potential of end-to-end IoT implementation on a smaller scale. With an accuracy of 95% for 24-hour forecasts of temperature, humidity, and pressure, the models have shown promise. However, expanding sensor coverage and refining predictive techniques will further enhance performance and enable broader application across various academic spaces. The study found low occupancy during weekends, overnight hours, and holidays, revealing opportunities to conserve energy through demand-based HVAC scheduling. Automated systems should be programmed to switch off HVAC systems during non-use periods. Leveraging machine learning models like Random Forests, the system can predict peak usage times and pre-cool or pre-heat the lecture room in anticipation of high occupancy, improving both comfort and energy efficiency. Temperature data showed afternoon peaks beyond recommended levels, suggesting the need for cooling setpoints to be adjusted to 21°C–23°C during periods of heavy use. This fine-tuning can enhance thermal comfort without overburdening the system. Institutions might also consider installing smart thermostats that automatically adapt setpoints based on real-time sensor inputs. The sensor data revealed humidity levels exceeding 60%, posing risks of mold and bacterial growth. Installing dedicated dehumidifiers configured to maintain humidity within the 40%–60% range will prevent such problems while promoting better air quality. The use of XGBoost models can enhance humidity control by predicting spikes and triggering dehumidification

systems preemptively. Further, the research identified VOC concentrations surpassing 4 million ppm during crowded periods, signaling inadequate ventilation. To address this, upgrading ventilation systems with HEPA filters and increasing air exchange rates will help maintain healthy indoor air. Strategically placing air quality sensors near HVAC vents and seating areas will provide more accurate environmental monitoring and allow real-time adjustments to ventilation. The study acknowledges the limitations of the current setup, such as the limited number of sensors and network disruptions that caused data gaps. Expanding the sensor network to cover multiple areas within lecture rooms, such as front, middle, and back sections, will offer better spatial coverage. Addressing network delays through redundant data storage solutions or backup data transmission protocols will enhance data continuity. Future research could explore cross-validation techniques to ensure model robustness under varying conditions. Additionally, the generalization of the models to other spaces—like administrative offices or larger lecture halls—remains a challenge. Transfer learning methods can be explored to adapt models built for one environment to other spaces with minimal re-training.

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Thermal Comfort Performance of Thermoelectric Peltier Module Refrigeration System in Built Environment

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Abstract

According to data provided by the International Energy Agency, nearly 1.6 billion air conditioning (A/C) systems were operating globally in 2017, accounting for approximately 6% of the overall final energy consumption. To address the energy and economic challenges posed by such extensive use of air conditioning for thermal comfort, it is imperative to identify alternative solutions that can effectively operate in warm-humid environments. This study explored the thermal comfort performance of thermoelectric module refrigeration (TEMR) system in built environment; installed in a single-room facility in Minna, Niger State, Nigeria, over a one-month period. The experimental setup involved a test room measuring 1.3 m x 2.6 m x 3 m, equipped with aluminum roofing, an asbestos ceiling, an aluminum-framed window, and a steel door. The TEMR system was assessed for its ability to regulate indoor temperature and humidity under varying external climatic conditions. The TEMR system operated at a constant current of 6.4A, with data collected at specific intervals throughout each day. Results indicated that the TEMR system significantly reduced indoor air temperature and relative humidity, particularly during peak operational hours (12:00 pm to 2:00 pm). Weekly variations showed temperature drops from 37°C to 22°C and humidity reductions from 60% to 32% within 60 minutes of operation. These findings align with ASHRAE Standard 55-2017 for indoor environmental quality. The study concludes that the TEMR system is effective in improving indoor climatic conditions, offering a sustainable and energy-efficient cooling solution. Its performance, influenced by external climatic factors, demonstrates potential for broader application, particularly in developing regions where long-term, low-maintenance, and environmentally friendly cooling solutions are needed.

Keywords: Keywords: Air Conditioned, Refrigeration, Thermal Comfort, Thermoelectric.

1. Introduction

The global surge in population necessitates the exploration of new energy sources that are both environmentally friendly and technically efficient. In hot-dry regions, the prevalence of air conditioning (A/C) systems is a direct response to the intense heat and dry climate, essential for achieving indoor comfort (United Nations Department of Economic and Social Affairs UN DESA, 2022; International Energy Agency IEA, 2023; Saidur *et al.,* 2023). Thermal comfort, defined as the human satisfaction with the thermal environment, hinges on inhabitants' thermal sensations (ASHRAE 55 - 2020). Yang and Moon (2018) further describe thermal comfort as a psychological condition influenced by past experiences and adaptability. The demand for modern, maintenance-free energy systems to replace outdated installations is rising. Scientists and engineers are dedicated to developing efficient heating and cooling energy systems, driven by the growing energy needs and advancements in engineering sciences (Jackson *et al.,* 2018; Van-Ruijven *et al.,* 2019). The International Energy Agency (2019) reported that approximately 1.6 billion A/C units operated globally in 2017, consuming about 6% of the total final energy, underscoring the need for alternative solutions to tackle energy and economic crises. Thermoelectric modules (TEMs) offer a promising alternative. These solid-state energy converters can generate a temperature difference using electric potential (Peltier effect) or generate electricity from a temperature difference (Seebeck effect) (Enescu and Virjoghe, 2014). Thermoelectric refrigeration, based on the Peltier effect, functions as a small heat pump, moving heat through the module when powered by a low voltage direct current (Wang and Zhang, 2023). This technology can be applied in various cooling scenarios, including refrigeration and down-hole measuring equipment (Huang and Zhang, 2022). As energy efficiency in buildings becomes crucial due to rising concerns over CO2 emissions and fossil fuel scarcity, the thermal performance of building envelopes significantly impacts cooling energy consumption (Liu and Liu. 2023; Chen and Yang, 2024). This study aims to assess the thermal comfort performance of thermoelectric Peltier module refrigeration systems in built environments. It investigates the advantages and disadvantages of existing HVAC systems, the impact of thermoelectric refrigeration on indoor air conditions, and the cooling power output in an experimental test room.

2. Literature Review

2.1 Reviews on Existing Heating Ventilation Air Conditioning (HVAC) Systems

Energy consumption in commercial and residential sectors is projected to increase annually by 0.5% and 0.8%, respectively, from 2013 to 2040 (US Energy Information Administration, 2015; Lee and Park, 2023). HVAC systems are significant energy consumers in these sectors, accounting for approximately 43% of energy use in buildings. Consequently, demand-driven control in HVAC systems has become essential, with occupancy-based control being a critical factor in reducing energy consumption. Advanced systems and techniques utilizing statistical and probabilistic models for occupancy detection and prediction are being explored (Zhao and Li, 2023; Kumar and Ahuga, 2024).

2.2 Thermoelectric Refrigeration System

Cooling devices account for nearly 20% of global electricity consumption in buildings, with space cooling energy use expected to rise significantly by 2050 (Birol, 2018). Traditional air conditioners contribute to urban heat islands and greenhouse gas emissions due to the use of hydrofluorocarbon refrigerants (Cao, 2016; McLinden *et al*., 2017; Smith and Brown; 2023). Thermoelectric cooling, leveraging the Peltier effect, offers an alternative with advantages like compact size, quiet operation, and reduced environmental impact. Despite its lower coefficient of performance (COP) compared to vapor compression systems, thermoelectric cooling's benefits, including no refrigerants and reliable temperature control, make it promising for niche applications (Ibañez-Puy *et al*., 2017; Wang and Lin, 2023; Zhang and Zhang, 2024).

2.2.1 Heat sink design and performance

Effective heat dissipation is crucial for thermoelectric devices. Heat sinks, typically made of aluminum, are essential for maintaining performance by transferring heat from the hot side of the thermoelectric module. Designs vary from natural convection, suitable for low power applications, to forced convection and liquid cooling for higher efficiency. Optimal designs must balance thermal resistance and airflow to prevent overheating (Liu and Zhang, 2023; Zhou and Zhao, 2024).

2.2.2 Applications of thermoelectric refrigeration

Thermoelectric cooling finds use in specialized fields due to its reliability and compact design. Applications range from domestic portable refrigerators to medical devices for temperature control in therapeutic settings, automobile mini refrigerators, and cooling systems for electronic components and scientific equipment (Li and Zhang, 2024; Sun and Chen, 2024). Despite its lower COP, technological advancements continue to expand its potential applications.

3. Materials and Methods

3.1 Materials Description

The Thermoelectric Refrigeration System utilized in this experiment comprises various components as detailed in Table 3.1:

Table 3.1: Performance Specifications of Experimental Materials

S/N	Equipment	Type	Quantity	Function	Specification
1	Peltier Module	TEC1-12706	5	Create temperature gradient	Qmax: 52-57 W, ΔTmax: 66-75 °C, Imax: 6.4 A, Vmax: 14.4-16.4 V, Resistance: 1.98-2.30 Ω
2	Heatsinks (Cross-fin)	Finned aluminum	5	Enhance heat dissipation	Density: 2.71 g/cm^3, Thermal conductivity: 202 W/m-K
3	Axial/Blower Fans	12V DC	-	Circulate air	-
4	Dry Cell Rechargeable Battery	SN12-7.5	1	Power source for TEMs	12V, 7.5AH/20HR, Initial current: 2.25 A max
5	Digital LCD Electronic Alarm Clock Hygrometer	HTC-1	1	Measure indoor weather	Temp accuracy: ±0.1°C

3.1.1 Peltier module

The Peltier Module, operating on the Peltier effect, creates a heating and cooling effect at the junction of two different conductors when electric current flows through. The heat generated at the junction (Peltier Heat) is given by

$$Q = (\Pi_A + \Pi_B) \times I \quad (I)$$

where Π_A and Π_B are the Peltier coefficients of the conductors, and I is the current.

Plate I: Peltier module

3.1.2 Heat sink

Heat sinks, typically made of conductive metals like aluminum or copper, dissipate heat from high-temperature components. Finned designs increase surface area for better heat transfer (Chen and Yang; 2023; Huang and Li, 2024).

Plate II: Heatsink

3.1.3 Blower fan

Blower fans provide active cooling by drawing cool air into the system and expelling warm air. These fans, usually operating on 12V DC, can ventilate large areas effectively. It can be used to ventilate up to 1,250 square feet (116 m^2) of area and can move air at up to 800 cubic feet per minute (400 L/s).

Plate III: Model of axial/blowerfans (12V DC)

3.1.4 Dry cell rechargeable battery

A DC device, the thermoelectric module, is powered by a rechargeable battery, allowing multiple charges and discharges. A rechargeable battery, storage battery, or secondary cell, (or archaically accumulator) is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use.

Plate IV: Dry cell rechargeable battery

3.1.5 Digital LCD electronic alarm clock hygrometer

This device monitors indoor temperature and humidity, offering high precision and low power consumption. It can record the highest and lowest temperature/humidity, set a daily alarm, and display time/temperature/humidity with a wide temperature measuring range from -58°F to 158°F; a humidity measuring range from 20% to 99% RH.

Plate V: Digital LCD electronic alarm clock hygrometer

3.2 Methods

Thermoelectric Assemblies (TEAs) were used for heating and cooling, with heat sinks to dissipate heat from the TEC. Theoretical performance equations for the TEC include

Voltage, $V = \propto(T_H - T_L) + IR)$ (2)

Input power $(P = \propto I(T_H - T_L) + I^2R)$ (3)

Cooling capacity $Q_L = I\propto T\_C(T_H - T_L) - 0.5I^2R)$. (4)

The cooling load calculation is given by Refrigeration Effect = $(m \times C_\rho \times \Delta T) / t$. (5)

3.2.2 Selection of Thermoelectric Modules

Parameters such as mass of indoor air, specific capacity, and temperature difference determined the number of modules required. The cooling capacity was measured in British Thermal Units (BTU), with calculations showing five TEC1-12706 modules were ideal for the test room dimensions (2.6 m x 1.3 m x 3.0 m). The assembled system was tested before mounting in the experimental setup.

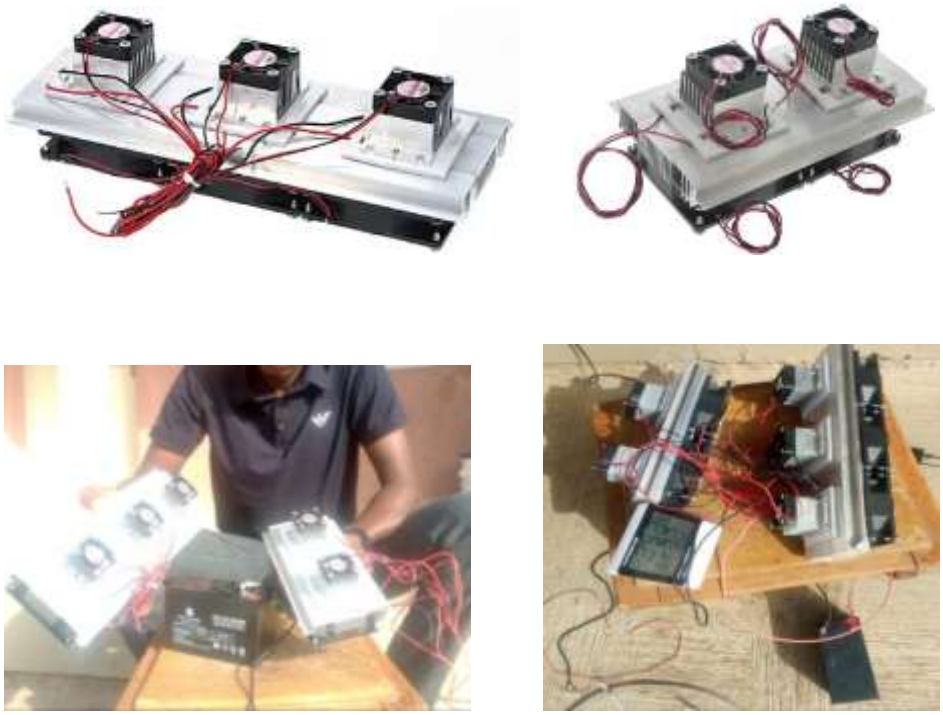

Plate VI: Show the assembly and installation of the Thermoelectric Refrigeration system

4. Results and Discussion

The experiment and data collection took place in a single-room house equipped with the thermoelectric refrigeration system in Minna, Nigeria (26° 32' N, 50° 13' E). The test room dimensions were 1.3 m x 2.6 m x 3 m, with an aluminum roof and asbestos ceiling.

4.1 Effects on Indoor Air Temperatures and Relative Humidity

The TEMR system operated at 6.4A during specified hours. Surface temperature changes indicated one side becoming hot and the other cold. Data recorded per ASHRAE Standard 55-2017 showed temperature and humidity differences were most significant during peak hours (12:00 pm - 2:00 pm). The system effectively reduced indoor temperature and humidity, with peak performance observed in the first week of operation (Figures 4.1 to 4.4).

4.2 On-Site Measurement Effect of the TEMR System on Room Temperature

As described above, study was carried out in a hot humid climate in the city of Minna, where outdoor temperatures and relative humidity were high. Due to the geographical location, there was no seasonal change, so, values usually fluctuate very little through the month of November. The average values for indoor air temperature (T_{a_indoor}) and indoor relative humidity (RH_{indoor}) were measured in each field test carried out for the purpose of this study. Therefore, the effect of implementing the TEMR system on indoor operative temperature and relative humidity of the test room at different time interval with input current supply of 6.4 A to TEMR system is presented in Figure 4.1 to 4.4.

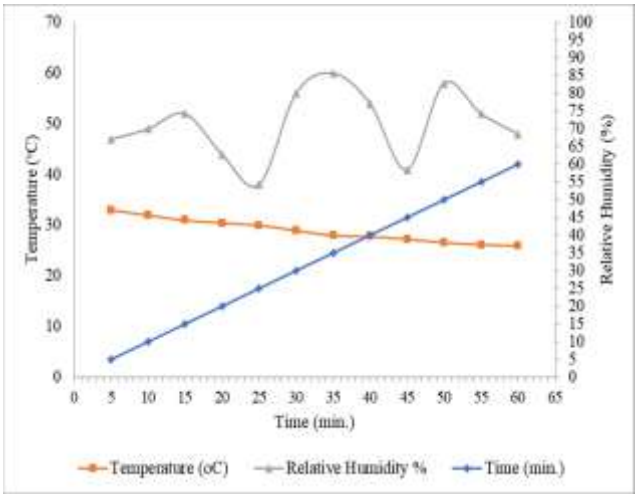

Figure 4.1: First week variation of indoor climatic conditions of the test room with time, when TEMR system operated at

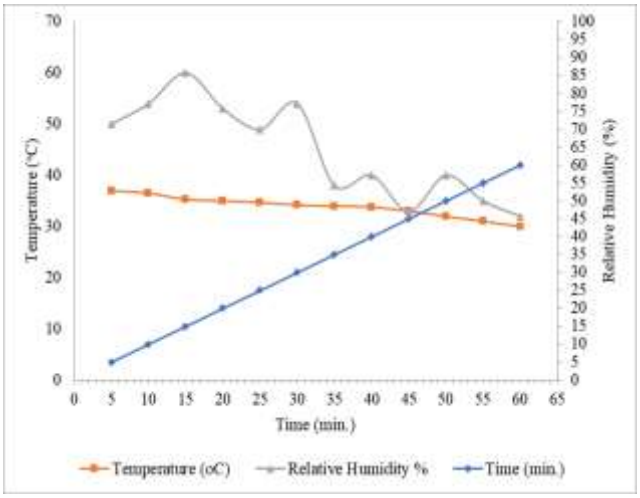

Figure 4.2: Second week variation of indoor climatic conditions of the test room with time, when TEMR system operated at 6.4A

Figure 4.1 shows the indoor climate variations over time in the test room with the TEMR system running. The indoor temperature dropped from 33°C to above 26°C in 60 minutes at 52W, with measurements taken every 5 minutes. The temperature and humidity fluctuations correlate with the cooling load and current draw of the TEMR components. The ideal indoor conditions were 27.3°C and 41% humidity at 45 minutes, which aligns with ASHRAE 55 (2017) standards for thermal comfort. Initially and finally, relative humidity was higher but decreased as the temperature dropped during peak hours. Figure 4.2 displays similar data for the second week, showing average temperature and humidity dropping from 37°C to 30°C and 60% to 32% respectively, within 60 minutes at 57W. Despite some fluctuations, the relative humidity was adequate, but temperatures were not ideal, influenced by high outside temperatures and humidity.

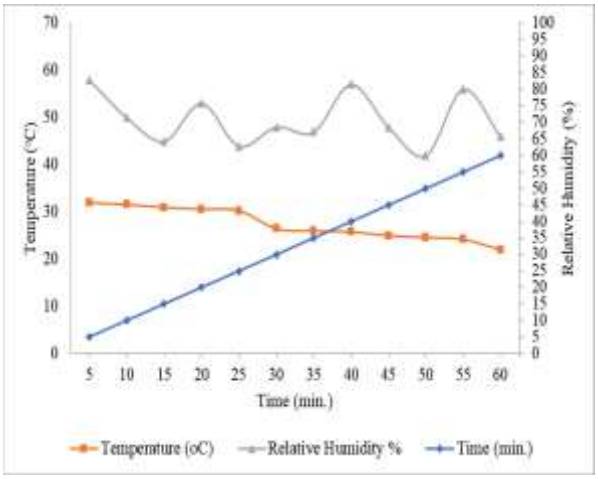

Figure 4.3: Third week variation of indoor climatic conditions of the test room with time, when TEMR system operated at 6.4A.

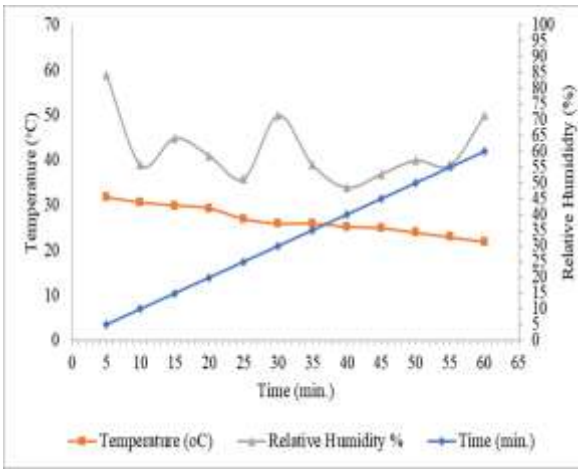

Figure 4.4: Forth week variation of indoor climatic conditions of the test room with time, when TEMR system operated at 6.4A.

Figure 4.3 shows the variation in indoor climate conditions over time in the test room with the TEMR system running. The indoor temperature dropped from 32°C to 22°C, and humidity fell from 58% to 42% within 60 minutes at 57W. The temperature and humidity decreased steadily over time, reaching a stable condition at 26.5°C and 48% after 30 minutes. Figure 4.4 depicts a similar trend, with indoor temperature dropping from 31.8°C to 22°C and humidity from 59% to 34% in 60 minutes at 52W. Despite some fluctuations, the conditions remained adequate, with the temperature and humidity stabilizing at 27°C and 36% after 25 minutes, aligning with ASHRAE 55 standards for thermal comfort.

4.3 Summary of Findings

The TEMR system demonstrated effective performance over the month, particularly during initial and final hours of operation. Peak operating hours saw high outdoor temperatures (above 37°C) and humidity (above 85%). The system, operating at 6.4A, achieved significant reductions in indoor temperature (4-5.7°C) and humidity (8-22%). The system's efficiency increased with higher heat pumping capacity on the cold side, which absorbed more heat from the ambient air, thus reducing the indoor temperature and humidity effectively. This performance aligns with the principles of thermoelectric cooling and the theoretical equations provided.

5. Conclusion and Recommendations

The experimental results indicate that the thermoelectric refrigeration system performs well under given conditions with forced air convection heat dissipation. A temperature reduction of 15°C was achieved in the test room from an ambient temperature of 37°C in 60 minutes. Given current energy and environmental challenges, thermoelectric refrigeration systems show promising potential for future thermoelectric generation and cooling, particularly in developing countries and remote areas where long life, low maintenance, and a clean environment are crucial. Environmentally, the thermoelectric refrigeration system is eco-friendly due to the use of the Seebeck module, which does not deplete the ozone layer. Technically, it is recommended for its high COP at low power input, reducing energy consumption. Optimizing the TER system's power operation is sustainable and advantageous over window air conditioners: it uses no chlorofluorocarbons, maintains precise temperature control, and offers flexible, small form factors. However, improving thermoelectric modules' conversion rate remains urgent for their commercialization.

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Effect of organizational culture on the safety practices of construction firms in Abuja

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Abstract

In building construction, there are many things that must be considered, one of which is work safety due to construction industry is a highly hazardous environment. Early signs of an organization's commitment to safety policies are manifested in the safety culture of the organization. Improving contractor safety culture can reduce work accidents on construction industry projects. It is unclear how to improve safety culture among construction industries, practically. The purpose of this study was to analyse the influence of safety culture and its association with management commitment in monitoring system of work safety. Structural Equation Modelling (SEM) method was used by researchers in testing the relationship between the measured variables and the latent construct. According to the results of this study, it can be concluded that Work Safety Culture has an influence on Work Safety based on the responses from the Respondent. The results of this study can be used as the basis for implementing a safety culture in the company because it is proven to have an important role in work safety so that it is expected to reduce work accidents with the support of management who are committed to consistently carrying out work safety monitoring systems. Increasingly, organizations are expected to improve their ecological and environmental performances. Researchers have suggested organizations plays a role in commitment to their safety. With a response rate of 100%. Analysis of data was carried out using MIS. Results show that dominant the most dominant type of organisational culture in Abuja construction firms is the "Hierarchy Culture. Adhocracy culture with the highest impact on construction firm safety (MIS = 4.081). Hence, it was concluded that there is a strong relationship between all types of organisational culture and adoption of safety practices, the strength of the relationship just varies for different cultures.

Keywords: Adhocracy, Hierarchy, Organizatonal Culture, Safety Control, Sem.

1. Introduction

The construction industry is one of the most dangerous workplaces in the world, accounting for more than half of all industry-related accidents and deaths (Tadesse and Israel, 2016). As a result, construction companies are increasingly concerned about the rising likelihood of accidents and fatalities (Abdullah and Wern, 2011). According to Health and Safety Executive (HSE), 2017, despite a 30 percent decrease in construction industry mortality, this sector is still responsible for the highest number of deaths in the world. 165 of every 1000 employees in Nigeria get wounded at work (Kanchana *et al*. 2015). Over-reporting and a significant number of informal construction workers in Nigeria have led to inaccuracies in Abuja's construction mortality and incidence rates. More than 50,000 workplace accidents were reported in Nigeria industry in 2014 and 2015, with over a third of them occurring in the construction sector, the sector accounted for 39.24% of the whole occupational accidents, according to official statistics (BPJS Ketenagakerjaan, 2016). In contrast, little research has been done on the Nigeria construction industry's safety culture. The lack of safety communication and a poor work environment were evaluated extremely poorly by respondents. Recently, the level of safety culture in Nigeria construction and infrastructure projects valuated; Workers' safety habits are strongly tied to their workplace's safety culture, which represents proactive indicators of safety performance. Health and safety (H&S) can be enhanced with the goal of improving H&S performance; however, there is little information available on how H&S may be improved in practice. The challenge is worsened even further by the several theories of H&S culture and the continuous dispute over whether or not culture can be measured.

The construction industry is inherently risky and safety practices play a critical role in mitigating hazards and ensuring the wellbeing of workers. Organizational culture has been identified as a significant factor influencing safety performances in various industries, including construction. However, limited research has focused on the specific impact of organizational culture on safety practices within construction firms in Abuja, Nigeria. Safety practices in construction firms are crucial for protecting workers and ensuring the successful completion of projects. the effectiveness of these practices is significantly influenced by the organizational culture within the firms in Abuja, Nigeria.

Increasing attention, the impact of organizational culture on the safety practices of construction firms in Abuja has become a critical area of study. The construction industry, a significant contributor to the environmental development urgently needs innovative strategies to promote safety practices. The role of organizational culture in shaping how construction companies approach the safety of construction workers on site for health and safety cannot be overstated, safety climate as a reflection of organizational culture, impact on safety behaviour, role of leadership, cultural barriers to safety implementation, long term stability (Lee & Kim, 2014).
The construction sector is widely recognized for its significant role in driving economic growth, meeting societal needs, improving quality of life, and creating employment opportunities.

2. Study Area

This study covers construction firms within the Federal Capital Territory, Abuja. This is due to the fact that Abuja is one of the rapid developing cities in Nigeria with a good number of construction firms operating in the city.

The study includes surveys and interviews with managers, safety officers, and frontline workers.

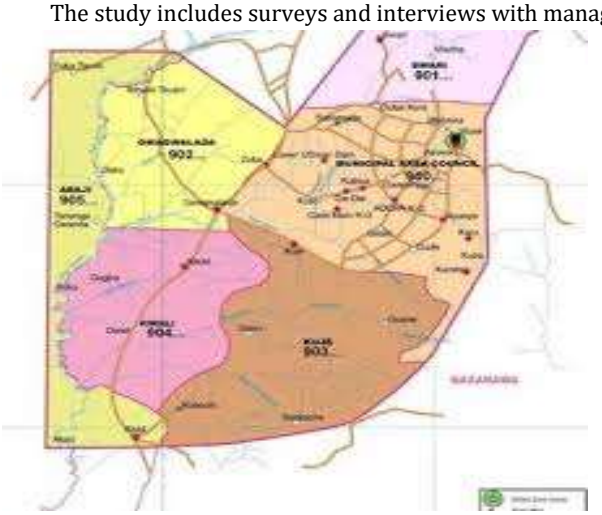

Figure 1: image of the study area (Source: www.directory.org.ng)

The study hence covers construction firms such as:

A. Alpha Praxis Nig. Ltd
B. Multi Engineering solutions & Design Limited
C. Gilmor (Jahi District)
D. TOLMAC Works and projects (M
E. Luxiar construction
F. Smooth Edge Construction Ltd
G. Hiltec Construction Co.Ltd

3. Methodology

This section addresses the overall structure of the project research. It details the general procedures and methodologies employed, including the types of data collected and their sources, the instruments and materials

ORGANIZATIONAL CULTURE FRAMEWORK: Scheins (2010) Organizational culture model. The framework is purposeful for expressing the relationship clarification, organizes various elements of organizational culture and also communicates how intertwined the relationship between Artifacts, espoused values and under laying assumptions, used for the project's successful implementation, as well as the methods of data processing and presentation.

The framework of the methods used are presented in Figure 2, And the safety culture model illustrated in figure 3.

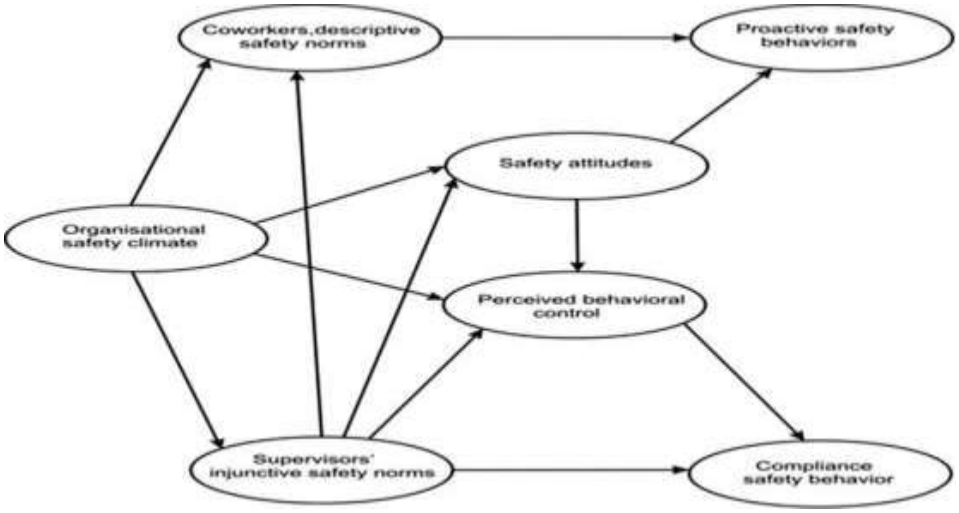

Figure 2: Conceptual framework

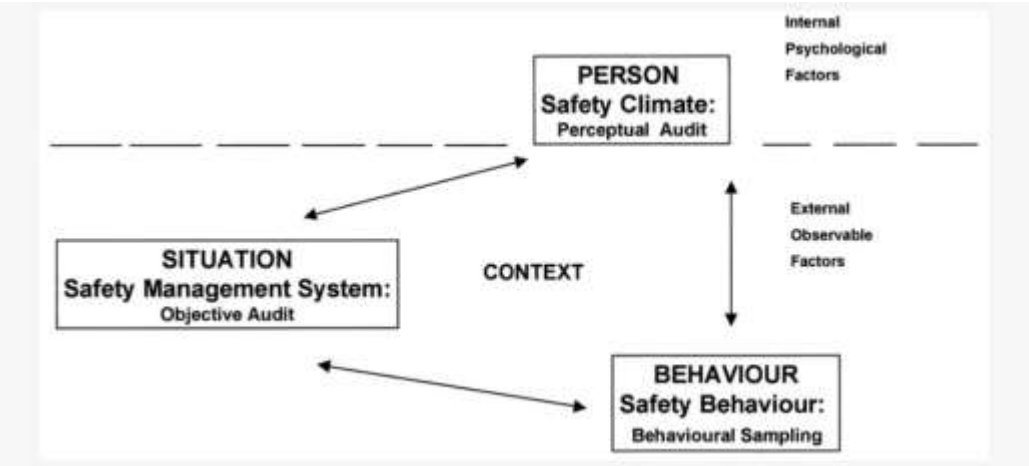

Figure 3: Safety culture model (Blaine Ryan)

3.1 Data collection methods

For this study, a quantitative approach was chosen. The research began by reviewing relevant literature to establish a theoretical foundation and identify the primary data needed. Subsequently, a structured questionnaire was developed and administered to the participants. The questionnaire utilized a five-point Likert's Scale format to collect data aligned with the research objectives. It consisted of four sections, each addressing specific aspects. The first section focused on gathering information about the respondents' profiles. The second and third sections dealt with Objective 1 and Objective 2 respectively, while the fourth section addressed issues related to Objective 3. The breakdown of the data collection method are below as follows:

Quantitative Research Design: survey and statistical analysis to identify relationship between organizational culture and safety practices.
Data Collection Methods: Quantitative data survey questionnaire administered to construction firm employees, safety officers and managers in Abuja (n= 94)
Organizational Culture Assessment Instrument (OCAI): To measure organizational culture dimensions (e.g clan, adhocracy, safety, and Hierarchy)
Quantitative Data: Structural equation modelling (SEM) to examine relationship between organizational culture and safety practices.
Sampling Strategy: Purposive sampling: selects construction firms with varying safety records.

Table 1: Table title

Objective	Research Approach	Target population	Unit of analysis	Research Instrument	Method of analysis
1.	Quantitative	Registered building construction firms operating within Abuja	Construction professionals (Architects, Safety officers Foremen, Builders and Civil Engineers)	Questionnaire	MIS
2.	Quantitative	Registered building construction firms operating within Abuja	Construction professionals (Architects, Safety officers, Foremen, Builders and Civil Engineers)	Questionnaire	MIS
3.	Quantitative	Registered building construction firms operating within Abuja	Construction professionals (Architects, Safety officers, Foremen, Builders and Civil Engineers	Questionnaire	MIS

3.2 Types of organizational culture

The types of organizational culture predominant in construction firms to foster safety practices in Abuja includes;

Table 2: The types of organizational culture therein in construction firms in Abuja

S/N	Types of Organizational Culture in construction firms	Source(s)
1.	Hierarchy Culture	Limin Gong *et al*, (2022)
2.	Adhocracy Culture	Limin Gong *et al*, (2022)
3.	Clan Culture	Limin Gong *et al*, (2022)
4.	Safety Culture	Limin Gong *et al*, (2022)

3.2.1 Challenges of safety culture in Abuja construction firms

Finding the challenges first by looking around the workplace rather than waiting for problems to happen is being proactive. This involves workers, supervisors, and managers observing jobs, communicating the hazards, making decisions on effective options, and then taking the necessary action. Four steps to an effective proactive action plan were reported. These included looking for potential hazards clues, assessing and prioritizing identified hazards, making improvements to reduce or eliminate the identified risk, and following up to see if the new steps introduced are effective.

3.2.2 Benefits of the adoption of safety practices in construction firms

The review of literature carried out for the study has been able to identify the following benefits of safety.

Firms with a strong safety culture are more likely to invest in safety training, provide adequate protective equipment, and enforce safety protocols. However, in many cases, the emphasis on cost reduction and meeting tight project deadlines can undermine safety practices, leading to a culture where safety is not prioritized. Empirical studies in Nigeria have highlighted the need for construction firms to develop a positive organizational culture that values safety. For example, a study by Umeokafor *et al*. (2014) found that Nigerian construction firms with a strong safety culture reported fewer accidents and better compliance with safety regulations compared to those with a weaker safety culture.

3.2.3 Suggested safety course contents for construction firms

The process Below are Safety outlines for proposed proactive safety culture:

1. The use of Personal Protective Equipment (PPE)
2. Permit to work analysis

3. Reporting and recording accidents/incidents
4. Process Safety
5. Principles of safety measurements
6. Safety rules and regulations
7. Introduction to security
8. Equipment management, lifting operations and stress management.
9. Importance of safety practices
10. Environmental Safety
11. Safety in the Workshop
12. Energy Management, Quality & Ergonomics
13. Best Practices in Safety Management
14. Product Safety and Liability
15. Basic first Aid training
16. Industrial Safety Analysis and Risk Assessment
17. Legal Administrative Framework for Industrial Safety Management
18. Cyber and Industrial Security Management
19. Introduction to incident investigation
20. Accident reporting and investigation
21. Simultaneous Operations (SIMOPs) - Guidelines
22. Introduction to Behavioral Based Safety (BBS)
23. Work at height - Guidelines
24. Industrial Fire Protection
25. Environmental Law and Regulation
26. Fundamental to occupational Safety
27. Safety Demand in Engineering & General Working Environments
28. Analysis of Degree of Safety
29. Design of Safety procedures
30. Technical Report on Operational Safety in Engineering Related Engagement

Suggested safety procedures for construction firms (Source: ALPHA PARTNERS)

4. Result and Discussion

The results of the study are discussed below:

4.1 Safety practices in firms

Table 3: Ranking level of organizational culture that promotes safety practices in firms

Code No	Types	MIS 3	Rank	Interpretation
B1	In your construction firm, decisions tend to flow from the top down with clear lines of authority. (Hierarchy Culture)	4.605	1st	Strongly Agree
B4	Your company places a high emphasis on safety and achieving measurable result. (safety Culture)	4.025	2nd	Agree
B3	There is a strong sense of comradeship and collaboration within our construction teams. (Clan Culture)	3.790	3rd	Agree
B2	Your company values protocols and encourages employees to follow safety rules in executing construction projects. (Adhocracy Culture)	3.358	4th	Neutral

It was revealed that respondents strongly agree with the statement "In your construction firm, decisions tend to flow from the top down with clear lines of authority. (Hierarchy Culture)" with a MIS of 4.60. Respondents explicitly perceive a strong top-down decision-making style in these firms. This centralized approach offers advantages like faster decision-making and clear lines of accountability. "Your company places a high emphasis on safety and achieving measurable result. (safety Culture)", MIS 4.02. This indicates a focus on Health/Safety and results, aligning with the fast-paced and project-driven nature of the construction industry. This emphasis on performance can drive productivity and as well maintain safety on site, but might compromise work speed if not balanced with other values. and "There is a strong sense of comradeship and collaboration within our construction teams. (Clan Culture)" with a MIS of 3.79. Despite the hierarchical and safety-oriented environment, Clan culture is noteworthy. This suggests the presence of a supportive team culture alongside the strong focus on achieving objectives which is safety. Fostering this

collaborative spirit can enhance communication, morale, and safety in the execution of tasks. There is a neutral opinion on the statement "Your company values protocols and encourages employees to follow safety rules in executing construction projects. (Adhocracy Culture)" with a MIS of 3.36. This hints at a hesitant approach towards following rules and regulations on safety. While the construction industry has inherent complexities and safety concerns, embracing some level of experimentation and new ideas can be crucial for long-term growth and adaptation.

4.2 Ranking types of safety practices in firms

Table 4: Ranking types of safety practices in firms

Types	MIS	Rank	Interpretation
Wearing PPE	4.432	1st	Very High
Awareness of signs	4.222	2nd	Very High
Provision of Instructions	3.988	3rd	High
Site Tidiness	3.704	4th	High
Tools Organization and Storage	3.519	5th	High
Use of Right Equipment	3.222	6th	Moderate
Emergency Response Plan (ERP)	3.136	7th	Moderate
Setting up Safeguards (Barriers)	2.988	8th	Moderate
Tools Inspection	2.951	9th	Moderate
Prompt Report of Accidents	2.691	10th	Moderate
Average MIS	3.485		Moderate

Table 4 revealed the MIS ranking level of respondents' firm use of ten safety practices used by construction firms identified from literature review. It was revealed that "Wearing PPE" and "Awareness of Signs" have a very high level of adoption with a MIS of 4.432 and 4.222 respectively. This indicate a strong emphasis on maximizing the use of Personal Protective Equipment. This aligns with global safety goals and demonstrates responsible safety management by these firms. Other practices ranging from "provision of instructions" (MIS=3.988), "Site Tidiness" (MIS=3.704), "Tools Organization and storage" (MIS=3.519) have a high level of adoption. "Use of right Equipment (MIS=3.222) and "Emergency response plan (MIS=3.136) "Setting up Safeguards" (MIS=2.988), "Tools inspection" (MIS=2.915) and "Prompt Report of Accidents" (MIS=2.691) have a moderate level of adoption, indicating quick information to management during accident which is very helpful practices. Encouraging their adoption could significantly increase health and safety and create a much safe work atmosphere within the construction sector. On the Average, all the safety practices have a moderate level of adoption (average MIS=3.485). While this is a positive step, continued efforts are needed to reach higher levels of safety integration, particularly in areas like "use of right equipment", "emergency response plan", and inspection practices like "Tool Inspection" and "prompt report of accidents". This is in agreement with the work of (Innocent Oboh *et al*., 2023) who expressed proactive safety in construction practices and concluded that safety practices are somewhat implemented at a firm level in Nigeria. And also with the work of Dodo, M, Umeaafor, N, Issac, D, Jones, k, (2014), their study evaluated the level of adoption, enforcement and application of safety practices among construction firms in Nigeria and recorded a moderate level of adoption of safety practices.

5. Conclusion and Recommendation

In construction firms in the Abuja, Organization culture plays a critical role in shaping safety practices. A positive, safety-oriented culture promotes adherence to safety regulations, encourages open communication about risks, and supports continuous safety training. Conversely, a culture that prioritizes profit or speed over safety may lead to unsafe practices, accidents, and non-compliance with safety standards. Therefore, fostering a culture that values safety can significantly reduce accidents and enhance the well-being of workers, ultimately improving the firm's reputation and productivity.

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Assessment of Electrical Energy Consumption in Some Selected Tertiary Institutions Administrative Buildings in Niger State

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Abstract

High electrical energy consumption in public buildings and institutions poses a significant challenge, particularly in developing countries like Nigeria. Inadequate empirical studies on building energy use have resulted in a lack of electrical energy data, especially in tertiary institutions where bulk metering is common. This study aimed to assess the electrical energy consumption in selected administrative buildings of tertiary institutions in Niger State, with the goal of reducing electrical consumption and improving energy efficiency. Experimental data collection involved direct field measurements using a real-time Efergy wireless energy (EW4500) monitoring device. Current transformer sensors were attached to the main distribution panels of the administrative buildings at the Federal University of Technology Minna, Niger State Polytechnic Zungeru, and Niger State College of Education Minna. The objectives included evaluating electrical energy consumption, comparing total consumption across buildings, and analyzing energy consumption patterns. Results indicated that the Senate building at FUT Minna had the highest consumption rate at 2604.7 KWh/m^2, followed by Niger State Polytechnic Zungeru at 2579.1 KWh/m^2, both exceeding the global benchmarks of 128 to 130 kWh/m^2 set by the Chartered Institute of Building Services Engineers (CIBSE) and the Building Energy Efficiency Guideline for Nigeria (BEEGN). In contrast, COE Minna's administrative building, with consumption levels averaging 1579.1 KWh/m^2, generally fell within these benchmarks. The elevated energy consumption at FUT Minna and Niger State Polytechnic Zungeru was primarily attributed to operational inefficiencies, such as the continuous operation of HVAC systems and equipment during non-essential hours, even when buildings were not fully occupied. Hourly consumption patterns revealed peak usage during early working hours, with significant seasonal variations; however, both FUT Minna and Niger State Polytechnic Zungeru exhibited high energy use during off-peak periods, reflecting poor energy management practices. To address these inefficiencies, the study recommends conducting comprehensive energy audits and installing energy-efficient appliances at FUT Minna and Niger State Polytechnic Zungeru. Additionally, implementing smart metering, occupancy sensors, and optimized HVAC controls would significantly enhance monitoring and reduce energy consumption. These measures are critical for improving energy efficiency and ensuring sustainable operations in both institutions.

Keywords: Electrical Energy Consumption, Tertiary Institutions, Administrative Buildings, Energy Efficiency, Sustainable Energy Practices

1. Introduction

The global increase in energy consumption, particularly in the building sector, has reached alarming levels due to population growth, increased demand for building services, and higher comfort levels (Pérez-Lombard *et al.,* 2008; International Energy Agency IEA, 2015; Allouhi *et al.,* 2015). Buildings account for approximately 40% of global electrical energy consumption, with projections indicating further growth due to rising living standards (Xing *et al.,* 2011; Urge-Vorsatz *et al.,* 2013; Nejat *et al.,* 2015; Ibn-Mohammed *et al.,* 2015). Emerging economies are experiencing the fastest increases, with energy use growing at an annual rate of 3.2%, compared to 1.1% in developed countries (IEA, 2017). In Nigeria, the challenges of energy consumption are particularly pronounced in tertiary institutions, where the recent 50% increase in electricity tariffs has significantly exacerbated the financial burden on schools (Oladeinde, 2021). Institutions such as the University of Lagos (UNILAG) and the Federal University of Technology Minna have struggled to meet these rising costs, often resorting to measures like rationing electricity usage (Funmi, 2021; Iyabo, 2021). This financial strain is compounded by inefficient energy usage, which not only impacts operational budgets but also contributes to resource depletion and environmental degradation (Choong *et al.,* 2012). The administrative buildings of tertiary institutions are critical for this study due to their size, functions, and energy consumption trends. These buildings typically house essential administrative functions that support the overall operations of the institution, making their energy efficiency vital for reducing operational costs. This highlights the need for targeted energy assessments to identify inefficiencies and implement effective energy management practices. Moreover, insufficient information and benchmarks on energy consumption in Nigerian tertiary institutions hinder

efforts to promote energy-saving initiatives (Bosch and Pearce, 2003; Entrop *et al.,* 2010). Addressing these challenges is crucial, as electrical energy consumption in universities is influenced by various factors, including building type, age, occupancy, operating hours, equipment, and weather conditions (Unachukwu, 2010). Addressing energy availability and consumption is critical for the functioning of tertiary institutions, impacting academic, social, and economic activities (Akanmu *et al.,* 2019). Therefore, this paper seeks to assess the electrical energy consumption in selected administrative buildings of tertiary institutions in Minna, Niger State, with the aim of reducing consumption and improving energy efficiency. By focusing on these specific buildings, the study aims to provide insights that can inform better energy practices and contribute to sustainable operations within the educational sector.

2. Literature Review

Energy is a crucial determinant of socio-economic growth and quality of life globally (American Society of Heating, Refrigerating and Air-Conditioning Engineers ASHRAE, 2013; Kousksou *et al.,* 2014). The rising energy consumption in buildings is alarming, with an average annual growth of 3.15% between 2005 and 2011, and global energy consumption predicted to reach 14 Gtoe/year by 2020, further increasing to 16.03 Gtoe/year by 2022 (Energy Information Administration EIA, 2008; EIA, 2022). Developed nations exhibit significant energy demands in the building sector: the US consumes about 40% of its energy in buildings, China consumes over 25%, and the UK's building sector accounts for 40-50% of energy use and over 100 million tons of CO2 emissions annually (Pout *et al.,* 2002; Perez-Lombard *et al.,* 2008; Bouchlaghem, 2012). In India, the building sector consumes 35% of total energy (Manu *et al.,* 2016), while Nigeria's building sector consumes about 40% of its electricity supply amidst inadequate and erratic supply (Akinbami and Lawal, 2009; Aderemi *et al*., 2009; Noah *et al.,* 2012). Despite the alarming trends in energy consumption, there is a notable lack of comprehensive studies focusing specifically on Nigeria and West Africa. While several studies have modeled and examined electricity demand determinants in both developed and developing countries, local research remains sparse. For instance, Ekpo *et al.* (2011) found that real GDP per capita, population, and industrial output drive electricity consumption in Nigeria, but the study did not delve into the specific energy consumption patterns of educational institutions. This gap is significant, as educational institutions are major energy consumers and face unique challenges related to energy management. In the context of higher education, studies such as those by Ward *et al*. (2008) and Hawkins *et al.* (2012) have identified correlations between energy consumption and factors like building size and occupancy in UK universities. However, similar analyses in Nigerian tertiary institutions are limited. For example, Adekunle *et al*. (2008) surveyed energy consumption at the University of Lagos, highlighting cooling load as the highest consumer, yet this study did not explore the broader implications of energy inefficiencies or provide actionable recommendations for improvement. Furthermore, while studies like those of Odunfa *et al.* (2015) have explored the impact of building orientation on energy demand in Nigeria, they do not address the operational inefficiencies that contribute to high energy consumption in administrative buildings. This study aims to fill this critical gap by focusing on the energy consumption patterns of administrative buildings in selected tertiary institutions in Niger State, providing insights that are currently lacking in the literature. Effective evaluation and assessment of energy use in buildings necessitate established criteria or indicators. Poel *et al.* (2007) describe energy-efficient buildings as those using "the amount of energy actually consumed or estimated to meet the different needs associated with a standardized use of the building." Cody (2009) adds that "energy efficiency is the relationship between the quality of the internal thermal environment in a building and the amount of energy consumption required to maintain this environment." Both definitions underscore the need for quantifying energy consumption, albeit with different occupant-related specifics. Standardization is crucial to ensure objective comparative analyses, taking into account parameters such as floor area and fuel type to avoid misleading conclusions (Deng and Burnett, 2000). This necessitates a responsive assessment approach tailored to specific buildings or building sets. Categorizing the built environment by purpose—residential, institutional, industrial, educational, recreational, and commercial—is an important step. Office buildings, in particular, consume significant energy despite their seemingly low proportion. For instance, office buildings in Canada and the USA are among the highest energy consumers (Perez-Lombard *et al.,* 2008; Lam *et al.,* 2010; EIA, 2009a). Similar trends are observed in Europe, Hong Kong, and China (Ürge-Vorsatz *et al.,* 2006; Li, 2008). Classifications serve as benchmarks to examine sectorial energy consumption profiles. The UK's Energy Consumption Guide (ECG19) and CIBSE Guide F highlight energy benchmarks and Energy Use Intensity (EUI) values for different building types (CIBSE, 2004). For example, CIBSE (2004) benchmarks for office buildings are 128 KWh/m^2/year for good practice and 226 KWh/m^2/year for typical practice. The Building Energy Efficiency Guideline for Nigeria (BEEGN) categorizes office buildings as follows:

- Under 130 KWh/m^2/year: best practice air-conditioned office.
- 130 - 210 KWh/m^2/year: good practice air-conditioned office.
- 210 - 320 KWh/m^2/year: typical existing air-conditioned office.
- Over 320 KWh/m^2/year: poorly performing air-conditioned office.

The globally accepted performance indicators are Energy Use Index (EUI), Energy Cost Index (ECI), and Carbon Emission Index (CEI). EUI, a widely used indicator in spatial context assessments, is calculated as follows:

$$\text{EUI (KWh/m}^2\text{/year)} = \frac{Total\ annual\ energyconsumption}{Total\ floor\ area\ of\ building} \quad (1)$$

Numerous EUI results for offices and other buildings have been reported globally (Deng and Burnett, 2000; Li, 2008; Perez-Lombard *et al.,* 2008; Saidur and Masjuki, 2008). Although no global threshold for building energy consumption exists, localized applications are crucial for developing specific evaluation frameworks. Economic indicators such as running costs can incentivize energy efficiency, particularly in developing countries (Zmeureanu *et al.,* 1999; Momodu *et al.,* 2010). Benchmarking is essential for raising awareness and improving the efficiency of non-domestic buildings (Carbon Trust, 2009). Whole-building benchmarking, using statistical standards, provides a simplified yet effective method for assessing energy performance (Wang *et al.,* 2016). Suitable reference benchmarks are crucial for accurate comparisons, especially where comprehensive performance data is lacking (Federal Ministry of Power, Works and Housing FMPWH, 2016).

3. Materials and Methods

A case study research strategy was adopted for this study to observe and analyze rising electrical energy consumption in a real-world context using multiple sources of evidence (Robson, 2003; Yin, 2009). Case study research is particularly suited to situations where context plays a significant role, especially when the boundaries between the subject of study and its context are not clearly evident (Yin, 2009).

3.1 Selection of Case Study Buildings

The administrative buildings selected were from three tertiary institutions: the Federal University of Technology Minna (FUT Minna), Niger State Polytechnic Zungeru, and Niger State College of Education Minna (COE Minna). These institutions were chosen based on their size, operational significance, and impact within Niger State's educational sector. As key administrative centers, these buildings represent a substantial portion of energy consumption within each institution. Their continuous, high-density use by faculty and staff during work hours makes them ideal for assessing patterns in energy use and identifying inefficiencies. The total ground floor area for each institution's administrative buildings was 16001.67m² at Senate building, 16,597.40 m² at Niger State Polytechnic Zungeru and 14,981.51 m² at COE Minna. These buildings were analysed at both their final design (architectural drawing) and operational stages to understand their real-time energy consumption and management practices.

3.2 Instrumentation and Setup

Hourly electricity use profiles were recorded using an Efergy Wireless Energy (EW4500) monitoring device, which captures energy consumption trends over time. This device comprises three main components:

1. Current Transformer (CT) Scanner: Measures the current passing through the live wire of the feed cable.
2. Transmitter Unit: Transmits measured data to a display unit.
3. Display Unit: Displays real-time data on energy usage, demand profile, and cost of consumption.

The CT sensors were clipped onto the main distribution panel of each administrative building's electricity distribution board. The sensor measures current inductively, transmitting data wirelessly to the display unit for analysis.

Display Unit Transmitter Unit CT Sensor Unit

Figure 3.1: Efergy Wireless Energy (Efergy E2 classic energy monitor components)

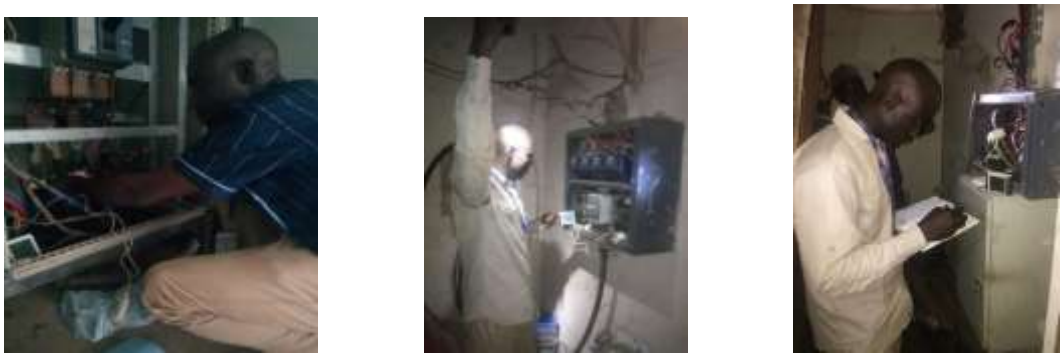

Figure 3.2: Clipping the jack-plug on the live wires at Zungeru Polytechnic and Niger State College of Education administrative blocks the main panel distribution board (MPDB).

Figure 3.3: Connection at the Zungeru Polytechnic and Niger State College of Education administrative buildings MPDB.

3.3 Sampling Strategy and Data Collection

To capture variations in energy demand, two sampling windows were established:

1. Morning Session (8:00 - 10:00 a.m. and 11:00 - 12:00 p.m.)
2. Afternoon Session (1:00 - 2:00 p.m. and 3:00 - 4:00 p.m.)

These sessions were chosen to reflect peak operational hours when energy consumption would likely be highest, given that each building's typical operational hours were 8:00 a.m. to 4:00 p.m., Monday through Friday. The exclusion of weekend and nighttime data presents a limitation in this study, as it does not account for non-operational periods, which could provide further insight into energy management practices.

3.4 Data Validation

The Efergy Wireless Energy monitor automatically calibrated before each measurement session to ensure precision. Additionally, data validation was conducted by comparing multiple readings over a set period, verifying that measurements were consistent and within the expected range. Any significant anomalies were re-measured to confirm accuracy.

3.5 Data Analysis

The collected data was quantitatively analyzed using Microsoft Excel. This software allowed for statistical analysis of energy patterns across different time frames and buildings, facilitating a comprehensive evaluation of consumption trends, peak usage hours, and inefficiencies across the three institutions. This systematic approach enabled the identification of key operational inefficiencies and the proposal of targeted recommendations to enhance energy efficiency in tertiary institutions in Niger State.

4. Results and Discussion

The study analysed electrical energy consumption within selected administrative buildings of three tertiary institutions: the FUT Minna, Niger State polytechnic Zungeru, and COE Minna. These institutions rely on electricity supplied from the national grid and generators. The lack of smart meters required direct monitoring through the Efergy wireless energy (ew4500) device.

4.1 Hourly consumption patterns

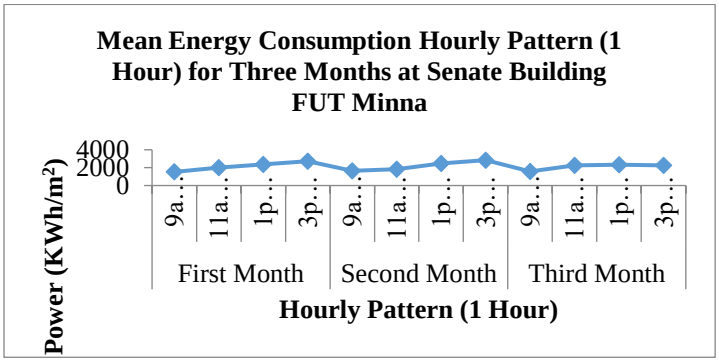

Figure 41: The mean energy consumption hourly pattern at Senate Building

Hourly energy consumption patterns revealed peaks during early working hours (9 a.m. To 12 p.m.) Across all institutions, as illustrated in Figures 4.1–4.3. At FUT Minna's senate building, energy consumption rates rose to 1522.75 kwh/m^2 in the morning, further increasing after lunch to 2350.25 kwh/m^2, reaching a peak of 2705.5 kwh/m^2 before declining as the day progressed. The early peak is attributed to heightened activity as staff begin work, requiring lighting, HVAC, computers, and other office equipment. The midday reduction correlates with the lunch break, where many occupants either leave or reduce their energy usage. Post-lunch increases suggest resumed high usage of energy-intensive devices.

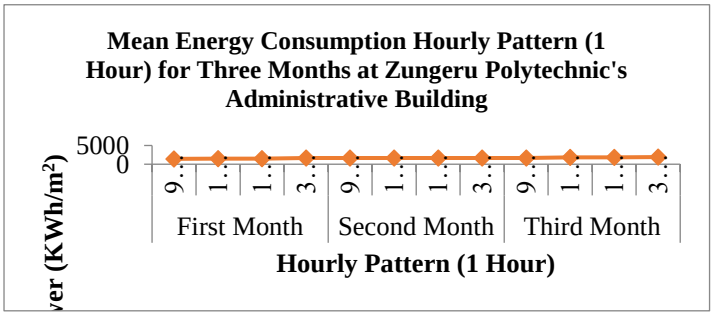

Figure 4.2: The mean energy consumption hourly pattern at admin block

For the administrative block of Niger State polytechnic Zungeru, hourly patterns displayed similar trends but with comparatively lower energy values, reaching peaks between 1433.75 kwh/m^2 and 1915.25 kwh/m^2. This comparatively lower usage may be due to fewer energy-intensive activities and reduced operational demands during off-peak hours. The increased number of people in the building means that more energy is required to keep the building functioning, such as lighting, and cooling; people tend to be more productive in the morning and require more energy intensive equipment to get their work done, such as computers, printers, and other office equipment and the higher energy consumption during this time was also likely due to the fact that more people are using the building's amenities. The decline in energy usage during lunch hours was likely due to the fact that many people leave the building to get food or take a break, thus reducing the number of people in the building and the associated energy consumption.

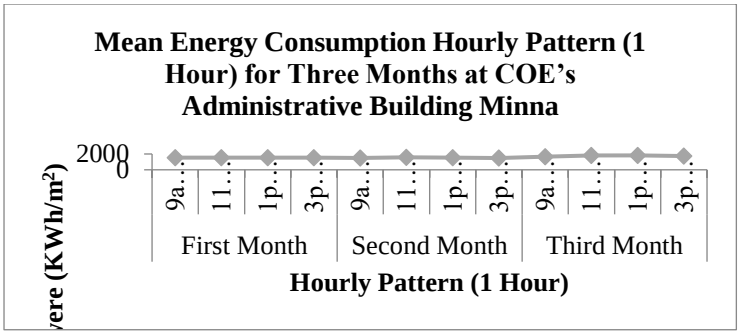

Figure 4.3: The mean energy consumption hourly pattern at COE administrative block

As shown in Figure 4.3, there was a stable trend variation in the mean energy consumption for the period of three months during when the research was conducted. There was an increase of energy consumed at 9am to 12pm,

decreased during launch hours and an increase after launch hours for the first two months while for the third month there were rise in energy consumption. The mean energy consumed values were as followed; 1557.25 KWh/m^2, 1530.5 KWh/m^2, 1555.5 KWh/m^2, 1518.25 KWh/m^2, 1512.5 KWh/m^2, 1564.5 KWh/m^2, 1544.5 KWh/m^2, 1486 KWh/m^2, 1667.5 KWh/m^2, 1813.5 KWh/m^2, 1813 KWh/m^2, and 1741.5 KWh/m^2. The decline in energy consumption during lunch hours may be due to the fact that many people take lunch breaks and may turn off their equipment or reduce their energy usage during this time. It is also possible that there are energy-saving measures in place that are activated during these hours, such as occupancy sensors that turn off lights when a room is unoccupied.

4.2 Variation Comparison of Mean Energy Consumed at the Studied Administrative Buildings

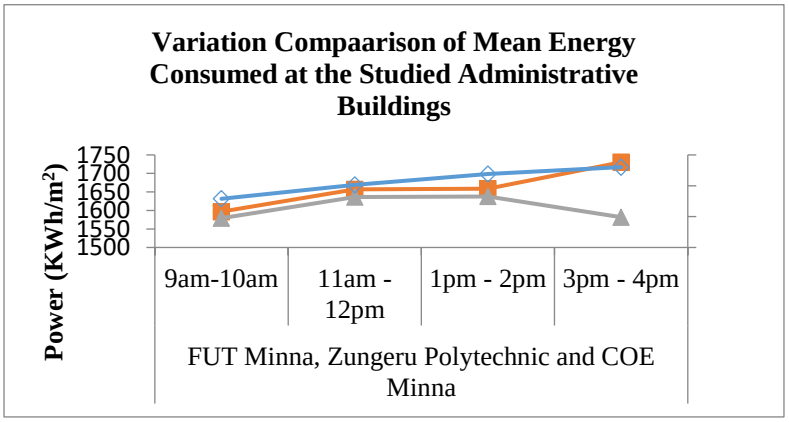

Figure 4.4: Variation Comparison of Mean Energy Consumed at the Studied Administrative Buildings

A comparative assessment indicates that Fut Minna consistently exhibited higher energy consumption compared to Niger State polytechnic Zungeru and COE Minna. Factors contributing to this discrepancy include the larger building area, higher occupancy, and increased reliance on HVAC systems at FUT Minna. These systems are frequently in use, even during off-peak hours, contributing significantly to elevated consumption levels. In contrast, COE minna demonstrated more consistent, lower energy consumption rates, peaking at approximately 1741.5 kwh/m^2. This indicates better energy management practices, likely including controlled hvac usage and possibly energy-saving policies or occupancy sensors that reduce energy demand when spaces are unoccupied

4.3 Operational inefficiencies and recommendations

The operational inefficiencies observed at FUT Minna and Niger State polytechnic Zungeru, such as continuous HVAC operation and high usage during off-peak hours, underscore the need for energy management improvements. These institutions would benefit from implementing smart metering, occupancy sensors, and optimized hvac controls to manage peak and off-peak energy usage effectively. Additionally, conducting comprehensive energy audits could further identify specific sources of inefficiency, allowing tailored solutions to minimize waste and improve sustainability.

5. Conclusion and Recommendations

The study assessed the electrical energy consumption in the administrative buildings of the FUT Minna, Niger State Polytechnic Zungeru, and COE Minna, focusing on typical operational conditions without smart metering. Results indicated that the Senate building at FUT Minna and the administrative block at Zungeru Polytechnic exhibited energy inefficiencies, especially in offices utilising air conditioning, where energy consumption exceeded established benchmarks. In contrast, the COE Minna administrative block's energy performance aligned more closely with benchmarks, sugg - 7esting better efficiency. Key contributors to high energy use at FUT Minna and Zungeru Polytechnic include building size, extensive cooling needs, and a higher density of electronic equipment. These findings highlight the importance of targeted energy management strategies in large, equipment-intensive administrative buildings to improve overall efficiency and reduce carbon emissions. The study's limitations include the absence of smart meters for precise, continuous monitoring and restricted sampling times (daytime hours only), which might not capture total daily energy variations. Future research should consider including nighttime and weekend measurements, alongside real-time smart metering, to provide a comprehensive profile of energy use. To enhance energy efficiency and establish effective energy management in Nigeria's tertiary institutions, the following recommendations are proposed: Initiate systematic energy audits across all administrative buildings to pinpoint high-consumption areas and equipment. Audits should specifically target HVAC systems and other major energy users, providing a basis for subsequent interventions. Investing in smart meters and energy monitoring systems such as Kill-

A-Watt and Belkin Conserve Insight will enable real-time data collection, offering administrators detailed insights into energy consumption patterns. This data can help manage peak loads and improve energy distribution. Develop and enforce institutional policies focusing on energy conservation. Training administrative staff on energy-efficient practices—such as turning off equipment when not in use, using energy-saving settings on devices, and reducing reliance on air conditioning—can foster a culture of conservation. Replace incandescent and fluorescent lighting with LEDs, install occupancy sensors in low-traffic areas, and encourage the use of energy-efficient office equipment. These steps can substantially reduce energy waste. By adopting these recommendations, Nigeria's tertiary institutions can reduce operational costs, lower carbon emissions, and serve as models of energy efficiency in educational administration.

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Assessment of Urban Development Expansion Using Object-Based Image Classification Technique. A Case Study of Asokoro City, Federal Capital Territory, Abuja, Nigeria.

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Abstract

Urban development expansion is critical to urban planning and management, particularly in rapidly growing cities. This study uses object-based image classification techniques to assess the urban development expansion of Asokoro, a prominent city in the Federal C apital Territory, Abuja. Satellite multi-spectral image data was employed to capture spatial changes over time, providing valuable insights into the dynamics of urban growth. The methodology involves collecting multi-temporal satellite image data covering various periods of three epochs (2003, 2013 and 2023) to analyses the trend expansion patterns of the study area. The Google image was pre-processed using a dehazing and shadow extraction algorithm. The segmentation process was carefully carried out, after which the features were extracted. Object-based image classification technique was utilized to accurately delineate urban features and monitor dynamics in land use and land cover of the study area. This approach allows for a more detailed and precise analysis than pixel-based classification methods. The outcome recorded about 14.42% of built-up areas in the year 2003. In the year 2013 and 2023, it recorded an increasing trend of about 5.21% and 7.03% respectively. Simple least square regression analyses technique was used to projection the built-up areas to the next ten years (2033). At 95% significant level, the built-up area is expected to record an increasing trend of about 7.24% which translate to be about 34.34% of the total area of Asokoro. The results reveal significant urban development expansion within the study area, characterized by increased built-up areas, infrastructure development, and changes in land use patterns. The findings provide valuable information for urban planners and policymakers to understand the spatial dynamics of Asokoro's growth and formulate sustainable development strategies.

Keywords: Object-Based Classification, Built-Up Patches, Urban Planning and Features Segmentation

1. Introduction

Humans have relied on land for food production and other economic development since the beginning, resulting in constant changes in the local environment. The quest for Development has increased stress on Earth's surface and is driven by the constant push to meet the needs of an ever-increasing population demand (Weinzettel *et al.,* 2013). Under these circumstances, human activity and the resulting dynamics of land use and land cover (LULC) have emerged as a pressing concern for the modern era, highlighting the threats of environmental degradation on a global scale (Li *et al.,* 2020). Since ancient times, many natural resources have been extensively exploited or completely depleted in the worst situations. Human activity have affected or created almost half of the world's terrain (Goldewijk *et al.*, 2011). Numerous factors, such as altered hydrological cycles, increased water extraction, deteriorated soil nutrients, increased surface erosion, loss of biodiversity, and altered climate, are all consequences of this widespread LULC change on the environment (Paiboonvorachat, 2008). As a result, data on land use/land cover, evolving trends, and the best use of available resources have evolved into predetermined standards for area-wide land use planning and efficient management of natural resources. The development brings about expansion, improvement, and positive change or adds components to the social, demographic, environmental, economic, and physical domains (Hazarika *et al.,* 2015). Development aims to raise the standard of living for the public while protecting the environment's resources and generating or increasing local, regional, and employment possibilities (Baba *et al.,* 2023). A development component is

the creation of conditions necessary for the continuation of the qualitative change. Although it doesn't always happen immediately, it is transparent and beneficial. Remote sensing and GIS techniques provide more reliable and cost-effective data assessments than conventional methods and surveys.. Scientists and researchers can detect large-scale changes in land use patterns with the knowledge acquired on a temporal and spatial level, allowing regional politicians and authorities to make future decisions (Robert *et al.,* 2000).

It is crucial to monitor the evolution of development as towns and cities expand, facilitating efficient planning, organization, and utilization of a community's resources (lopez *et al.,* 2020). In this context, "development" refers to structures and their various purposes, such as residential and commercial, government initiatives, executing a government-mandated maintenance plan for a city, and many more. Land use managers require access to up-to-date, spatially precise time series data on land resources and changing patterns to plan for the future (Ayele *et al.,* 2018). As a result, it is critical to assess how urbanization and population growth have affected development. Before implementing any further conservation measures, it is imperative to understand the state of development in a specific area. A comprehensive analysis of time series fine-scale satellite images is required to monitor the pattern and development change (Yang and Zeng, 2023) since satellite images are the most often utilized data source for change detection, quantification, and mapping of change trends since they can be precisely geo-referenced and give repeated data (Liu and Madhavan, 2019). One of the world's most planned and fastest-growing modern cities is the capital of Nigeria. After Maitama District in the federal capital city of Abuja, Asokoro is arguably the cutest residential habitant (dwelling) (Unah, 2019). The type of infrastructure development has changed, disregarding the master plan as more and more residential, commercial, and social activity structures are constructed. Asokoro is a residential area where the population has gradually been taking over, leading to increased commerce due to the growing need for public buildings. However, given Asokoro's situation, the development's aspect categories, and the requirement to ascertain the extent of the city's coverage as of the year 2023, it is necessary to checkmate the rate of its growth. This study aims to portray Asokoro City's urban growth trend pattern in Abuja's Federal Capital Territory (FCT).

2. Study Area

Abuja is a young city that began on 3rd February 1976 when the federal military government established the FCT (Falola, 2008). Located in the north-central part of Nigeria, Confluence of the Niger and Benue Rivers. The city is Nigeria Federal Capital Territory (FCT), whose land area is about 8000 km2. The area's geography is defined by two renowned rock formations: The Zuma Rock, from whose base the FCT begins, and the Aso Rock, located east of the city. Abuja lies at latitude 9.07_N and longitude 7.48_E and at an elevation of 840 m (2760 ft.) above mean sea level, which is located on the shores of the Atlantic Ocean at 35 m (11 ft.) above sea level. Figure 1, show the map of the study area.

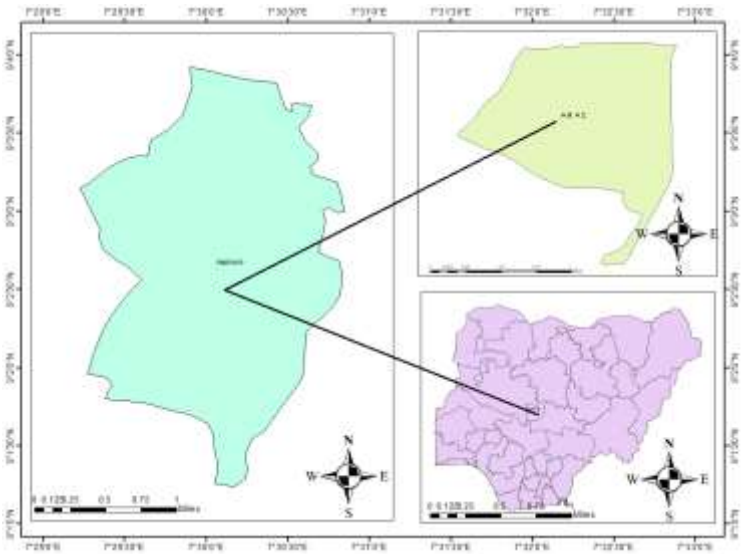

Figure 1: Map of Nigeria to the right down, map of Amac (FCT Municipal Area) of Abuja to the right up and map of the study area Asokoro to the left.

3. Method

3.1 Data Acquisition

The satellite image data was sourced from Google Earth Pro from the year 2003, 2013 and 2023. The characteristics of the data used are depicted in Table 3.1

Table 3.1 Data Characteristics

S/N	Data	Type	Epoch	Format	Resolution	Source	Relevance
1	Administrative boundary	Secondary		Shapefile		OSGOF	To define the spatial boundary
2	Google earth aerial imagery	Secondary	2003,2013 and 2023	TIFF	30m	USGS	For image classification analysis

Google Earth Pro was launched, the location of interest was navigated, and the north arrow toggle was manipulated to be aligned to meet the satellite images that needed to be retrieved. The four points were indicated on the four cardinal points of the images using the point tool, and their ground coordinates were generated to enable geo-referencing. The coordinate points were used to geo-reference the satellite imagery using "Add control Points" in the geo-referencing toolbar. The image was corrected from the distortion caused by the sensor, haze, terrain displacement, and sun angle. The haze in the image was removed using image processing techniques called dehazing algorithms. These algorithms work by estimating the transmission and atmospheric light in the scene and then removing the effects of haze from the image (Jian and Xiaoou, 2011).

$$I_{dehazed} = \frac{I_{raw}-A}{t} + A \qquad 1$$

Where

$I_{dehazed}$: Dehazed image, I_{raw}: Raw image, A: atmospheric light, which is assumed to be constant throughout the image, t : the transmission map, indicating the proportion of light transmitted through the haze at each pixel.

The Terrain displacement, where buildings appear skewed due to perspective distortion, was corrected by geometric corrections. The correction is aimed to remove the effects of terrain displacement and restore the correct proportions and geometry to objects in the scene. Correction for sun angle effects involves adjusting the image's brightness, contrast, and color balance to compensate for these variations. Figure 3.1 depicts the conceptual workflow of the research

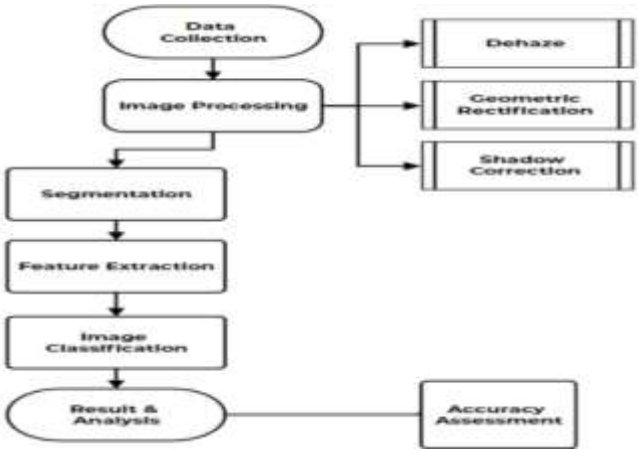

Figure 3.1. Conceptual Work Flow of the Research

3.2 Segmentation

In object-based classification, segmentation is the primary stage that determines accuracy outcomes; nevertheless, multiresolution segmentation algorithms are widely used and have been used in numerous research (Ma *et al.,* 2015). Because the scale, shape, and compactness parameters are crucial in determining how the algorithm behaves and can be adjusted by the analyst, this algorithm may be intricate and user-dependent. To get the ideal values for the segmentation's associated parameters presumably based on the analyst's experience. The multi-resolution algorithm typically requires trial and error, mainly when employed for the first time (Laliberte and Rango, 2009). According to Hussain *et al*. (2013), the scale parameter is a crucial component of the object-based classification strategy since it establishes the permissible size of the picture objects, which governs all other steps in the classification process. According to Blaschke *et al.* (2014), semantically meaningful regions exist at different scales. Identifying all the objects required for the classification may be necessary to experiment with changing the scale parameter during the segmentation step. Since the trial-and-error method introduces subjectivity into scientific research, it is undesirable. Various techniques have been developed to identify the ideal scale parameter value (Johnson and Wichern 2011), but none of them have been able to identify a value that is suitable for all types of imagery. High feature counts can often complicate the structure of any algorithm and, consequently, the research process, making them less useful for classification because they are time-consuming to analyses (Pal and Foody, 2010). However, feature extraction is essential in creating a more compelling image classification considering context, spectral, and spatial information.

3.3 Image Classification

Spatial maps can be several types that change based on the research scale, which can be local, global, or any other scale depending on it goal (Forghani *et al.,* 2008). Pixel-based classification is the earliest and, as a result, most popular method for classifying imagery in remote sensing. It treats each pixel in an image as a separate component of the scene based on its spectral information, independent of its geographical context. When creating classified maps using a pixel-based method, the primary problem is typically the lack of precise and comprehensive spatial context and potential class confusion caused by spectral responses from major geographic features in urban areas being similar to one another. The development of object-based classification makes spatial classification of features on map easier and accurate (Hussein *et al.,* 2013). The object-based classes' correctness is evaluated using an error matrix. The patches of the classification are shown in Table 3.3. The research's aims guided the determination of the categories.

Table 3.3 Patches used for the land used land cover change.

s/n	Patches	Description
I	Vegetation	Lands covered with natural vegetation
Ii	Agricultural Land	Rangeland, cultivated land
Iii	Built-Up area	Lands are used for residential, commercial, industrial, roan networks, etc.
Iv	Bare surface	Sparse vegetation; lands with exposed soil, rocks

The process involves categorizing pixel values from multi-raster images to create a thematic layer, and the process uses a maximum likelihood classifier, which assumes the statistics of each class in each band that are usually distributed and calculates the probability of a given pixel belonging to a specific class. Based on the model, a training set of pixels was selected for a supervised classification using a Maximum Likelihood (ML) classification algorithm for four categories (agricultural land, built-up, bare land, vegetation) classes, after which the LULC classification was derived.
The projection was executed using a simple least square regression method to find the line (or curve) that best fits a set of data points. It works by minimizing the sum of the squared differences between the observed (y) values and the values predicted by the regression line for each corresponding (x) value. In simpler terms, the principle involves finding the line closest to all the data points.. According to Montgomery and vining (2012), the relationship between $(y)\ and\ (X)$

$$y = mx + b \quad (2)$$

Where

(m); slope of the line (coefficient of x),(b): y-intercept (the point where the line crosses the y-axis). To compute the values of (m) and (b) That best fits the data; you can use the following.

$$m = \frac{n(\sum xy)-(\sum x)(\sum y)}{n(\sum x^2)-(\sum x)^2} \quad (3)$$

$$b = \frac{\sum y - m(\sum x)}{n} \quad (4)$$

Where

n:The number of data points, $\sum x$: the sum of all (x) values, $\sum y$:The sum of all (y) values, $\sum xy$: The sum of the products of each (x) and (y) pair, $\sum(x)^2$ Is the sum of the squares of each (x)

4. Results and Discussion

The results of the object-based image classification for the years 2003, 2013 and 2023 are presented in Figure 4.1. Table 4.1 shows the vector statistical data for the object-based LULC of Asokoro City of the Federal Capital Territory Abuja for 2003, 2013 and 2023. Table 4.1 depicts the accuracy assessment of the map.

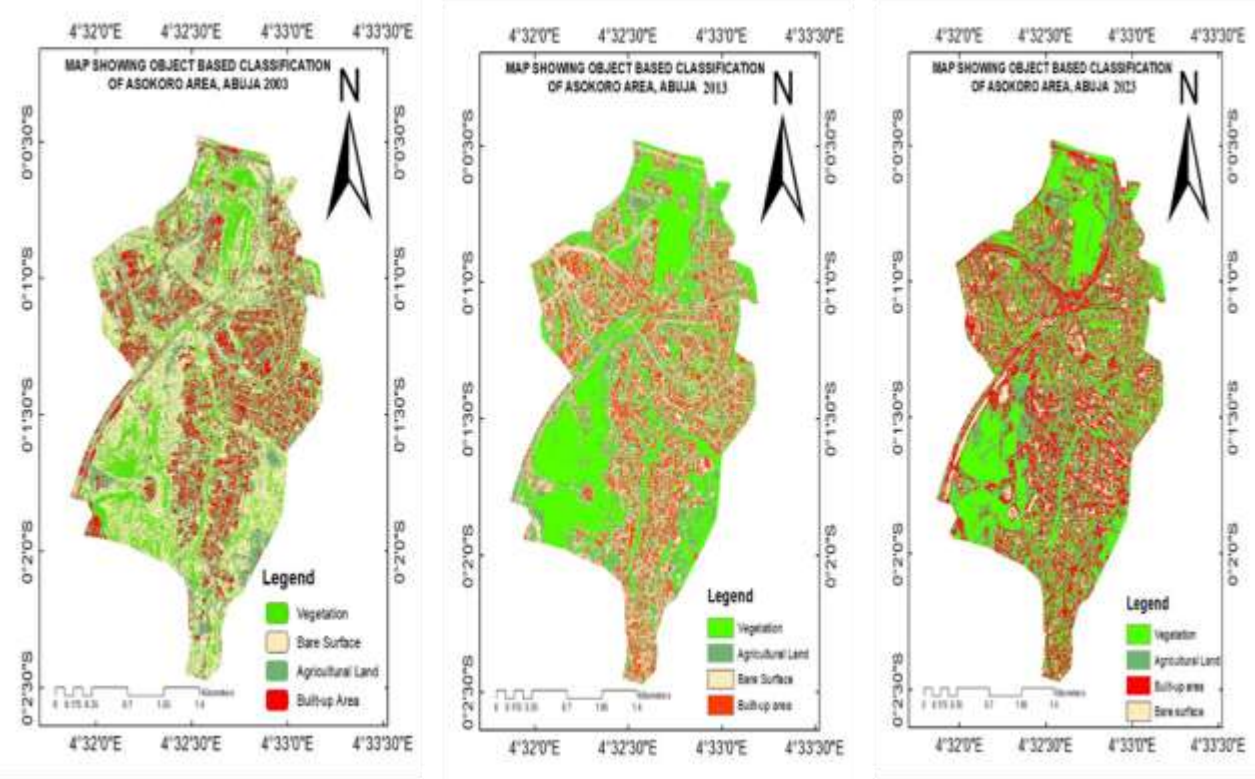

Figure 4.1. LULC change map of Asokoro city for the years 2003, 2013 and 2023

Table 4.1: Vector Statistics Data for Asokoro City for 2003, 2013 And 2023.

Patches	2003	User	Produ cer	2013	User	Produce r	2023	User	Produ cer
Agricultural land	28.181	81.11	81.53	25.065	77.57	71.29	32.688	82.85	79.25
Bare Land	39.034	86.41	83.03	26.176	81.81	71.29	13.227	66.15	66.25
Built up Area	14.442	75.34	82.04	18.790	71.14	74.43	27.945	85.84	78.44
Vegetation	18.344	71.11	89.69	29.969	71.14	61.05	27.140	65.24	64.28
Overall Accuracy	89.4%			87.5%			83.4%		
Kappa Coefficient	0.768			0.731			0.724		

4.1 Discussion

From Table 4 above, in 2003, agricultural patches constituted around (28.18%), the bare land surface recorded about 39.034%, and vegetation covered about 18. 344%, while built-up areas recorded about 14.442% of the total area. The outcome indicates the land used as of the year 2003. The accuracy assessment was done by deploying 200 stratified random samples on the classified image and critically comparing the classified image with ground reference information (Bing Map). The accuracy of the classification falls within the acceptable threshold; the producer accuracy, which depicts the classification on the map, while the user accuracy depicts the level of accuracy attained of features on the ground, all fall above the acceptable threshold(citation) (see table 4.2) and of kappa coefficient obtained was (0.881)

The year 2013 recorded a decreasing trend of about 3.12% for agricultural patches, indicating that agricultural practices decreased compared to the previous epoch. Bare land surfaces also recorded a downward trend of about

12.23% compared to the previous epoch. Built-up patches recorded an increasing trend of about 4.35% compared with the previous epochs, and it also shows how other patches compensated for the built-up areas, which signifies that a portion of other reducing patches are compensating for built-up areas. The vegetation area also experienced an increasing trend of about 11.36%. The vegetation area was intentionally preserved for beautification and landscaping of the environment.

In 2023, the agricultural patch decreased by about 4.72% because Asokoro is mainly for residential structures. Bare land surface recorded a slight decrease of about 3.01%. The built-up area recorded an increasing trend of about 07.03%, indicating many structural developments (estate and other structural infrastructure) from 2013 to 2023. The vegetation area also indicated a slight increase in vegetation area. It recorded a 0.37% increase for 2023 compared to the previous epoch. (Figure 4.2) indicate the trend pattern of built-up patches from the year 2003 to 2023. For the accuracy assessment for both years (2013 and 2023), see Table 4.2, which shows the error matrix for the LULCC map for 2013 and 2023. In Figure 4.2, bar chat represented the LULCC data, depicting the trend pattern for the built-up categories.

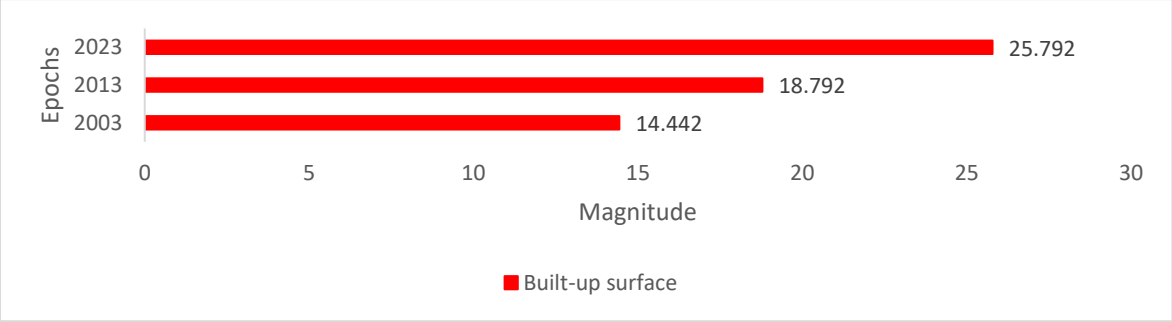

Figure 4.2: Magnitude of Built-up Areas from the years 2003, 2013 and 2023

Figure 4.2 shows the trend pattern of the built-up areas in Asokoro city of Abuja for twenty years. It has shown the city's growth rate over the years. Other patches, such as agriculture and bare land surfaces, compensated for the growth of built-up patches. Over time, part of the agricultural and bare land surfaces was converted to built-up areas for infrastructural development. However, it was also observed that the vegetation patches recorded a significant growth from the epochs. These could be the number of reserved areas and landscaping aesthetics from the city's master plan. It used a simple least square regression technique to project the growth of the built area in the next ten years. Figure 4.3 shows a bar chart of the projection rate for the next year

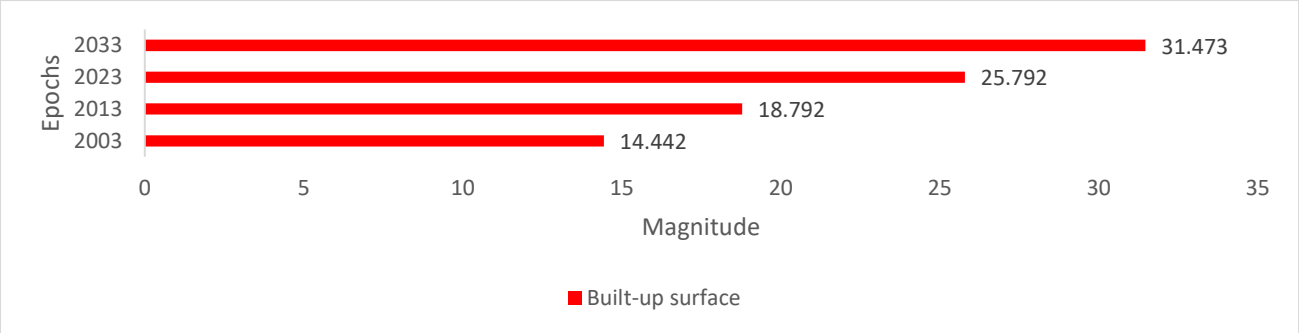

Figure 4.3: LULCC projection for the year 2033

5. Conclusion

Accurately mapping LULC change using object-based classification is extremely helpful for many environmental applications such as urban planning, land rehabilitation, land management, and risk analysis. This research aimed to assess the rate of land use and land cover change dynamics (built-up expansion) in Asokoro, the city of the federal capital FCT, Abuja. The method used in this research has proved to be more reliable and accurate, judging from the results. The growth rate of Asokoro city, Abuja, is not scary as it is the second most recognized city from Maitama, Abuja. The residential city showed a sharp change from 2003 to 2023. It recorded a gross change of about 13.503% from the year in view (2003-2023) and an additional projection change of about 7.2% to 2033. The generated error matrix justified the results' outcomes based on the user, personal accuracy and the overall and kappa coefficient obtained. There is a need to measure the land use rate, especially in Abuja, the country's capital. It will go a long way in

checking the master plan of the smart city and also guide administrators on policies to be made regarding the protection of the master plan and the avoidance of people going against it.

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Spatio-Temporal Analysis of Perennial Flooding of Niger Plain Communities In Lokoja Metropolis

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Abstract

Flood is a natural disaster which occurs almost regularly in Lokoja metropolis of Kogi state, Nigeria. The frequency of floods and their impact on human life and the environment are on the increase which could be as a result of human-induced climate change. Giving people access to relevant information through mapping of the flood plain inundation is one strategy to lessen the impact of flooding by being able to plan against flood catastrophes. This research is aimed to assess the extent of flooding imparts of Lokoja LGA of Kogi State. In order to achieve this, satellite imageries covering the study area for the year 2010, 2015 and 2020 at 5 years interval were obtained. The image were pre-processed and supervised image classification was carried out using nearest neighbour classifier algorithm using Geographic Information System (GIS) tool. The extent (coverage) of water surface area over time was for the year 2010 was $652.42 Km^2$ which translate to be 21.03%. In the year 2015, it recorded a decrease of about 1.22% and in the year 2020, it recorded an increase of about 3.59%. Normalized Difference Water Index technique (NDWI) recorded 0.0493361 (24.30%) pixel count for the year 2010, recorded a decrease of about 0.36% for the 2015 and an increase of about 3.64% for the year 2020. Simple least square regression was used to predict the change for the next ten (10) years. At 95% confident level, the water patches in LULC change indicated an upward trend of about 30.68% coverage, while NDWI also recorded an upward trend of about 38.57%. Therefore, for the meantime, adaptive measure can be put in place to save lives and properties of the indigene in the community. It is recommended that; further study should be conducted to understand the causes of this perennial flood event that has become an annual ritual in Kogi state.

Keywords: Flood, Climate Change, Inundation, Flood Mitigation, Adaptation Procedure

1. Introduction

Flooding is a natural hazard caused by a combination of hydrological and meteorological factors. It happens when normally dry land becomes temporarily submerged as a result of water overflowing at a river's natural or artificial banks, including groundwater brought on by long-lasting or intense rain (Ali, 2018). According to European Commission (EC) (2007), this natural disaster occurs due to climate change, blockage of drainage with refuse, dam failure/release of dam water, population increase in urban areas and extreme metrological events like heavy rainfall causing rivers to overflow their banks, which has a far-reaching effect on the people and environment. Although many efforts have been made to mitigate the risk and damages from natural disaster, flood remains the most devastating natural hazard in the world (UNDRR, 2022). Lokoja, Kogi state is comprises of both a highland/mountainous and lowland state. Lokoja metropolis is located at the confluence of river Niger and Benue which makes flooding a frequent phenomenon occurring in this part of the state, especially during the raining season (April – October) which causes severe damage to crops and lives (Aderoju *et al*, 2014). During the rainy season, the water level rises to such a level that the streets finally get submerged in surplus water. Flooding has emerged as a persistent environmental issue, killing more people than any other natural occurrence in Lokoja city and causing terrible damage to infrastructure and houses (Nwilo, 2013). For instance, Ganaja Village and its environs were heavily flooded to the peak in the year 2012, 2018 and 2020, turning the inhabitants to refugees. According to Onuigbo *et al.*, (2017), the year 2012, flood assaulted places like Ganaja village, Galilee, Kpata, Jimgbe, Kporoko, Gadumo, and Sarkin- Norma and Saudana areas, all within the Lokoja metropolis. Following the flood, farmlands were submerged, farm products were destroyed, homes were destroyed, and ultimately, migration of people caused a food shortage. The Lokoja city frequently experiences riverine flooding and even flash floods, depending on the local geology and drainage system (Nwilo, 2013). Due to it repeated recurrence, researchers started paying attention to flood risk assessment and management in order to explore and lessen the adverse effects of flood disaster on society and the economy.

Natural disasters such as floods have constituted major problems in many developed and developing countries. Over the years, Lokoja metropolis has been affected by flooding which is caused by heavy rainfall and River Niger overflowing its channel as well as poor drainage system. The topology of the terrain makes low lying areas mostly affected. In addition, the consistent and heavy torrential rains in the year 2012 and 2018 and most recently, in 2020 causes flooding in Lokoja metropolis (Onuigbo *et al*, 2017). Residents of the riverine area suffered the most harm as a

result of the floods. However, Poor planning for flood mitigation in our cities, indiscriminate construction of structures on floodplains, and dam failures, along with other unsuitable environmental practices, raise the risk of flooding (Onuigbo *et al*, 2017). Therefore, this research seeks to investigate the level of flooding in Lokoja metropolis, together with areas prone to flood risk and possible adaptation procedure in mitigating the flood in Lokoja and it allied communities.

2. Study Area

Lokoja is located between latitude 7° 45' 27.56'' N and 7° 51' 04.34'' N of the equator and between Longitude 6°41' 55.64' E and 6° 45' 36.58''E of the Greenwich meridian. It has a total land area of 29833km^2 (Adefisan and Egiku, 2018). It is located between 45 and 125 meters above sea level, towards the north-south at the foot of the Patti Ridge, which rises to a height of 400 metres above Mean Sea Level (MSL), on the western side of the confluence of the Rivers Niger and Benue. The rainy season and the dry season are two well-known seasons in Lokoja. The dry season spans from November to March, whereas the rainy season starts in April and lasts until October (Sinh, 2009). The annual rainfall in the area is between 1016mm and 1524mm while the mean annual humidity is about 70% (FEMA, 2014). A temperature ranges, between 15°C - 40°C usually experienced in the area with an annual average temperature of 33°C and an annual average sunshine hour of 6.7/day (FEMA, 2014). Figure 1 illustrate the study area.

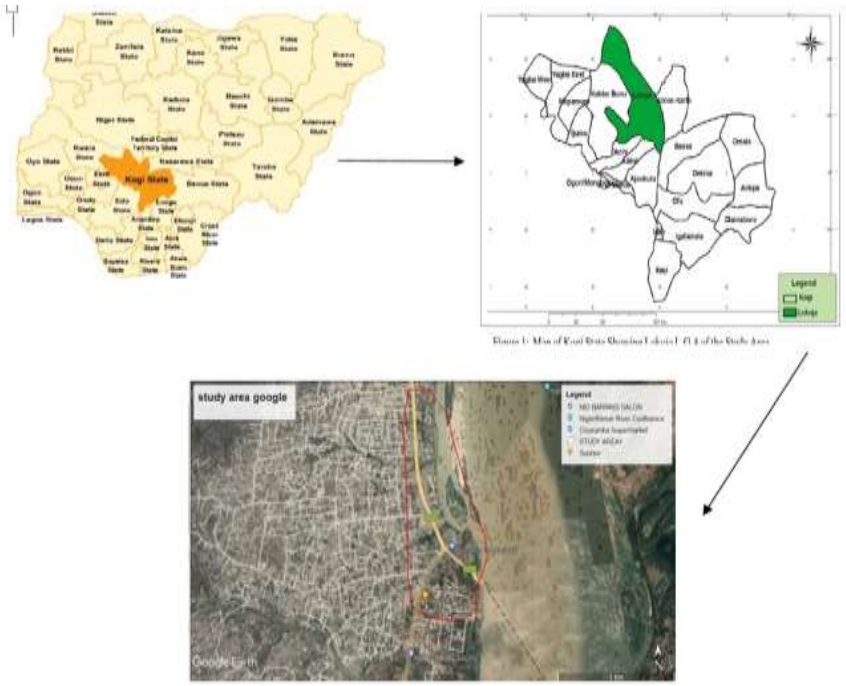

Figure 1: Map of Nigeria to the Left: Map of Kogi State to the Right and Satellite Image Depicting the Study Area below Ganaja Village

3. Method

3.1 Data Acquisition

This research involves the spatial data analysis spanning the year 2010, 2015 and 2020. The satellite imageries involves Landsat 7 for the year 2010, Landsat 8 for the year 2015 and 2020 were acquired (Table 1). All the satellite imageries were obtained from online open source from United State Geological Survey (USGS). Also, Shuttle Radar Topography Mission (SRTM) of the Digital Elevation Model of Lokoja was acquired from Global Vision (GLOVIS) section of United State Geological Survey (Earth explorer).

The google earth image of the study area was downloaded in kmz file format and was imported to google mapper to obtain the boundary of the study area. The Digital Elevation Model (DEM) of the study area obtained from shuttle radar topographic mission (SRTM) was then used to generate the contours. The DEM was exported to the ARCMAP software and this was further processed using the data management tool on the Arc Tool Box to clip the study area extent on the DEM. As they both have the same coordinate system, (WGS_1984_UTM_Zone_32N), this allowed the imageries to be overlaid on each other.

Table 1. Data used

DATA	PERIOD	Resolution	SOURCE
Land sat 7 (TM+)	2010	30m	USGS
Land sat 8 (OLI)	2015&2020	30m	USGS
DEM (SRTM)	2020	30m	USGS

3.2 Land Use Land Cover Change Detection and NDWI Analysis

Image classification was carried out in order to analyze the spatial extent of land inundated for each epoch (2005, 2015 and 2020) band 5, 6 and 4 was used to form the Land/Water composite. On this band, Vegetation appears in shades of green, urban areas in brown and water body appears in blue. This band combination is good for Urban Studies and drainage monitoring (Lillesand *et al.,* 2007). The area of interest (Lokoja) was clipped out of the composite created using ARCMAP. On the same platform (ARCMAP), four classes (settlement, bare land, Vegetation, and Water Body) were created and these sample sets were subjected to full interactive supervised classification.
The satellite imageries were used to produce the difference in classification by using formula for combination of bands to arrive at the given result on arc GIS using the raster calculator.

i. Normalized Difference Water Index (NDWI

The Normalized Difference Water Index is used for water body analysis. Higher NDWI values indicates sufficient moisture while low value indicates water stress. (Xu, 2006) The Normalized Difference Water Index is calculated using the following formula:

$$NDWI = \frac{Green-NIR}{Green-NIR} \quad 1$$

The NDWI Values Corresponds to the Following Ranges

i. 0.2 – 1 – Water surface
ii. 0.0 -0.2 –Flooding, Humidity
iii. -0.3- 0.0 –Moderate drought, non-aqueous surfaces
iv. -1 - -0.3 –drought, non-aqueous surfaces

The projection of LULC change and NDWI was executed using a simple least square regression method to find the line (or curve) that best fits a set of data points. It works by minimizing the sum of the squared differences between the observed (y) values and the values predicted by the regression line for each corresponding (x) value. In simpler terms, the principle involves finding the line closest to all the data points. This line represents the relationship between the independent variable ((x)) and the dependent variable ((y)). By minimizing the squared differences, the regression line becomes the "best fit" line explaining the variables' relationship. This technique is called "least squares" because it minimizes the sum of the squares of the vertical distances between the data points and the regression line. According to Montgomery *et al.* (2012), the relationship between $(y)\ and\ (X)$ is:

$$y = mx + b \quad 2$$

v. Where :
vi.
vii. (m) Is the slope of the line (coefficient of x)
viii. (b) Is the y-intercept (the point where the line crosses the y-axis). To compute the values of (m) and (b) that best fits the data; you can use the following.

$$m = \frac{n(\sum xy)-(\sum x)(\sum y)}{n(\sum x^2)-(\sum x)^2} \quad 3$$

$$b = \frac{\sum y - m(\sum x)}{n} \quad 4$$

ix. Where
x. n:The number of data points, $\sum x$: The sum of all (x) values, $\sum y$: The sum of all (y) values,
xi. $\sum xy$: The sum of the products of each (x) and (y) pair, $\sum(x)^2$ Is the sum of the squares of each (x)

4. Result and Analysis

Result is presented relative to the methodology of the research. Table 2 and Figure 2 respectively depict the statistical values and map of the land used land cover of Lokoja for the years in view.

Table 2 Vector statistics of LULC change Map of Lokoja for the year 2010, 2015 and 2020

Category	Year	Area (Km^2)	Percentage	Accuracy assessment
Water Body	**2010**	652.42	21.03	Overall classification
Vegetation		1450.64	46.76	92.3%
Bare Land		568.96	18.34	Kappa coefficient
Settlement		430.30	13.87	0.901
Water Body	**2015**	614.17	19.81	Overall classification
Vegetation		1423.35	45.91	89.4%
Bare Land		593.40	19.14	Kappa coefficient
Settlement		469.39	15.14	0.84
, Water Body	**2020**	701.24	23.35	Overall classification
Vegetation		1317.23	44.05	0.94%
Bare Land		390.83	13.07	Kappa coefficient
Settlement		584.07	19.53	0.923

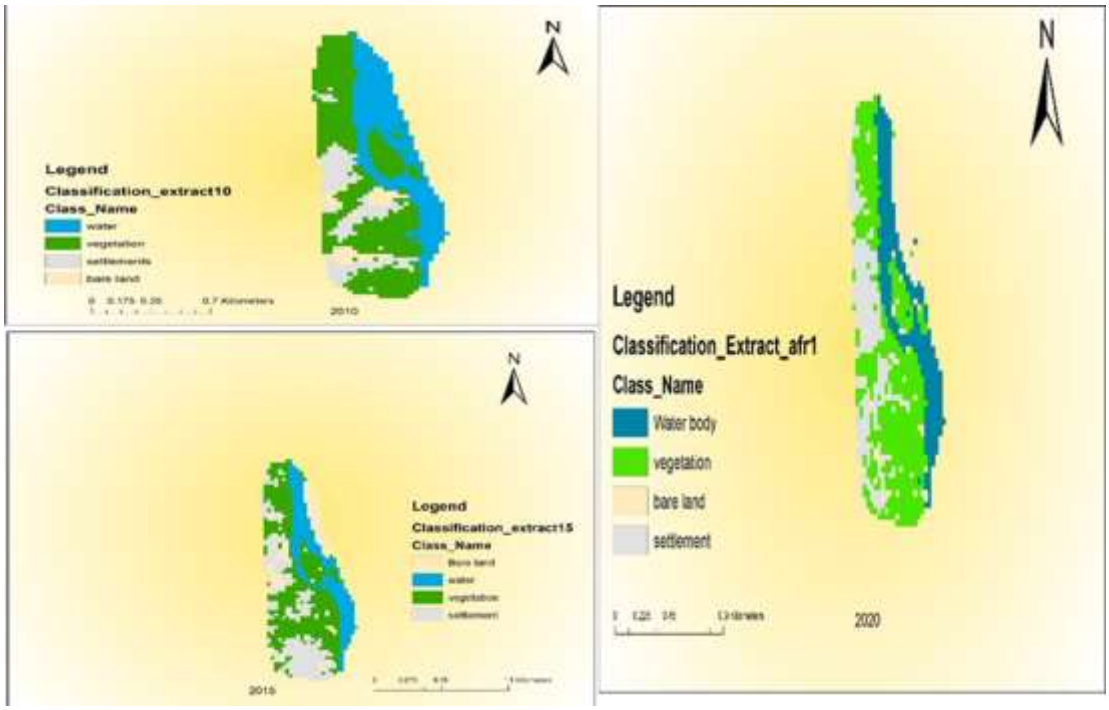

Figure 2. (LULC) Map of Lokoja for the Year 2010, 2015 And 2020.

From the LULC change map of the year 2010, the water body patches covered about 21.03% of the total space in Lokoja LGA. This is large considering the composition of the remaining patches, it also confirmed the flood activities that took place same year (Onuigbo *et al.,* 2017). Other patches such as vegetation recorded about 46.76%, bare land surface recorded about 19.15% and built-up (settlement) recorded about 15.14%. The percentage of bare land surface is higher that the percentage of built-up areas, one can inferred the state of development as at the year 2010. The second epoch was in the year 2015, it shows the reduction of the inflow of water from the water source. Water body patches recorded a down trend of about 1.22% when compared with the previous epoch. This could be as a result of stability of the previous flood experienced in the area. The vegetation patches recorded a downward trend of about 0.85%, the decreased compensated for the increase in built-up areas. The bare land surface recorded an increased trend of 0.8% while the built-up area recorded an upward trend of about 2.40%. This indicates that there was infrastructural development within the period which also translate that the population of the LGA will experience increase in density. The LULCC statistical data for the year 2020 indicated an increasing trend for the water bodies. It recorded an increase of about 3.54% compared with the previous epoch. The rate of growth is sharp and it call for concern to the necessary authority responsible. It also indicated that about 2.71% of land designated for agricultural purposes might be loss to flood. Knowing that 75% of the residence of Lokoja are farmer, it could result to serious hunger outbreak in the community. Also, it shows how the bare land surface where loss to water bodies patches. It loss about 6.07% on flood. However, it should be note that LULC change defined the extent of patches covered over time, it described the rate of

change of this patch relative to time which of course, could influence certain environmental factor. Figure 3. Summarized the patches trend for the three epochs and Figure 4 show the NDWI map.

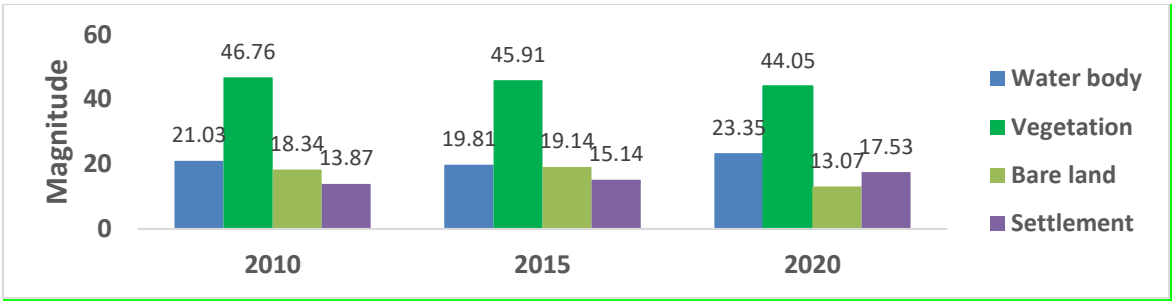

Figure 3. LULC change of Lokoja LGA for the year 2010, 2015 and 2020

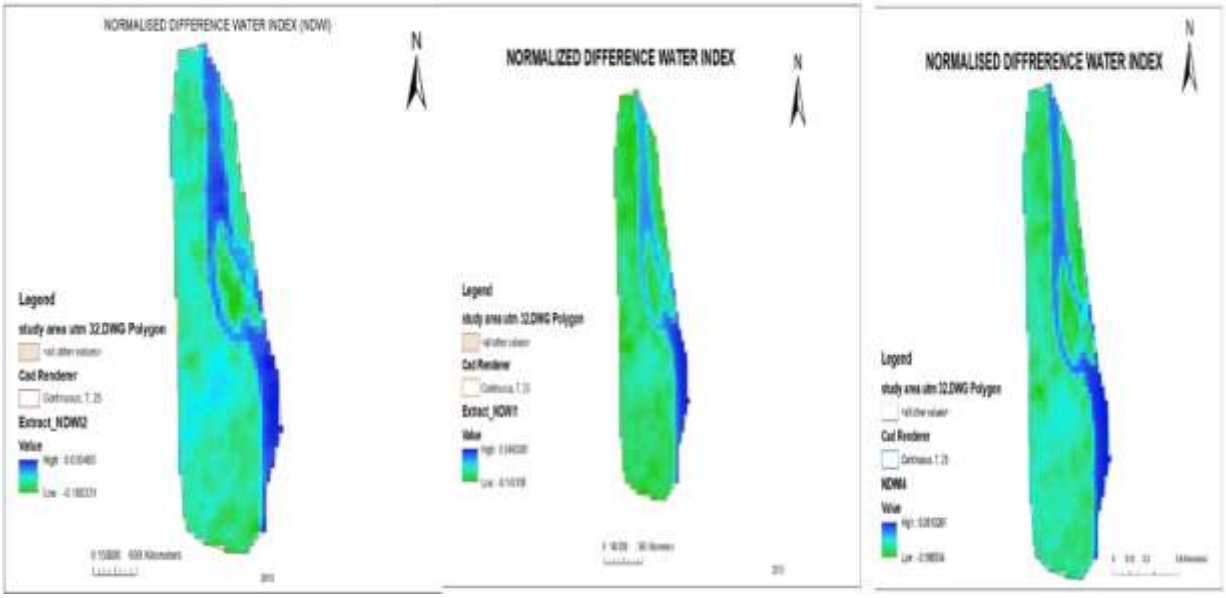

Figure 4. Normalized Difference Water Index for the year or 2010, 2015 and 2020

Table 3. Normalized Difference Water Index (NDWI)

epochs	2010	%	2015	%	2020	%
NDWI	0.0493361	24.30%	0.030485	23.94%	0.0810261	27.62%

The Table 3 shows the water extent for each epoch, the value recorded about 24.30% for the year 2010. The area covered by water is high when compared with the total land area of the case study. The year 2015 recorded a drop of about 0.36%. The drop is insignificant compared to the volume of stagnant water which is on the surface of the earth. This could be a source of disease outbreak since the water can serve as a breeding ground. The year 2020 recorded an upward trend, it recorded an increase of about 3.64% when compared with the previous epoch. This also confirm the pattern of water body patches (Figure 2) in LULC map. Table 3 also depicts NDWI at low and high level. Figure 5 represent the bar chat depicting the trend of NDWI for the years in view.

Projecting water patches from LULC change and NDWI is aimed to estimate the rate of change relative to time. The period considered was ten (10) years. Using simple least square regression model to determine the change in water patches to the year 2030. Figure 6 depicts the bar chart showing the LULC change and the NDWI prediction for the year 2030.

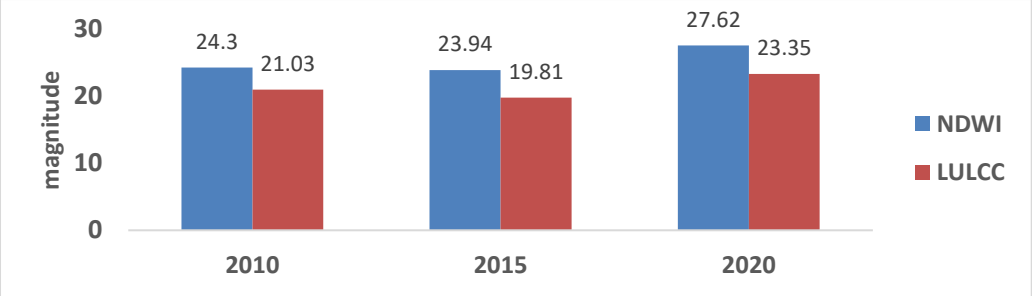

Figure 5. Combination of LULC change and NDWI

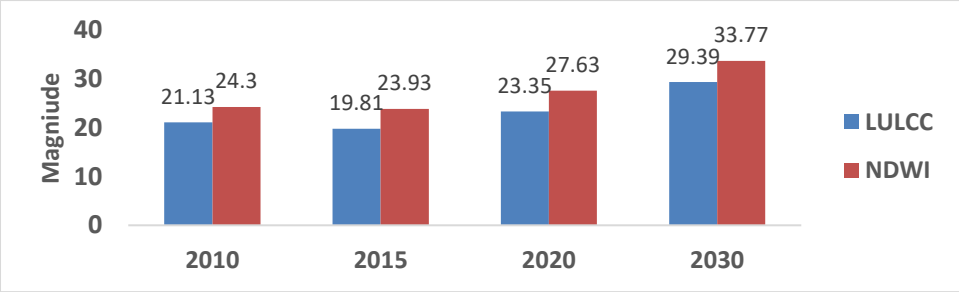

Figure 6. Projection of LULCC & NDWI to year 2030

5. Conclusion

Flood risk mapping is an important component of smart land use planning in flood plain areas and it aids municipal planners' and administrators' efforts to organize their mitigation or relief efforts according to priority (Adjei-Darko, 2017). Spatio Temporal Analysis of perennial Flooding in Niger plan communities in Lokoja Kogi state have been conducted in this study, Landsat images of 2010, 2015 and 2020 were utilized in this study. OLI Landsat 8 image was used for 2015-2020 while Landsat 7 (TM+) was used for 2010. The imageries were processed and classified using the interactive supervised classifier and then the area of coverage of water body was extracted and the spatio temporal changes of water body from 2010-2020 was analyzed. It was found that there was a drastic reduction in water coverage in 2015 while a very high rise in water level was noticed in 2020, this agrees with high flood event recorded in the year 2020 across Nigeria for which Kogi state was named one of the top states that was affected. The study reviewed that the application of remote sensing for delineation of flood inundation area cannot be over emphasized and findings of this study can be used for further planning of flood mitigation strategy in the study area.

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Conceptual Framework for Artificial Intelligence Implementation in Nigerian Construction Projects Management

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Abstract
This study develops a conceptual framework for implementing artificial intelligence (AI) in Nigerian construction project management to improve performance. Utilizing a desktop research approach, prominent AI tools, implementation barriers, drivers, and managerial roles are analyzed. The proposed framework is intended to guide Nigerian construction firms in AI adoption for enhanced project outcomes. Findings suggest that the synergy between operational requirements and managerial roles is critical for effective AI integration. Further empirical research is recommended to validate the framework through a Smart-PLS Structural Equation model.

Keywords: Conceptual framework, Construction projects management, Project manager, Construction projects Performance, Artificial Intelligence

1. Introduction

The construction industry contributes to about 13% of the global Gross Domestic Product (GDP) with a projection of about 85% by the year 2030 (Akinosho *et al.,* 2020). However, the growth of the industry is hampered by the numerous complex challenges to include labour shortages, cost and time overruns. These challenges are extended to other areas of construction practices such as health and safety, productivity, supply chain management, construction contract management, contract dispute, planning, estimating, scheduling, project management, risk management, procurement of material as well as waste generation (Abioye *et al.,* 2021; Adeloye *et al.,* 2023).

Construction projects which are the product of the construction industry are also faced with the challenges of schedule delays, low-profit margins, waste management and safety problems; all of which are affecting performance of construction projects (Yaseen *et al.,* 2020; Smith and Wong, 2022). Construction projects all over the world have reported a very poor performance often leading to cost overruns, time delays and poor-quality products (Sota 2020; Smith and Wong, 2022).

These challenges of project management are not different in Nigeria (Owolabi *et al.,* 2022), as Adeloye *et al.* (2023) observed that construction projects are faced with other complex challenges of inaccuracies in cost forecast and problems of cost overrun despite all the different techniques and tools available.

Also, in Nigerian the unwillingness of the construction industry to adopt new technologies like the AI is often associated with cost inefficiencies, poor product quality, project delays, uninformed decisions, and poor performance in aspects related to health, safety, procurement of materials and productivity in the construction projects (McNamara and Sepasgozar, 2021; Abioye *et al.*, 2021; Galindo-Martín *et al.,* 2021; Adeloye *et al.,* 2023).

To successfully address these problems, the construction processes need emerging technologies like AI that would broaden human smartness in the construction project management throughout the project life cycle, in order to optimise the project management and organizational decision making processes (Makaula *et al.,* 2021).

Presently, it has become apparent that the construction project in Nigerian is in dire need to embrace digitalization and new technology like AI to effectively overcome problems of labour shortages, health and safety and project management performance (Oey and Lim ,2021; Grenčíková *et al.,* 2021; Galindo-Martín *et al.,* 2021; Abioye *et al.,*2023).

Artificial Intelligence (AI) is a philosophy which is considered an advancement of the computer systems, capable of executing activities ordinarily, by demanding human intellects and scrutinising what method to capture and comprehend the logical conduct of computers, or in what way to answer predicaments with the use of computers that necessitate interoperability (Paschek *et al.,* 2017; Makaula *et al.,* 2021). It is relatively vast and comprises numerous sections, such as Machine Learning (ML) and Personal Computer (PC) optics (Makaula *et al.,* 2021).

The AI technologies have enhanced automated processes and currently remain one of the prominent technologies for tackling the construction challenges (Akinosho *et al.,* 2020; Akinradewo *et al.,* 2021; Regona *et al.,* 2022). Developed

countries like China, USA, India, Mexico and Canada, have embraced artificial intelligence and in adopting this technology in construction projects management, whereas developing countries like Kenyan, South Africa and Nigerian are very slow in implementing the usage of AI technology in construction projects management (Chemutai, 2020; Tjebane *et al.,* 2021).

AI has the potential to revolutionize how projects are planned, executed, and controlled in project management (Darko *et al.,* 2020; Savio and Ali, 2023). AI-powered tools also help to analyze vast amounts of historical project data, identify patterns, and create valuable insights, assisting project managers in making informed decisions and mitigating risks. Kamilu *et al.* (2024) stated that AI helps in decision making in projects, supports problem solving functions, used in project planning, improves efficiency of large volume of data usage in projects, allocation of resources and distribution of tasks, and has the potential to increase project success and mitigate project failure. AI tools also help project managers to handle and administer critical tasks in construction projects (Lahman, *et al.,* 2018; Kamilu *et al.,* 2024).

The AI technique is receiving wider acceptance in the construction industry, but its implementation in construction projects management in Nigeria is sub-optimal (Owolabi *et al.,*2022). Hence, what AI Implementation conceptual framework can be developed to address performance problem in construction projects management in Nigeria?

Thus, this research seeks to develop a conceptual framework for AI implementation in construction projects management in Nigeria with a view to enhancing the performance of construction projects management in Nigeria. With the following objectives to examine prominent AI tools that are relevant to different operations of construction projects management in Nigeria; assess the barriers to the implementation of the AI tools in the relevant operations of construction projects management in Nigeria; examine the drivers to the implementation of the AI tools in the relevant operations of construction projects management in Nigeria; assess the role of project managers in the implementation of AI tools in the relevant operations of construction projects management in Nigeria; establish the operational requirements for implementation of the AI tools in the relevant operations of construction projects management in Nigeria and, develop a conceptual framework for AI implementation in construction projects management in Nigeria.

This research will consider large construction projects organisations that are adopting AI, who are registered with Federation of Construction Industry (FOCI) in Nigeria. The respondents will comprise Construction projects site AI stakeholders comprising of Project managers, AI specialists, AI consultants and Contractors.

2. Literature Review

2.1 Current AI Frameworks

2.1.1 Hybrid AI model

The Hybrid Random Forest and Genetic Algorithms (RF-GA) Model was developed by Yaseen *et al.* (2020) who dealt with identification of factors and sources of delay problems and developed model for project delay predictions. The model is not holistic enough, as it's specifically focused on project delay. Thereby leaving out other important areas of construction project management like project scheduling, project planning and control, logistics management and project cost estimation. Moreover, the model was not for implementation but rather for adoption and some is basically for prediction.

In a similar study Chemutai (2020) developed a conceptual model for AI adoption and the model identified factors that discouraged the adoption of AI in construction industry as lack of capital investment, resistance, lack of awareness and legal issues and regulations. The model is not holistic enough, as it specifically focused on decision making. Thereby leaving out other important areas of construction project management like project scheduling, project planning and control, logistics management and project cost estimation. Moreover, the model was not for implementation but rather for adoption.

2.2 AI framework for construction industry by Min *et al.* (2023)

Particular emphasis is drawn to conceptual frame work developed by Min *et al.* (2023) which identify the challenges faced by construction companies during implementation and investigate the impact of AI system in the construction industry. The model is not holistic enough, as it specifically focused on health and safety problems, risk management, and decision making respectively. Thereby leaving out other important areas of construction project management like project scheduling, project planning and control, logistics management and project cost estimation. Moreover, the model was not for implementation but rather for adoption.

Additionally, the existing model have some methodological limitations which include a demographic different in states and online data collection that cannot be generalized to construction projects,

2.3 AI framework for construction industry by *Min et al.* (2023)

Bharati and Sandbrink (2024) developed AI adoption framework by managers which concentrated on strategies to adopt AI and project management Areas Impacted by AI. The framework was faced with some methodological limitations which include a small participant sample, a focused solely on project managers' perspectives and reliance

on self-reported interview data that cannot be generalized to construction projects. The framework was designed for adoption rather than implementation of AI in construction project management.

2.4 Theoretical findings

The framework of Hybrid RF-GA Model was developed by Yaseen *et al.* (2020) deal with identification of factors and sources of delay problems and develop model for project delay predictions. Consequently, conceptual model was developed by Chemutai (2020) which identified factors that discouraged the adoption of AI in construction industry.
In a similar study developed by Min *et al.* (2023) which identifies the challenges faced by construction companies during implementation and investigates the impact of AI system in the construction industry, without a specific focus on the prominent AI tools and its operational requirements for its implementation that will be leading to achieve an effective implementation.

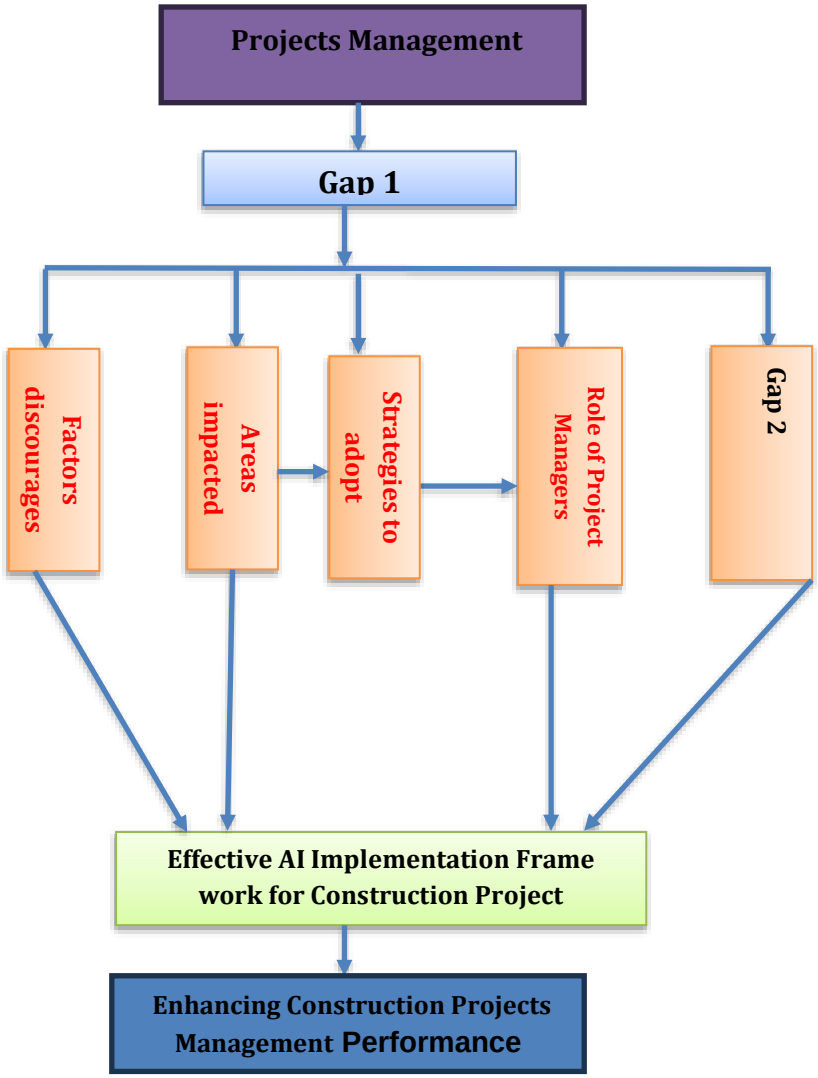

Figure 1: Theoretical Framework of Effective Implementation of AI in Project Management.
Source: (Researchers' construct, 2024; Adapted from existing literature)

2.5 Challenges in AI Adoption

Existing theoretical issues highlighted above were not holistic enough, as they specifically focused on health and safety problems, risk management, project delay and decision making respectively. Thereby leaving out other important areas of construction project management like project scheduling, project planning and control, logistics management and project cost estimation. Moreover, the frameworks were not for implementation but rather for adoption and some are basically for prediction.
The frameworks also failed to provide linkages between prominent AI tools and the construction projects management, barriers, drivers, role of project managers and operational requirement.

Additionally, the existing frameworks on AI are faced with the following limitations during development to include a small participant sample, focused solely on project managers' perspectives, demographic difference in states, single point of data collection, online data collection and reliance on self-reported interview data that cannot be generalized to construction projects.

Most of these frameworks are not Nigerian based that could not be entirely domesticated in Nigeria owing to the differences in the economic, political, social situation of Nigeria and other operational requirement such as unavailability services, investment cost, technical know-how, electricity supply, internet diffusion, cyber security as well as infrastructure for the model is to be effectively implemented in Nigeria. Thus, the need to develop a conceptual framework for Artificial Intelligence implementation in construction projects management in Nigeria.

2.6 Role of Project manager in AI implementation

Integrating AI with human managers can improve productivity and decision-making in various sectors. Project managers play vital roles in establishing reasonable goals, encouraging teams, building team skills, ensuring accountability, empowering team members, facilitating communication, using tools, adapting to change, and evaluating performance (Pereira *et al.,* 2021; Bharati and Sandbrink ,2024).

Bharati and Sandbrink (2024) further asserted that the factors influencing the role of the project managers to implement AI are promote flexibility and adaptability, skill enhancement and continues learning, for self and the team, Human-AI collaboration and complementarity, factor in organizational structure and address change management and navigate ethical considerations and data integrity.

3. Research Methodology

This research adopted the desktop research methodology by conducting a thorough literature search on existing frameworks relating to prominent AI tools, barriers, drivers, role of project management and operational requirement from Google scholar databases which 69 only journal papers were search and limited 32 journal papers published between the period of 2020 to 2024 based on the search criteria set which form basis for development of the theoretical framework for artificial intelligence implementation, which informs the development of the conceptual framework for the research.

4. Results and Discussion

4.1 Research Conceptual Framework

This section presents the researcher concepts on the constructs that emanate from the research in attempts to fill the theoretical gaps identified in this study.

The proposed constructs for the Conceptual Framework based on the identified gaps and the stated objectives for this research include the following:

4.2 Construction projects management

Construction projects which are the product of the construction industry are also faced with the challenges of schedule delays, low-profit margins, waste management and safety problems; all of which are affecting performance of construction projects (Yaseen *et al.,* 2020; Smith and Wong, 2022).

4.3 Prominent AI tools in project management

Taboada *et al.* (2023) indicated that artificial intelligence, predominantly machine learning, can be considerably useful in the management of construction and IT projects; it is notably encouraging for enhancing the planning, measurement, and uncertainty performance domains by providing promising forecasting and decision-making capabilities. A construction site AI chatbot to get real-time updates about site activities would prove to be very helpful for project managers and other relevant stakeholders (Abioye *et al*., 2021).

4.4 Barriers to the implementation of AI tools in project management

Regona *et al.* (2022) perceived project risk, security of data, and lack of capabilities are the most common AI constraints to implementation of AI in project management in the construction projects management. These barriers also include cultural issues, security, higher initial costs, project uniqueness, robotics, institutional barrier and Information Sharing.

4.5 Drivers for the implementation of AI tools in project management

Bodea *et al.* (2020) explained that the important factors acting as drivers for adopting AI technologies in project management are the availability of AI driven systems within the organization, the available experience and stakeholder's demand for innovation and value, which are closely connected with the main reasons for adopting the AI which are: increased productivity, decision making and overall performance within project management practice.

4.6 Role of project managers

Project managers play key roles in establishing reasonable goals, encouraging teams, building team skills, ensuring accountability, empowering team members, facilitating communication, using tools, adapting to change, and evaluating performance (Pereira *et al.,* 2021; Bharati and Sandbrink,2024). Bharati and Sandbrink (2024) further highlighting the role of project managers for integration of artificial intelligence (AI) into project management, as anticipated changes in job roles, dynamics, potential displacement of human workers, complementarity between human and AI intelligence, and the possibility of humans being at par.

4.7 Operational requirement

Salleh and Aziz (2022) stated that the operational requirements for the implementation of AI in project management are strategy – the extent to which an organization considers AI as a core strategy, investment – investment in AI digital platform, culture – the extent to which employees are empowered to take a risk, participating in organization's AI journey, capabilities – organization's capability to develop deploy and monitor AI models, infrastructure – availability of data and tools to support AI, and data – availability of data including quality, timeliness, and governance of data.

4.8 Conceptual Framework for Effective Implementation of AI in Construction Projects Management in Nigeria

Figure 2 shows that to achieve effective implementation of AI in any construction projects management, the prominent AI tools that is relevant to different operation of construction projects management need to be considered all through the barriers, drivers, role of project manager and operational requirement which mean that without AI tools in any of these the implementation will not be effective. However, the construction projects management has direct link to prominent AI tools, prominent AI tools have direct link to barriers, drivers, role of project manager and operational requirement which also mean without AI tools across the implementation will not be effectively.

Furthermore, for these to be effectively implemented all the constructs must have synergy among them self and without operational requirement the AI implementation will not be effectively. Finally, for AI tools to be effectively implemented in any construction projects management, the role of project manager, barriers, drivers and operational requirement must be considered with AI tools across all through the implementation processes.

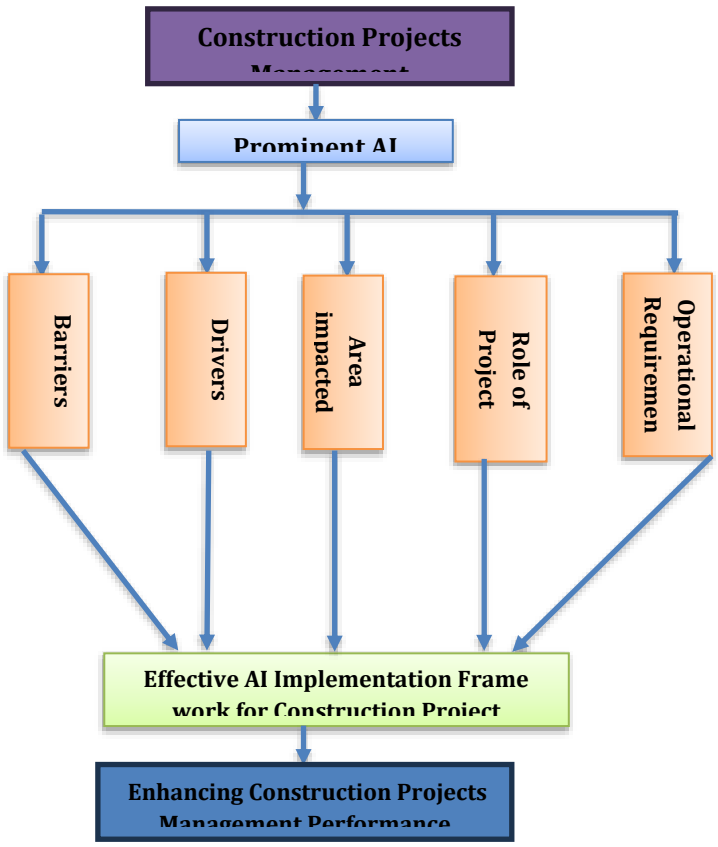

Figure 2: The Conceptual Framework for Implementation of Artificial Intelligence in Construction Projects Management in Nigeria Source: Researcher's Construct (2024)

Therefore, the following 5 links were developed to serve as the proposed hypothesis for the proposed Smart-PLS Structural Equation Modeling:

i. Link 1: Prominent AI tools and Barriers
ii. Link 2: Prominent AI tools and Drivers
iii. Link 3: Prominent AI tools and Role of project managers
iv. Link 4: Prominent AI tools and Operational requirement
v. Link 5: Prominent AI tools and Construction projects management

5. Conclusion and Recommendation

The lack of public awareness and knowledge of artificial intelligence, legal issues and regulatory challenges such as stringent laws and lack of sufficient legal framework and lack of capital investments are the major factors hindering implementation of Artificial Intelligence (AI) in project management can hinder successful AI implementation and affects construction projects management performance. Most of these frameworks are not Nigerian based that could not be entirely domesticated in Nigeria owing to the differences in the economic, political, social situation of Nigeria and other operational requirement such as unavailability services, investment cost, technical know-how, electricity supply, internet diffusion, cyber security as well as infrastructure for the framework is to be effectively implemented in Nigeria. The frameworks also failed to provide linkages between prominent AI tools and the construction projects management, barriers, drivers, role of project managers and operational requirement. Thus, this research developed a conceptual framework for the implementation of AI by the construction projects management through a desktop methodology. The conceptual framework revealed that for AI tools to be effectively implemented all the constructs must have synergy among them self and without operational requirement the AI implementation will not be effectively. Finally, for AI tools to be effectively implemented in any construction projects management, the role of project manager, barriers, drivers and operational requirement must be considered with AI tools across all through the implementation processes. It is recommends the development of the full Smart-PLS Structural Equation model using empirical data to aid effective implementation of AI tools for performance improvement in construction projects management in Nigeria and also recommends for Nigerian construction industry stakeholders, such as practical steps for AI implementation.

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Conceptual Framework for Total Quality Management Implementation in Construction Organisations in Nigeria

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Abstract

This study addresses performance challenges in Nigerian construction organizations by developing a conceptual framework for Total Quality Management (TQM) implementation. A literature-based desktop methodology identifies TQM factors that impact organizational performance. The proposed framework aims to guide Nigerian firms in applying TQM to enhance quality, customer satisfaction, and operational efficiency with a view to developing a final-path model for addressing the performance problems of construction organizations in Nigeria. The existing theoretical models developed for TQM implementation failed to holistically consider the key factors of TQM practices and also failed to provide linkages between TQM factors and the performance indicators, in the areas of customer results, market and financial, social responsibility, innovation and operational performance as it relates to organisational characteristics. This research therefore, adopted a desktop methodology, by conducting a thorough literature search on the existing frameworks that relate to TQM implementation which further informed the development of the conceptual framework for effective implementation of TQM in construction organizations in Nigeria. The conceptual framework revealed that to achieve effective implementation of TQM concept in any construction organization, The TQM related factors must be considered all through the implementation process which will in turn affect the organisational performance of minimizing costs and create products with high quality characteristics through continual improvement. The study recommended the development of the full path model to aid effective implementation of TQM for performance improvement in construction organization in Nigeria.

Keywords: Conceptual framework, Construction Organisations, Organisational characteristics, Organisational Performance, Total quality management.

1. Introduction

Construction organisations in Nigeria are performing below expectations when compared to those in developed nations in the areas of customer and stakeholder management, resource management, partnerships and supply management relationships, innovation and continuous improvement measurement (Jimoh *et al.* 2018; Gumo *et al.,* 2018). These organisations are facing challenges of delivering quality works to clients to sustain competitive advantages (Adusa-Poku and Anokye, 2020). Polat *et al.* (2011) noted that the chronic problems of construction organisations which include low productivity, poor health and safety, inferior working conditions, and inadequate quality, are well known, but great amount of time, money and resources, are wasted by construction organisations as a result of poor or absence of quality management procedures (Hoonakker *et al.,* 2010).

Total Quality Management (TQM) concept was introduced in the construction industry in developed countries as a philosophy and a culture to improve productivity and quality. It is a holistic quality improvement approach to organisations for the purpose of improving performance in terms of higher quality products, greater customer orientation to satisfaction, reduced costs, improved financial, quality and innovation performance, improved employee satisfaction and better management of workers within companies (Gumo *et al.*, 2018; Adusa-Poku and Anokye, 2020). Organisational effectiveness and efficiency are contingent upon three key organisational characteristics: decision-making style, management style, and organisational structure (Potosky & Ramakrishna, 2002). However, construction organisations in Nigeria have been continuously struggling with its implementation (Waziri, 2016; Jimoh *et al.* 2018).

The TQM technique developed in the manufacturing industry has received wider acceptance in the construction industry, but its implementation in construction organisations in Nigeria is constrained by ineffective model for performance improvement (Gumo *et al.,* 2018; Osuizugbo, 2020). The frameworks on TQM implementation developed by Shaker *et al.* (2015), Likita (2018), Digehsara (2018); and Murali and Ponmular (2021) are foreign based that could not be entirely domesticated in Nigeria owing to the differences in the economic, political, and social situation in the area of meeting the financial performance of the construction firms. Gowthami *et al.* (2022) noted the importance of developing a TQM implementation model that suits every location, as they may have different form of customer satisfaction, cost, time, and quality requirements

Thus, this research seeks to develop a conceptual framework for TQM implementation in construction organisations in Nigeria with a view to enhancing the performance of construction organisations in Nigeria. With the following objectives to assess factors that affect implementation of TQM practices in construction organisations in Nigeria; examine effects of TQM implementation factors on performance of construction organisations in Nigeria; examine effects of organisational characteristics on TQM implementation in construction organisations in Nigeria; establish operational requirements for implementation of TQM principles for effective performance of construction organisations in Nigeria; and, develop a conceptual framework for TQM implementation in construction organisations in Nigeria.

2. Literature review

2.1 Quality management theory

Deming's model of quality improvement activity structured into four phases: Plan, Do, Check, and Act cycle (PDCA). The Plan phase begins with a study of the current situation, during which facts are gathered to be used in formulating a suitable set of actions for quality improvements. In the Do phase, the planned actions are implemented. During the Check phase, results are compared with those specified in the plan stage and techniques and procedures used to identify the extent to which they are really solving the identified problems. Finally, the Act phase is used to standardize successful methods so that new techniques introduced are put into continuous action (Oakland, 1995).

In another study, Juran (1993) considered quality management as three basic processes namely: quality control, quality improvement, and quality planning. The approach to managing for quality consisting of the sporadic problem is detected and acted upon by the process of quality control; the chronic problem requires a different process, namely, quality improvement.

Furthermore, Oakland (1995) developed a TQM model that identifies customer-supplier relationships, manage processes, change the culture, improve communication and show commitment surrounded by the management necessities of the systems (based on international standard), tools (for analysis, correlations and predictions for action for continuous improvement to be taken and teams (the council, quality improvement teams, quality circles and corrective teams).

These models proposed by early advocates were only guidelines as it is difficult to devise a universal "cookbook" for TQM implementations. The effectiveness of each TQM implementation guideline differs from one industry to another and from one organization to another. They each provided wisdom and powerful drivers for thought, but none have provided a complete and final answer in the form of a TQM framework, where their work was rather considered as advice for management to follow.

2.2 Quality Awards

This model comprises a set of well-designed processes capable of meeting customer requirements and quality performance. The Baldrige Award judges the results companies show through their management practices in seven specific areas according to Sources: Adusa-Poku and Anokye (2020): leadership; information and analysis; strategic planning; human resource focus; process management; business results and company performance and, customer focus and satisfaction. The European Quality Award (EQA) has established a model for organisations to assist their performance which is the European Foundation for Quality Management Excellence Model (EFQMEM). However, the model is used to assess all applicant quality management performance and is divided into two parts: enablers and results. The model recognises that processes are the means by which an organisation harnesses and releases the talents of its people to produce results; they are the "Enablers" that produce the "results". The EFQM model places much more emphasis on tactical issues relating to the diffusion and implementation of strategy and the monitoring of customer, employee and society results,

2.3 Total Quality Management Implementation Models

Elghamrawy and Shibayama (2008) developed a model for TQM implementation in the Egyptian construction industry. The model consists of the following steps: commitment by management; orientation; planning of the program; training on TQM; conducting quality projects; improving jobsite quality; and measuring results. However, the model only addresses the jobsite reforms at an early stage.

Pheng and Teo (2004) developed a framework which asserts that implementing TQM requires a major organizational change that would transform the culture, processes, strategic priorities, and beliefs of an organization. The study also confirmed that understanding of TQM requirements which include customer/supplier involvement, continuous improvement, top management commitment, strategic review of education and implementation plans, provision of ample budgets and resources, teamwork, training, and timely feedback are important factors for TQM implementation. However, the model failed to highlight the statistical tools and techniques at various stages of construction process.

In another study, Koh and Low (2012) identified eight elements quality implementation. These elements can be implemented at different levels within the medium band; customer and process management, and top management leadership were implemented at a "moderately-high" level, supplier management moderately, while the remaining four elements of people management, continual improvement, and organizational learning were implemented at the lower level with quality information management implemented at the lowest level as indicated.
In another study in Ghana, Adusa-Poku and Anokoye (2020) asserts that Process Management, Leadership Commitment, and Customer Focus are the three basic criteria needed for a successful implementation of TQM Framework. They are the triangular pillars on which TQM derives its support.
Most of these frameworks failed to provide a definite process to be followed in order to effectively implement TQM in construction organizations.

2.4 Theoretical Findings

The existing theoretical issues revealed that previous theories have focused on quality management, quality control and quality management process, including their practices, organizational characteristics and performance, without a specific focus on the concept of Total Quality Management (TQM) implementation and its operational requirements for its implementation as shown in figure 1. The theories failed to consider TQM processes to follow to achieve an effective implementation.

Figure 1: Location of Theoretical Framework of Effective Implementation of TQM in Construction Organizations. Source: (Researchers' construct, 2024; Adapted from existing literature)

2.5 Gap to be filled by the study

Existing theoretical issues highlighted above failed to reflect the following key issues: Holistically consider the key factors of TQM practices in one model (for instance, leadership, customer focus, training, supplier quality management, process management). The frameworks also failed to provide linkages between TQM practices and the performance indicators, in the areas of customer results, market and financial, social responsibility, innovation and operational performance as it relates to organisational characteristics. These problems hinder effective implementation of total quality management in construction organizations. Thus, the need to develop a conceptual framework for Total quality management implementation in construction organizations in Nigeria.

3. Methodology

This research adopted the desktop research methodology by conducting a thorough literature search on existing frameworks relating to quality management, total quality management and organisational characteristics which form basis for development of the theoretical framework for total quality management implementation, which informs the development of the conceptual framework for the research.

4. Findings and Discussion

4.1 Research Conceptual Framework

This section presents the researcher concepts on the constructs that emanate from the research in attempts to fill the theoretical gaps identified in this study.
The proposed constructs for the Conceptual Framework based on the identified gaps and the stated objectives for this research include the following:

1. **Organisational Characteristics:** this includes management styles, decision making styles, organisational culture and organisational learning.

2. **TQM performance requirements:** This includes operational performance, market and financial performance, employee's performance, innovation performance, customer result performance indicators and social responsibility performance.
3. **Operational requirements for the implementation of TQM**: this may include creation of TQM unit for managing TQM affairs in the organization; scope definition for TQM; formation of competent TQM implementation team in the organization etc).
4. **Total Quality Management Factors**
   - i. **Top Management Commitment:** Clear and consistent communication by the management in defining the organization's quality value; creating and supporting long term quality improvement processes; alignment of management policies with site quality/operational plans to strengthens compliance.
   - ii. **Employees Training and Development:** Enabling environment for employees training on quality improvement in organizations; Provision of the required resources that will enhance quality training of employees in the organization.
   - iii. **Teamwork:** Formulation of a quality team to enhance new skill development and performance; Capacity building opportunities for staff development; Establishment of peer-teams to enhance workforce efficiency.
   - iv. **Process Management:** Inspection-test plan that directly affect quality; Ensure clarity of work-process instructions to employees, artisans and site staff.
   - v. **Customer Focus:** Setting up a system where customers' requirements are used as basis for achieving quality; Responding effectively to client's enquiries and complaints; Undertaking both preventive and corrective actions to delight customers.
   - vi. **Supplier Management and Partnership Relation:** Management of external partnerships and strategic alliances between suppliers to ensure quality in the organization; Benchmarking supplier performance based on cost and quality; Providing a clear and good quality specification to suppliers by providing technical assistance.
   - vii. **Continuous Improvement:** Identification of non-value adding areas for continuous improvement in organizations; Utilization of a check-list sheet as a quality tool for design and construction for process improvement in organizations; and continual review of project completion time

4.2 Conceptual Framework for Effective Implementation of TQM in Construction Organizations in Nigeria

The constructs in Figure 2 shows that to achieve effective implementation of TQM in any construction organizations in Nigeria, the relevant TQM factors (i.e. top management factors, employees training factors, team work, customer focus etc) must be considered and this would in turn affect the organisational characteristics (management styles, decision making styles, organisational culture and learning) and the same factors must would affect TQM performance requirements which include, customer results performance, market and financial performance, employee performance and innovation. The organisational characteristics and TQM performance requirements must all be linked to operational requirements for the implementation of TQM to include (Creation of TQM unit for managing TQM affairs in the organization; scope definition; formation of competent TQM implementation team in the organization etc). This will in turn lead to effective implementation of TQM in construction organizations in Nigeria.

Figure 2: The Conceptual Framework for Implementation of Total Quality Management in Construction Organizations in Nigeria
Source: Researcher's Construct (2024)

Therefore, the following 5 links were developed to serve as the proposed hypothesis for the proposed path model:

vi. Link 1: TQM implementation factors (TQMif) and Organisational Characteristics (OC)
vii. Link 2: TQM implementation factors (TQMif) and TQM performance requirements (TQMpr)
viii. Link 3: Organisational characteristics (OC) and Operational requirement for TQM implementation (OrTQMi)
ix. Link 4: Operational requirement for TQM implementation (OrTQMi) and TQM performance requirements (TQMpr)
x. Link 5: Organisational Characteristics (OC) and TQM performance requirements (TQMpr)

5. Conclusion and Recommendation

One of the challenges facing TQM implementation process is the failure to determine the management related factors limiting its success. Some identified factors that hinder the implementation of total quality management which include the thought that its implementation can be time consuming, bureaucratic, formalistic, rigid and impersonal can hinder successful TQM implementation and affects organisational performance. The existing frameworks on implantation of TQM could not be applied in Nigeria because they failed to holistically consider the key factors of TQM practices in one model (for instance, leadership, customer focus, training, supplier quality management, process management). The models also failed to provide linkages between TQM practices and the performance indicators as it relates to organisational characteristics. Thus, this research developed a conceptual framework for the implementation of TQM by the constructions organisations through a desktop methodology. The conceptual framework revealed that total quality management practices must be effective and considered throughout the implementation process to enhance organisational performance which will affect the overall project objectives of meeting with time, cost, quality, environment and safety. It is recommends the development of the full path model using empirical data to aid effective implementation of TQM for performance improvement in construction organization in Nigeria.

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Assessment of the Digital Terrain Models for Flood Planning and Disaster Management in Minna, Niger State

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Abstract

The occurrence of floods and their effects on human existence as well as the general environment has unfortunately been on the increase owing to human-induced climate change and poor infrastructural location. Hence, the aim of this project was to assessed and modeled the digital terrain models of Minna and its environs using geographical information system tools. The data used are from open source and ground observation using handheld GPS. A geospatial technique was used to map and analyze the study area's hydrological characteristics. A map showing the vulnerable areas was produced using buffering and indicating the risk zone areas. Additionally, the Digital Elevation Model (DEM), Land use land cover map, and the geomorphological map were developed representing the physical characteristics of the study areas. The research findings show that the lack of a proper drainage system is a contributing factor to flooding in Minna. Increased rural-urban migration and building on water waterways are additional factors. The study recommended that proper drainage and government building regulations should be followed to reduce the amount of drainage blockage.

Keywords: Flood, Vulnerable, Riverbanks, Assessment.

1. Introduction

Natural disaster is one of the most serious problems facing all countries of the world. Hence, a remarkable global trend towards growing deaths, casualties, and economic losses resulting from disasters has been seen in recent years are associated with flooding (Alrehaili *et al*., 2022). Flooding may occur when water from a lake, river, dam, or rainfall overflows beyond the natural boundaries of dry land which causes some negative effects on life and properties (Onuigbo, 2017). The negative effects which are debilitating and multifaceted, ranging from the destruction of the ecosystem, agricultural activities, infrastructural facilities and amenities, injury, illness, death, inhibition of access to education, health services, comfortable housing, drinking water and sanitation, aggravation of poverty and hunger, among others (Birmah *et al*., 2021; Musa *et al*., 2015 and Dallil *et al*., 2015). Thus, in order to mitigate the negative effects of flooding, several researchers have developed different models depending on the flood scenario (Asgary, 2006).

Despite the availability of several disaster management models, disasters are frequently managed inefficiently. Asgary (2006) states that disaster management is a newly developed discipline and profession. Thus, those in charge of managing disasters should continue to improve their models so that it remains a professional and scientific discipline. In Minna, floods usually occur along the bank of River Suka when Minna records an unprecedented amount of precipitation or when the river is inundated by a high amount of water from upstream. However, its effects can be mitigated or eliminated through drainage construction, which unfortunately does not cover the entire length of the study area (Dallil *et al*., 2015). The southern part of Minna usually experiences floods to some degree that usually result in disaster. Hence, the aim is to develop a digital terrain model for planning and disaster management and to further understand the flood patterns of Minna.

1.1 Study Area

The study area of this project covers part of Bosso and Chanchaga local government area of Minna, Niger State. Lying on latitude and longitude of 9º36'30" N, 6º31'11" E and 9º35'47", 6º34'42". Niger State is one of the 36 states in Nigeria. The state was created on the 3rd of February 1976 out of the northwestern region of Nigeria. Minna is the capital with different ethnic groups of people speaking diverse languages, but Nupe and Gbagyi are predominant. The major activity of the people is farming. Figure 1 below describes the study area. The population of Minna, the capital of Niger State, Nigeria, is projected to be 513,000 in 2024. This is a 3.43% increase from 2023 when the population was 496,000. Minna is located in the North-Central geopolitical zone of Nigeria. It has a land area of 6,789 square kilometers and a population density of 34.48 people per square kilometer. The main reason Minna was selected is due to the constant

and continuous flooding experience within the southern parts. Another factor was the frequent rural-urban migration which resulted in building houses without government approval (Odaudu and Musa, 2018).

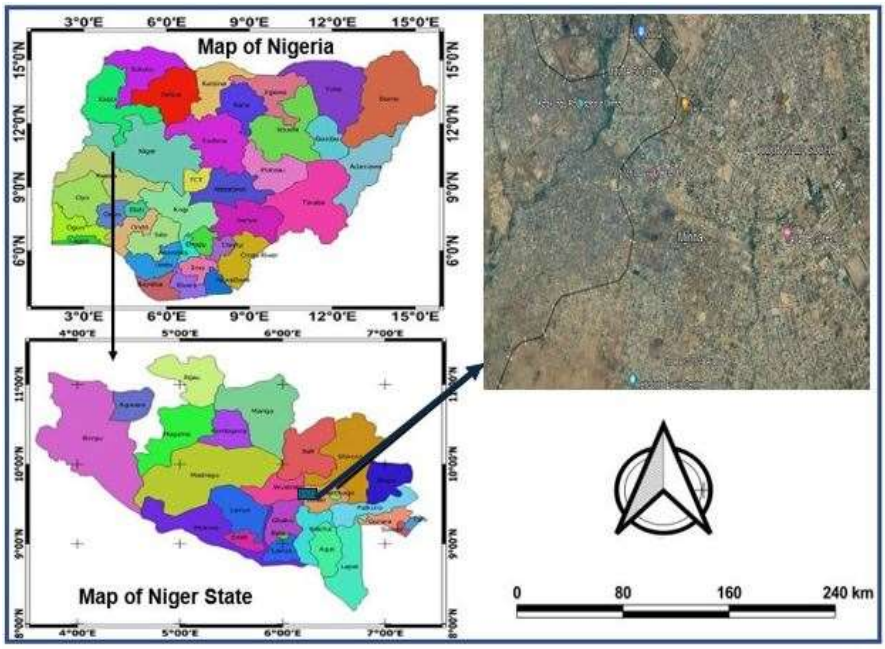

Figure 1. Study area embellished map showing the area of the project. Source: Google earth and processed in the lab.

2. Material and Method

This section describes the procedures used to achieve the purpose of this research. In this phase, the site was visited, "though some parts" in order to understand the physical nature of the study area. Garmin 76 handheld GPS was used to pick some points for reference purposes. Consequently, Figure 2 describes the methodology flow chart used for the execution of the project. In addition, the data employed in this investigation comprises a digital elevation model and other types of data as presented in Table 1 below. The data to use for this project are from the years 2023 and 2024, while the Land use data are for 1990, 2005, and 2020, respectively.

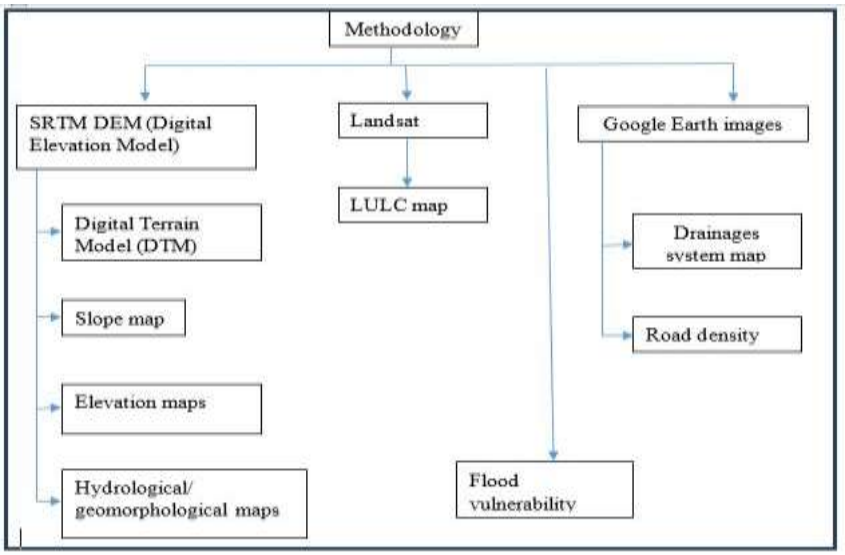

Figure 2: Methodology flow chart. Source: Research lap

Table :1 Data source and data type used in this project

SN	Data description	Data type/ resolution	Year	Source
1	LANDSAT-8 OL1	Satellite images	1990, 2005 and 2020	usgs.gov/landsat-missions/landsat-8
2	Aster DEM	25m	2023	OpenDEM
3	Google-Earth image		2024	Google-earth engine
4	Ground control points	±2m	2024	Garmin handheld GPS.

2.1 Land use land cover data processing and Geomorphology

The land use land cover of the study area was done to evaluate the development trend that have occurred over the years starting from 1990, 2005 and 2020; indicating fifteen years interval. The components that determine the trend were classified into five (5); namely vegetation, built-up, forest, bare land, water and agriculture. The Landsat imagery was downloaded from the USGS website in Tagged Image File Format (tiff) for the years 1990, 2005, and 2020, as shown in Table 1. Image enhancement was conducted to improve the quality of the data by removing errors caused by the atmospheric condition, scan line error, and radiometry effect using QGIS software.

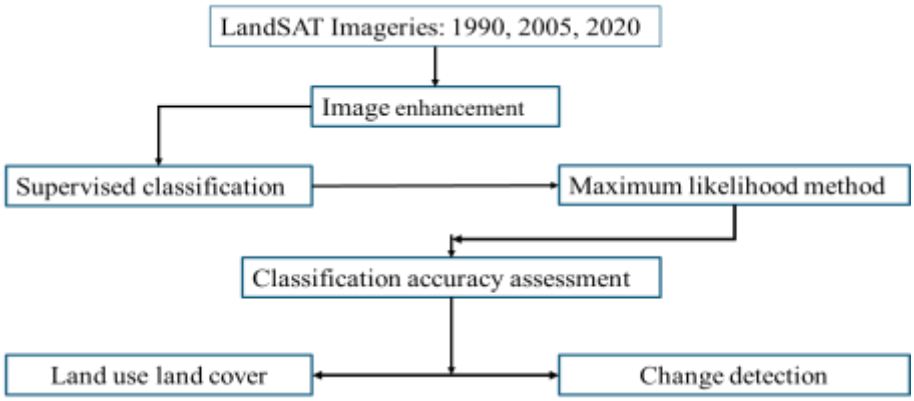

Figure 3: Land use land cover procedures. Source: Research lap

The raster calculator tool was used to perform the atmospheric correction, and the Fix Landsat 7 scanline error tool was used to correct the scanline error of Landsat 7". Additionally, the RGB band was obtained using the composite tool in the raster processing toolbox. These processes were performed for all the imagery of the project area. Supervised classification was employed by selecting the training samples. The final classification accuracy assessment obtained is 85.8% by comparing the pixels and polygon of the classified image against the ground-referenced data.

2.2 Digital Elevation Model Processing and Development of the Geomorphology

The STRM digital elevation model from OpenDEM obtained from the United State Geological Survey (USGS) archieve was processed using QGIS 3.16.3 with GRASS 7.8.5 software within the QGIS environment. The image was processed to produce the digital terrain model (DTM) of the study area which represent the topographic nature of the terrain. Figure 4 shows the digital terrain model (DTM) in the QGIS software working environment. Consequently, Figure 5 shows the developed vulnerability DEM for the study area. The project developed the geomorphology of the study area to understand the dynamics of the flow characteristics. The development of the channel network distance, analytical hill shade, drainage basins, the stream network, slope map, aspect map, and the topographic wetness map were all done in the QGIS environment.

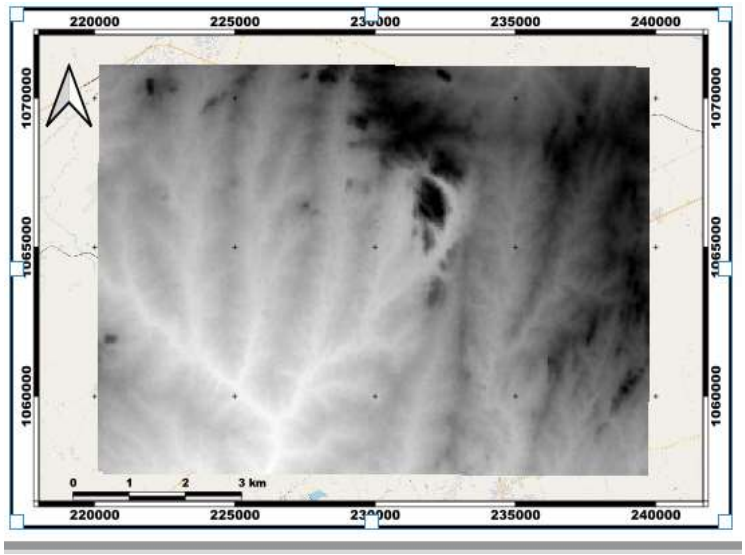

Figure 4: Developed DEM of the Study area

3. Result and Discussion

3.1 Land Use Land Cover Outcome

The results of the analysis were carried out for the land use trend of the study area. Figure 4 below shows the land use land cover of Minna City for the 1990(a), 2005(b), and 2020(c). In 1990, land was dominated by agricultural land (50%), followed by vegetation land (30%). The built-up area was less than 10% indicating that urban heat stress was limited. It was observed that the built-up area concentrated at the center and north-western segments of the city (Fig. 4).

In 2005, bare ground dominated the land use type of Minna city and environs at 45% (Fig. 4b). This was followed by agricultural land at the rate of 35%. The built-up area occupied 15% of the entire land surface area of the city, indicating a moderate rise from the previous decades. In this year, built-up area was found to be concentrated in the centre and around all segments of the city. This implies that urban heat must have increased, making the city more uncomfortable for the inhabitants. In 2020, the land use type showed a rise in agricultural land at the rate of 37% (Figs.4a and 4.b). This was followed by bare ground at an alarming increase of 36%.

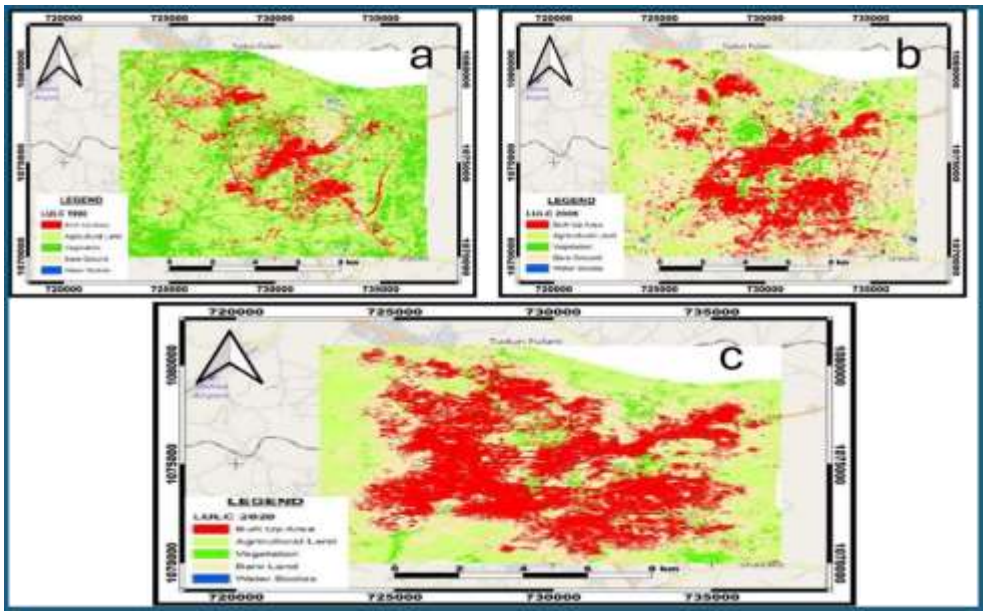

Figure 4: Land use land cover of Minna City of 1990(a), 2005(b) and 2020(c). Source: Research lap

3.2 Flood Vulnerability Map

Flood vulnerability measures the level of proneness of any area, infrastructure, or ecosystem to flooding. It considers geography, land use, infrastructural resilience, and community preparation (Vignesh *et al*., 2021). Flood vulnerability

of the study area was developed as presented in Figure 4.. The color scale varies from red to blue indicating high and low points within the study area. In addition, the project-output as depicted in Figure 4 shows that Minna topography rises and fall at the southern section. This observation suggests that southern parts of the study area are under danger in the event of flooding. However, the saving advantage is that Minna main city has larger and deeper culverts which is controlling most average flooding scenarios. Climate variability and human-induced factors have exacerbated the flood recently, leading to increased displacement across Nigeria, which is in agreement with Dalil *et al*., 2014. However, other researchers like Dalil *et al*. 2014 and Musa *et al*., 2018 researched on flood impact on the Minna metropolis without looking at the hydrological components that exacerbate flood impact at any given instance of flood disaster.

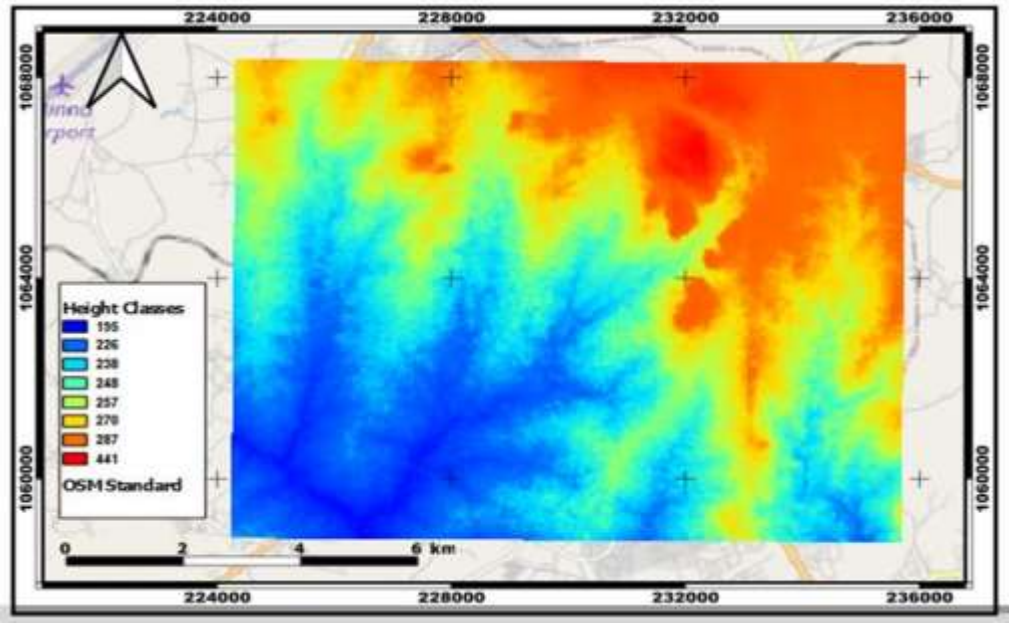

Figure 5: Flood vulnerability Map of Minna City center

4. Conclusion

In this study, a geospatial technique was used for mapping and analyzing flood extent and the vulnerable areas. The vulnerable areas were displayed using buffering and pointing out the risk zones areas. The land use and land cover map shows the increase in the built-up area owing to inflow of people and decrease in the vegetation over the years. Minna is a fast growing area due to its administrative and commercial center of Niger state. The research found out that there are increased physical planning problems as buildings are constructed on mostly all the available space including the marginal flood plains and river banks. The project revealed that hhe topography of Minna is slopy and steep towards the southern region which is another contributing factor of frequent floods in axis. The result that obstruction of water channels and drainage lines are also components leading to flooding. The dumping of refuse and dirt along river channels has reduced the free flow of water which leads to flooding in the study area.

Although, previous researches have shown that a hundred percent (100%) success of flood control may not always be achieved especially in urban environment yet, their damaging effects can be mitigated through management measures that are carefully designed by the government or affected communities. These must be effectively and economically funded and supervised.

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Impact of Petroleum Subsidy Removal on Survival of Micro Small and Medium Construction Enterprises in Abuja, Nigeria

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Abstract

The removal of petroleum subsidy is a consequential economic policy decision with far-reaching implications for various sectors of the economy. One of the sectors profoundly impacted by such a policy change is the construction industry, particularly small and medium-sized construction firms. This study investigated the impact of petroleum subsidy removal on the survival of Micro, Small, and Medum Enterprises (MSMEs) in Abuja, Nigeria, with a view to enhancing the performance of construction MSMEs. A total of 105 structured questionnaires were administered to the Chief Executive Officers (CEOs) of small and medium-sized construction firms (SMEs) operating in the Federal Capital Territory (FCT). The collected data was analysed using the Mean Item Score in order to rank and determine the important survival factors of the construction MSMEs. Inferentially, simple linear regression was used to analyse the impact of construction MSMEs factors on the survial MSMEs after petroleum subsidy removal. The findings revealed that the most important factor that affects the survival of construction MSMEs in Nigeria was lack of finance (RII = 0.96), fuel subsidy removal (RII = 0.95), lack of adequate infrastructure (RII = 0.93), lack of access to technology (RII = 0.90) and lack of managerial skills (RII = 0.90), respectively. The study concludes that providing government support to enterprises in terms of loans and grants and exploring marketing opportunities were the most important strategies to adopt for the survival of construction MSMES in Nigeria after petroleum subsidy removal. Based on the conclusions drawn in this study, the following recommendations were suggested MSMEs should focus on reducing operational costs through improvements in resource utilization, labor management, and procurement practices.

Keywords: Impact, Micro Small and Medium Enterprises (MSMES), Petroleum, Removal, Subsidy, Survival

1. Introduction

SMEs are crucial for the sustainable and equitable development and growth of any economy. About 90 percent of businesses that operate in the world today fall under the category of SMEs (Algan, 2019). But the failure of Nigerian' industrial development process over the last few years has made it largely impossible to obtain a strong and efficient SME's sub-sector. Thus, even though an overwhelming percentage of the country's business are SMEs, the sub-sector is known to make just small contribution to the country's overall GDP.

According to Olawunmi *et al.* (2021), inadequate fund/working capital is one of the most mentioned problems for SMEs, access to credit is a major problem militating against the effective performance of SMEs in Nigeria despite all the funding programmes that have been put in place all over the years. Unfriendly macroeconomic policy (monetary, fiscal and external sector policies) is major problem limiting the performance of the SMEs in Nigeria. Ogunnusi, (2023) asserted that according to specialists, the sudden removal of petroleum subsidy results in a rise in the prices of construction materials and transportation. The removal of petroleum subsidy in Nigeria poses a critical challenge for the micro, small and medium construction enterprises that are the lifeblood of the construction industry in that region (Elohor *et al.* 2022). The policy change has raised several pressing issues that warrant in-depth investigation and analysis: with the removal of fuel subsidies, construction enterprises are confronted with the immediate consequence of increased fuel prices. As these enterprises heavily rely on fuel for their machinery and transportation, this price hike translates directly into higher operational cost.

Unfortunately, these problems have also led to low productivity as well as distortion of the macroeconomic structure, and are therefore a major hindrance to the development of SMEs in the country. The primary concern is how these rising costs impact the financial viability of construction projects (Echem *et al.,* 2022). The implications of such failures are quite so dire for the growth of the private sector, industrialization of the country and sustainability of economic growth.

Okafor (2020) noted that MSMES often operate with tighter budgets and limited resources and thereby making the implication of subsidy removal particularly pronounced and this leading to a decreased profit margin. Most construction MSMEs pay little attention on the impact of petroleum subsidy removal on MSMEs survival parameter (Profitability, rate -of- return, management return and turnover), in Nigeria. Thus, this study seeks to assess the impact of petroleum subsidy removal on the survival of MSMEs in Abuja, Nigeria.

2. Literature review

Understanding the overall challenges that constrain the development of MSMEs is a critical and pivotal point. Because some challenges or factors can stifle enterprise growth or harm the establishment of SMEs, these factors may have an immediate impact on the firm's operation or internal growth. However, in the long run, it impacts overall economic development (Abraham *et al*., 2017).

2.1 Lack of access to market and marketing skill

Every enterprise or organization that is involved in business requires marketing to continue or survive. Marketing knowledge helps SMEs gain a competitive edge in the market by increasing customer demand and understanding, as well as identifying and capturing the target market position (Jovanov and Stojanovski, 2012).

Marketing is critical for businesses to identify their customers' needs and desires. Customer satisfaction is more important for businesses to profit, grow, and survive. In this perspective, marketing supports enterprises by determining market size, targeting niche markets, identifying appropriate strategies, and selecting market segments. Although marketing is essential in the development of enterprises, various marketing-related problems and other factors are adversely affecting the growth of these enterprises. SMEs face a variety of challenges, including access to finance or capital, inefficient management, a lack of skilled labor, a lack of infrastructure, and a lack of marketing skills, particularly in marketing research and development.

According to Ebitu *et al*. (2016), most small enterprises are unaware of the value of marketing research and development. Moreover, this hindered the development of these enterprises compared to large enterprises because marketing-related problems are problems related to marketing barriers that limit the growth and development of small enterprises and other firms. Moreover, marketing issues are the primary impediments to enterprises making a profit, obtaining consumer satisfaction, generating income, and creating value for enterprises. Besides that, problems related to marketing skills, such as the inability to analyze market opportunities, a lack of promotion and advertising for their product, inefficiency in operation and production, a lack of product standardization, low-level quality products, and a lack of an effective pricing strategy, are some factors that affect the performance and profitability of these sectors (Ebitu *et al*., 2015).

In the lack of marketing skills, it isn't easy to get potential customers for product and services. According to Van Scheers (2011), no one will do business with you if the potential consumer in the market does not have adequate information or awareness about the product and service you provide.

2.2 Lack of managerial skills

SMEs are critical development tools that require various improvements in terms of business competitiveness. In this regard, managerial skills are the most critical factor in improving the internal problems and competitiveness of SMEs. Management skills are required to develop adequate and appropriate strategic planning, which aids in developing MSMEs. Moreover, these management skills assist managers in determining and implementing enterprise goals. Enterprises will achieve market competitiveness through management skills (Leyva Carreras *et al*., 2018).

The success of SMEs is determined by an entrepreneur's or manager's managerial abilities. This means that managers can make businesses succeed or fail (Popescu *et al*., 2020). According to the findings of Leyva Carreras *et al*. (2018), strategic planning and managerial skills are internal factors that influence SMEs' competitiveness. According to Muhammad *et al*. (2015), internal and external factors are vital to the success and performance of SME entrepreneurs

in their businesses. Internal factor skills related to SME management, such as conceptual, technical, and interpersonal skills, are crucial for developing MSMEs.

Managerial skills are required to efficiently and effectively manage, control, and operate the activities of MSMEs. Moreover, for small enterprises, skilled human labor and material resources are essential tools for running their operations efficiently and effectively. Even though managerial skills and knowledge are the most important factors for businesses, the majority of MSMEs in developing countries lack managerial skills such as planning, organizing, directing, and controlling. Furthermore, small businesses in these countries have been constrained by a lack of basic skills and techniques to operate and sustain their operations (Abehi, 2017).

2.3 Lack of finance

Access to finance is one of the most important factors that allow MSMEs to keep growing. Finance can assist the development of enterprises from start-up to operation throughout their life cycle. Finance can include the cost of organizing and arranging products, machines, equipment, and sales premises in a startup (MOUDH, 2016). Finance supports the development of SMEs in a variety of ways. The first is that it increases their investment, which supports the growth of production in businesses, export, product, and service diversification (World Bank, 2018). Access to credit, particularly adequate and timely credit supply, promotes enterprise development and helps to solve problems (Getahun, 2016).

However, many African MSMEs, which include Ethiopia, are experiencing difficulties obtaining financial support. Although some African countries have established institutions to facilitate loans to small enterprises, most Sub-Saharan African countries remain financially constrained (Appui au Développement Autonome, 2016). One of the most significant barriers to the growth and development of SMEs in developing and emerging countries is a lack of access to finance. In comparison to large enterprises, the ability of SMEs to obtain bank loans is limited. Because of this problem, most SMEs rely on internal resources, such as cash from their own savings families, and friends, especially during the start-up period (World Bank, 2018).

Even though finances are required for businesses to start, develop, or expand more successfully way, the majority of MSMEs in Ethiopia are financially constrained. These challenges affect the enterprises both during the start-up phase and in ongoing activities; for instance, a lack of capital hindered the establishment of the enterprises, while other access affects ongoing business activities (Wami, 2020). Lack of finance is one of the major challenges that impede the development, growth, and productivity of MSMEs (Owensn and Wilhelm, 2017).

3. Methodology

The general strategy for addressing conceptual research challenges via data collection, interpretation, and analysis is known as research design (Van-Wyk, 2015). By giving respondents structured questionnaires, this study used the survey design approach, which made use of the quantitative method's characteristics. The nature of inquiry led to the selection of the survey design approach. The targeted population for this research consisted a total of 389 CEOs and top managers of construction MSMEs that are registered and functioning within Abuja, Nigeria. This figure was obtained from the finelib.com directory. The choice of Abuja as of study region in this context is based on its status as one of Nigeria's major metropolitan areas with a significant concentration of construction MSMEs and construction activities. In order to calculate the sample size for this study, the population value of 389 construction MSMEs in Abuja was subjected to the Krejcie and Morgan Table. The sample size was determined based on a 5% margin of error and a 95% confidence level. The initial figure of 389 was decreased to 120, which represents the minimum sample size required for the questionnaire to be conducted. Hence, the sample size for the research is 120. The Mean Item Score (MIS) was used to rank the survival of construction MSMES in Nigeria

4. Findings and Discussion

A total of One hundred and twenty (120) questionnaires were administered to the research population, and one hundred and five (105) were retrieved, representing a response rate of 87.5%.

4.1 Demographic Information of Respondents

Table 1 shows the demographic characteristics of the respondents. As regards educational qualification, 9.5% had a Higher National Diploma (HND), 56.2% had a bachelor's degree, 11.4% had a postgraduate diploma, 21.8% had a master's degree, and the remaining 1.1% were PhD holders. The study revealed that the respondents were adequately educated to provide meaningful information for this research.

In terms of the professional background of the respondents, 43.8% were quantity surveyors, which was the majority. This was followed by builders with 18.1%, architects with 17.1%, and civil and structural engineers with 13.4%, while other professionals accounted for 7.6%. The major professions in the Nigerian construction industry are well

represented. Regarding positions within the organisation, 42.8% were CEOs, 34.2% were MDs, while others managers accounted 22.8%. In the case of years of experience, 8.6% of the respondents had 15-20 years of working experience, 36.2% had 10-15 years of working experience, 17.1% had 1–5 years of working experience, and 38.1% had 5–10 years of working experience. This implies that the respondents are well-experienced and can provide valuable information for this research. Regarding the number of employees in the respondents' organisation, 36.2% had 10–35 employees, 24.8% had 36–75 employees, 20.0% had 50–10 employees, and the remaining 19.0% had fewer than 9 employees.

Table 1: Demographics Characteristics of Respondents

Variables		Frequency	Percentage (%)
Educational qualifications of respondent	HND	10	9.5%
	BSc/ B. Tech	59	56.2%
	PGD	12	11.4%
	MSc/MTech	23	21.8%
	PhD	1	1.1%
	Total	105	100.0%
Profession of respondents	Architect	18	17.1%
	Quantity surveyors	46	43.8%
	Builders	19	18.1%
	Civil/Structural Engineer	14	13.4%
	Others	8	7.6%
	Total	105	100.0%
Position of respondent	CEOs	45	42.8%
	MDs	36	34.2 %
	Others Managers	24	22.8%
	Total	105	100.0%
Respondents' Years of Experience	1-5Years	18	17.1%
	5-10 Years	40	38.1%
	10-15 Years	38	36.2%
	15-20 Years	9	8.6%
	Total	105	100.0%
Number of employees in your organization	Fewer than 9	20	19.0%
	10-35	38	36.2%
	36-75	26	24.8%
	50-100	21	20.0%
	Total	105	100.0

Source: Author's field work, (2024)

4.2 Factors that Affect Survival of Construction MSMEs in Nigeria

The findings revealed the factors that affect the survival of construction Micro, Small and Medium Enterprises (MSMEs) in Nigeria, as shown in Table 2. Six (6) factors were very important, ranging from lack of finance (RII = 0.96), fuel subsidy removal (RII = 0.95), lack of adequate infrastructure (RII = 0.93), lack of access to technology (RII = 0.90) and lack of managerial skills (RII = 0.90) respectively. Furthermore, twenty-seven (27) factors were found to be important, ranging from a lack of supportive government policy and regulation (RII = 0.89) to a lack of adequate training (RII = 0.70). The remaining eleven (11) factors were deemed 'fairly important' by the respondents, and these factors range from lack of government support (RII = 0.68) to supply chain resilience (RII = 0.60). The least important factors that affect the survival of construction MSMEs in Nigeria were supply chain resilience (RII = 0.60), ranking 44th. On average, all 44 factors that affect the survival of construction MSMEs in Nigeria were important (RII = 0.76).

This study aligns with the World Bank's 2018 report, which asserts that access to finance is a crucial factor that enables MSMEs to sustain their growth. Finance can assist the development of enterprises from start-up to operation throughout their life cycle. In a startup, finance can include the cost of organizing and arranging products, machines, equipment, and sales premises (MOUDH, 2016). Finance supports the development of SMEs in a variety of ways. The first is that they increase their investment, which supports the growth of production in businesses, exports, products, and service diversification (World Bank, 2018). Access to credit, especially an adequate and timely supply, fosters enterprise development and aids in problem-solving. Access to finance is one of the most important factors that allows MSMEs to keep growing. Finance can assist the development of enterprises from start-up to operation throughout their life cycle. In a startup, finance can include the cost of organizing and arranging products, machines, equipment, and sales premises (MOUDH, 2016). Finance supports the development of SMEs in a variety of ways. The first is that they increase their investment, which supports the growth of production in businesses, exports, products, and service diversification (World Bank, 2018). Access to credit, particularly adequate and timely credit supply, promotes enterprise development and helps to solve problems.

Table 2: Factors that affect survival of construction MSMEs

SN	Factors that affect Survival of Construction (MSMEs)	RII	Rank
B3	Lack of finance	0.96	1st
B7	Fuel subsidy removal	0.95	2nd
B4	Lack of adequate infrastructure	0.93	3rd
B5	Lack of access to technology	0.90	5th
B2	Lack of managerial skills	0.90	5th
B6	Lack of supportive government policy and regulation	0.89	7th
B1	Lack of access to market and marketing skill	0.87	8th
B8	Low margins of production and productivity	0.84	9th
B9	Labour shortage	0.84	9th
B16	Lack of capacity to employ competent workers,	0.84	9th
B17	Poor pricing, tendering and contract documentation skills	0.81	12th
B18	Lack of policy for implementation of new technologies and training	0.80	13th
B12	Bankruptcy of construction companies	0.80	13th
B15	Lack of technical, managerial and entrepreneurial skills	0.79	15th
B10	Employee's lack of compliance to health and safety standard	0.78	16th
B11	Interruption of planning and scheduling	0.78	16th
B13	Staff retrenchment	0.78	16th
B14	Lack of jobs/contracts for MSMEs	0.77	19th
B22	Change in market location	0.77	19th
B41	Competition with large corporations	0.77	19th
B33	Erratic power supply	0.76	22nd
B45	Failure to reach intended target in terms of project delivery	0.75	23rd
B20	High cost of doing business in the construction environment.	0.75	23rd
B34	High Price of Raw Materials	0.75	23rd
B35	High Transportation Costs	0.75	23rd
B23	Inadequate experience of the owner	0.75	23rd
B29	Increased operating costs	0.75	23rd
B21	Ineffective marketing strategies	0.74	29th
B30	Inflation	0.73	30th
B43	Instability in prices of construction materials	0.72	31th
B38	Lack of Adaptation and innovation	0.70	32th
B25	Lack of adequate training,	0.70	32th
B39	Lack of Government support	0.68	34th
B46	Lack of investment incentives	0.68	34th
B26	lack of skill to handle complex construction work	0.68	34th
B36	Low Market Demand	0.68	34th
B28	Poor Information and communication channels	0.66	38th
B27	Poor management practice	0.65	39th
B24	Poor mentoring and fronting for established contractors,	0.65	39th
B42	Production and productivity challenges	0.63	41th
B31	Profit Margins	0.61	42th

SN	Factors that affect Survival of Construction (MSMEs)	RII	Rank
B19	Under-capitalisation, lack of access to capital, low financial and capital base	0.61	42th
B40	Supply chain resilience	0.60	44th
	Average RII	**0.76**	

Source: Author's field survey (2024).

5. Conclusion and Recommendation

The study concludes that lack of finance, fuel subsidy removal, lack of adequate infrastructure, lack of access to technology, and lack of managerial skills are the important factors that affect the survival of construction MSMEs in Nigeria after the removal of fuel. The key rate of return survival parameter for construction MSMEs are: return on investment (ROI), return on assets (ROA), and return on equity (ROE), respectively. The key rate of management return survival parameter for construction MSMEs are employee turnover and internal rate of return (IRR), respectively. Based on the conclusions made in this study, the following recommendation were suggested:

i. MSMEs should focus on reducing operational costs through efficiency improvements in resource utilization, labor management, and procurement practices. This might involve renegotiating contracts with suppliers, optimizing transportation logistics, and adopting lean construction principles.

ii. Given the potential increase in fuel prices, MSMEs should explore alternative energy sources such as solar, wind, or biomass for powering construction equipment and site operations. Government incentives and grants may be available for adopting renewable energy technologies.

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Assessing the Environmental Effect of Informal Sand Mining on Artisanal Miners' Livelihood in Amac (Abuja Municipal Area Council), F.C.T, Abuja, Nigeria.

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Abstract

Sand mining is a global practice driven by the increasing need for building materials to support rapid urbanization and infrastructure development. This demand has led to both formal and informal mining operations worldwide. Informal sand mining, often referred to as artisanal or small-scale mining, is prevalent in many developing countries, providing employment and income opportunities for local communities. This study aimed at assessing the environmental effects of mining activities on the livelihoods of artisanal miners in AMAC, Abuja through identifying the types of informal sand mining activities in AMAC, Abuja and assessing the environmental impact of informal sand mining on the artisanal miners' livelihood activities. A quantitative approach was employed with stratified random sampling, using structured questionnaires. The sample size was determined using the Krejcie & Morgan (1970) formula, yielding a sample size of 384 to ensure a representative sample of artisanal sand miners. Data analysis involved were descriptive statistics and Chi-Square analysis representative sample of artisanal sand miners selected. None of the distributed questionnaires were returned, resulting in a 0% return rate. The questionnaire covered components such as demographic information, types of mining activities, locations of sand mining sites, methods and techniques used environmental impacts, perception of environmental impact on livelihood, environmental impacts reported by miners on livelihood and awareness of impact. Data analysis involved were descriptive statistics and correlation analysis using SPSS software which reveals significant environmental impacts such as land degradation, water pollution, and habitat destruction. The most common mining activities were surface mining, with manual extraction being the predominant technique. Miners reported high severity of environmental impacts on their livelihoods, with awareness levels closely linked to educational attainment. The recommendations are the need for enhanced awareness, education, and stricter enforcement of environmental regulations to promote sustainable mining practices collaborative approach involving all stakeholders to develop sustainable mining practices and implementing an integrated environmental assessment, management, and monitoring program for sand extraction operations. An integrated approach involving all stakeholders is essential to balance the economic benefits of sand mining with environmental sustainability, thereby promoting sustainability in AMAC.

Keywords: Artisanal, Effect, Environmental, Impact, Informal, Miners, Mining, Sand

1. Introduction

Sand mining is a global practice driven by the increasing need for building materials to support rapid urbanization and infrastructure development. This demand has led to both formal and informal mining operations worldwide (Peduzzi, 2014; Torres *et al*., 2017). Informal sand mining, often referred to as artisanal or small-scale mining, is prevalent in many developing countries, providing employment and income opportunities for local communities (Koehnken and Rintoul, 2018).

In Nigeria, the construction sector's growth, fueled by urbanization, population increase, and infrastructure development, has led to a significant rise in demand for sand, a crucial component in concrete and other construction materials. This surge has resulted in the proliferation of informal sand mining activities across the country, including the Federal Capital Territory (FCT), Abuja (Nwakwoala and Ike, 2020).

Informal sand mining is a widespread practice across many developing countries, driven by the increasing demand for construction materials and the lack of alternative livelihood opportunities (UNEP, 2019). Informal sand mining in Abuja Municipal Area Council (AMAC) is driven by rapid urbanization and construction boom, leading to the extraction of sand from rivers, beaches, or other natural sources without proper regulation or oversight (Koehnken and Rintoul, 2018). These activities can have significant adverse environmental effects, including land degradation, water pollution, and habitat destruction (UNEP, 2019).

Understanding the environmental impacts of informal sand mining on the livelihood of artisanal miners in AMAC is crucial. These insights can inform policies and interventions aimed at improving their livelihoods while promoting sustainable mining practices (Koehnken and Rintoul, 2018). Evaluating the environmental impacts of informal sand mining can help identify areas where mitigation measures are needed to prevent further degradation and protect the natural resources upon which the livelihoods of artisanal miners depend (UNEP, 2019).

Evaluating the environmental impacts of informal sand mining can help identify areas where mitigation measures are needed to prevent further degradation and protect the natural resources upon which the livelihoods of artisanal miners depend (UNEP, 2019).

Informal sand mining activities often involve the use of heavy machinery and equipment, which can contribute to air and noise pollution, further exacerbating the environmental impact (UNEP, 2019). The unregulated nature of these activities also raises concerns about the potential for occupational hazards and the exploitation of artisanal miners (Koehnken and Rintoul, 2018).

2. Literature Review

Informal sand mining refers to the extraction of sand outside the legal and regulatory framework. It is often small-scale, using simple tools and techniques, and typically lacks environmental protection measures (Hilson and Maconachie 2020). This practice is common in developing countries where the demand for sand is high due to rapid urbanization, yet governance is weak, and economic opportunities are limited (Mngeni 2014). Poverty, unemployment, and a lack of alternative economic options drive people into informal mining, even though the environmental and health risks are considerable (Hilson and Garforth 2012).

Though it provides crucial income for many, it leads to severe environmental degradation, including land erosion, habitat destruction, and water resource depletion. Sand extraction alters river morphology, increases turbidity, and lowers groundwater levels, while also contributing to biodiversity loss and pollution (Adedeji *et al*. 2018).

The environmental impacts of informal sand mining are extensive. Land degradation is a major consequence, as sand extraction drastically alters the local landscape and soil composition, leaving areas prone to erosion and vulnerable to natural disasters like landslides and flooding (Adedeji *et al*. 2018). The removal of vegetation further exacerbates soil erosion, disrupts habitats, reduces biodiversity, and accelerates shoreline erosion in coastal areas, endangering infrastructure and ecosystems (Musah and Barkarson 2019). Informal sand mining also negatively affects water resources, particularly in riverbeds and floodplains. Sand extraction alters river morphology, increases riverbank erosion, and changes sediment transport patterns (Padmalal and Maya 2014). The increased turbidity from mining activities harms aquatic ecosystems and degrades water quality for human consumption and agriculture (Ololade and Annegarn 2021). Additionally, over-extraction lowers groundwater levels, reducing water availability and, in coastal regions, risking saltwater intrusion into freshwater aquifers (Jonah *et al*. 2015).

Economically, informal sand mining accounts for a significant portion of household incomes in regions like Nigeria and Ghana (Akande and Idris 2021). However, miners face health risks, economic insecurity, and environmental degradation, which jeopardizes the long-term sustainability of mining as a livelihood (Hilson and Maconachie 2020).

Sustainability in informal sand mining involves balancing the immediate economic needs of communities with long-term environmental protection and resource conservation.

Environmental sustainability requires resource conservation to prevent over-exploitation and ecosystem protection to minimize the impact on aquatic habitats and riparian zones (Padmalal and Maya 2014). Post-mining land rehabilitation, such as re-vegetation and slope stabilization, can help restore ecosystems (Mngeni 2020). Economic sustainability involves stabilizing incomes, promoting value-added activities, and encouraging alternative livelihoods (Hilson and Maconachie 2020). Social sustainability focuses on community engagement, gender equity, and improving occupational health and safety (Lahiri-Dutt 2020).

The Sustainable Livelihoods Approach (SLA) and Political Ecology Theory are needed to understand informal sand mining's environmental and socioeconomic impacts. The SLA views livelihoods as a combination of capabilities, assets, and activities necessary for living. It emphasizes human, social, natural, physical, and financial capital as key components in shaping livelihood outcomes (Scoones 1998). This framework helps explain how artisanal miners utilize these different forms of capital, such as social networks and skills, to sustain their livelihoods through sand mining (Hilson and Maconachie 2011). However, critiques of SLA have called for a stronger focus on power dynamics and long-term environmental sustainability (Scoones 2009).

Political Ecology Theory examines how power, politics, and broader socio-political factors influence human-environment interactions, particularly in natural resource extraction (Robbins 2012). This approach is valuable in understanding how access to resources like sand is shaped by power relations, how environmental narratives are constructed, and how local and global forces interact to shape sand mining practices (Peluso and Ribot 2020). Combining the SLA and Political Ecology

Nigeria, and Ghana to illustrate the diverse challenges and impacts of informal sand mining. In Nigeria, informal sand mining in Lagos and Enugu States is driven by urbanization and construction demands, leading to severe environmental degradation, including coastal erosion and water pollution (Adedeji and Ademiluyi 2019). Similarly, in Ghana, sand mining along the Volta River has caused substantial riverbank erosion, threatening local communities and agricultural land (Mensah 2018).

Weak enforcement of mining regulations exacerbates the environmental and social impacts of informal sand mining. In Nigeria, the Nigerian Minerals and Mining Act of 2007 provides a legal framework for resource extraction, but enforcement is hindered by corruption, limited resources, and the dispersed nature of small-scale operations (Oladipo *et al*. 2020). International best practices from countries like Malaysia and India, where technology such as drones is used to monitor illegal mining, offer potential solutions to improve governance in Nigeria (Ying *et al*. 2021).

To promote sustainable practices, recommendations include formalizing mining operations, enhancing monitoring and enforcement, promoting alternative livelihoods, and involving communities in resource management. These steps can help balance economic development with environmental conservation (Hilson and Maconachie 2020; Akinyemi *et al*. 2021).

3. Methodology

This study employed a research design to comprehensively assess the environmental effects of informal sand mining on the livelihood of artisanal miners in Abuja Municipal Area Council (AMAC), Abuja. The approach involved in collecting and analysing the quantitative data, provides a holistic understanding of the research objectives.

3.1 Data Collection

Quantitative Data: A structured questionnaire was administered to a representative sample of artisanal sand miners. Stratified random sampling was employed to ensure diverse representation across different mining sites. The survey included closed-ended questions was employed to determine the types of informal sand mining activities in the study area and environmental effects on livelihood activities, the use of Likert scales was used to measure perceptions and awareness regarding the environmental effects of sand mining and its impact on their livelihood activities.

3.2 Data Analysis

Quantitative data were analysed using statistical software (e.g., SPSS), employing descriptive statistics and Chi-Square analysis to summarize the data and inferential statistics to examine relationships between variables.

3.3 Sample Size

To determine the sample size for this study, the following formula was used (Krejcie and Morgan, 1970):

$$S = X^2NP(1 - P) \div d^2(N - 1 + X^2P(1 - P) \quad (1)$$

Where:

- S represents the sample size,
- X^2 represents the critical value from the chi-square distribution for the desired confidence level,
- N represents the population size,
- P represents the estimated proportion of the population,
- d represents the desired margin of error.

The sample size for the study was calculated using the Krejcie and Morgan (1970) formula i.e Eq(1). With a population of 1,967,500 for AMAC, a 95% confidence level (X^2 = 1.96), a 5% margin of error (d = 0.05), and assuming a population proportion (P) of 50%, the required sample size was approximately 384 respondents.

3.4 Sample Frame

The sampling frame will comprise a number of categories, including people of AMAC, a list of locations known to be used for sand mining, and artisanal miners working within AMAC. In order to find and incorporate any previously undiscovered sand mining sites and artisanal miners in the sample frame, field observation exercises were also carried out. To attain representative and trustworthy results, it was essential to make sure the sample frame was large and current. A thorough evaluation of the research objectives required an understanding of the traits and viewpoints of the artisanal sand miners.

3.5 Study Area

The geographical location of AMAC, in Nigeria's Federal Capital Territory (FCT), covers 1,769 km^2 with a tropical climate. It was established in 1976, AMAC is one of the Local Government Area Council in Nigeria's capital in 1991, previously inhabited by indigenous ethnic groups. The major ethnic groups include Gbagyi, Koro, Ganagana, Gwandara, Afo, and Bassa. AMAC's population grew rapidly from 300,000 in 1991 to an estimated 1,967,500 people by 2023. AMAC's economy is diverse, with public and private sector jobs, agriculture, a significant informal economy, and a growing tourism and hospitality sector. Urbanization has also led to challenges like informal settlements and inadequate infrastructure.

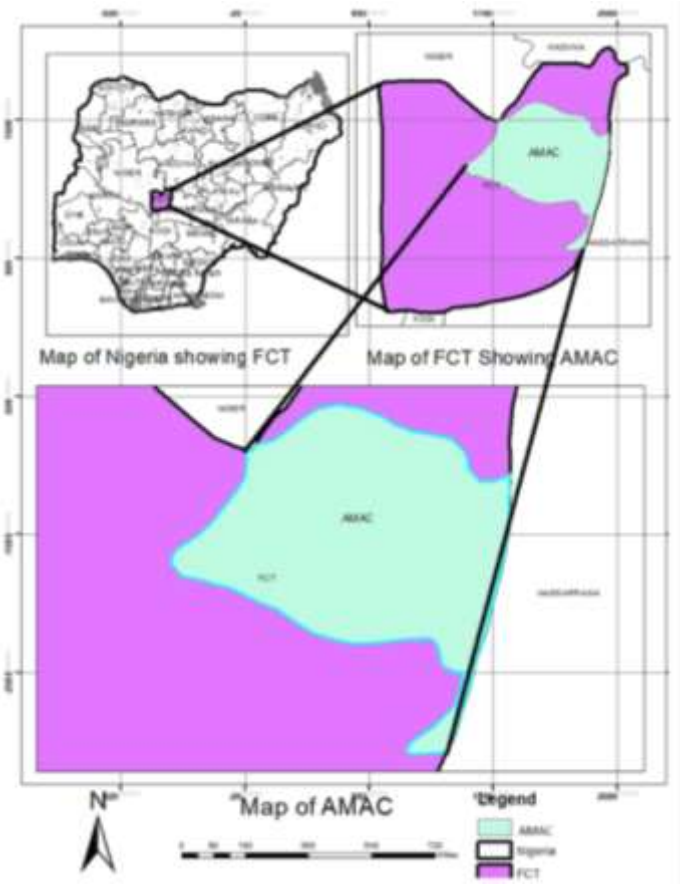

Figure 4: Location of study area

4. Results and Discussion

4.1 Informal Sand Mining Activities

Table 1: Type of Sand Mining Activities

S/N	Mining Activity	Number of Mining Activities
1	Riverbed Mining	3
2	Open-Pit Mining	3
3	Borrow Pit Mining	70
4	In-stream Mining	5
5	Surface Mining	68

The table 1 provides information about the number of Mining involved in various types of mining activities. 3 Riverbed Mining activities was conducted, similarly, 3 open-pit mining activities, for Borrow Pit Mining 70 activities involved, 5 In-stream Mining activity was conducted and 68 engaged in Surface Mining which is the most prevalent.

Table 2: Locations of Sand Mining Sites

S/N	Location	Number of Sites
1	Jabi	5
2	Gwarinpa	3
3	Wuse	3
4	Lugbe	1

5	Kubwa	1
6	Karu	4
7	Nyanya	3
8	Garki	3

The table 2 provides information about the number of sand mining sites located in various areas within the Abuja Municipal Area Council (AMAC). There are 5 sand mining sites in Jabi, making it the location with the most sand mining activities, Gwarinpa has 3 sand mining sites, Similarly, Wuse also has 3 sand mining sites, there are 1 sand mining site in Lugbe and Kubwa, there are 4 sand mining sites in Karu and 3 sand mining sites in both Nyanya and Garki. Jabi has the highest number of sand mining sites, followed by Karu. Gwarinpa, Wuse, Nyanya, and Garki each have a moderate number of sites. Lugbe and Kubwa have the fewest sand mining sites, with only one each.

Table 3: Methods and Techniques Used

S/N	Technique	Number of Miners	Percentage
1	Manual Extraction	150	39%
2	Mechanical Dredging	100	26%
3	Hydraulic Mining	70	18%
4	Excavator Use	64	17%
	Total	384	100%

The table 3 provides the techniques used range from Manual Extraction (39%) to more mechanized methods like Mechanical Dredging (26%), Hydraulic Mining (18%), and Excavator Use (17%). The high percentage of manual extraction highlights the labour-intensive nature of this activity and the limited access to advanced machinery.

4.2 Environmental Effects on Livelihood Activities

Table 4: Environmental Impacts Reported by Miners on Livelihood

S/N	Environmental Impact	Frequency	Percentage
1	Land Degradation	113	29.43%
2	Water Pollution	90	23.44%
3	Habitat Destruction	77	20.05%
4	Alteration of Water Courses	51	13.28%
5	Loss of Arable Land	33	8.59%
6	Health Issues (Respiratory)	20	5.21%
	Total	384	100%

The table 4 provides information on the environmental impacts reported by miners and their frequencies, along with the corresponding percentages. Land degradation is reported by 113 miners, accounting for 29.43% of the total impacts, making it the most frequently reported environmental impact. Water pollution is reported by 90 miners, making up 23.44% of the total impacts, and is the second most common impact. Habitat destruction is reported by 77 miners, constituting 20.05% of the total impacts. Alteration of water courses is reported by 51 miners, representing 13.28% of the total impacts. Loss of arable land is reported by 33 miners, which is 8.59% of the total impacts. Health issues, specifically respiratory problems, are reported by 20 miners, accounting for 5.21% of the total impacts, making it the least frequently reported impact.

Table 5: Perception of Environmental Impact on Livelihood

S/N	Impact Severity	Frequency	Percentage
1	Very High	96	25%
2	High	146	38%
3	Moderate	85	22%
4	Low	38	10%
5	Very Low	19	5%
	Total	384	100%

The table 5 provides information on the perception of miners regarding the severity of environmental impacts on their livelihood. A total of 96 miners perceives the environmental impact on their livelihood as very high, which accounts for 25% of the total perceptions. The most frequently reported perception is that the impact is high, as expressed by 146 miners, making up 38% of the total perceptions. Moderate impact is perceived by 85 miners, constituting 22% of the total perceptions. Low impact is perceived by 38 miners, representing 10% of the total perceptions. The least frequently reported perception is very low impact, noted by 19 miners, which accounts for 5% of the total perceptions.

Table 6: Awareness of Environmental Imapct

S/N	Education Level	Very Aware	Aware	Somewhat Aware	Not Aware
1	No Formal Education	0.72	1.34	0.05	11.56
2	Primary Education	0.11	0.17	0.00	0.03
3	Secondary Education	0.86	0.02	0.10	2.08
4	Tertiary Education	0.00	0.26	0.06	1.72

The Chi-Square distribution table 6 provides, the critical value and a significance level of 16.92 and 0.05 respectively. Since the value (19.08) is higher than the crucial value (16.92), the null hypothesis is rejected. The awareness of environmental impacts is lowest among miners with no formal or primary education, balanced with secondary education, and highest among those with tertiary education. These findings highlight the crucial role of education in raising environmental awareness among artisanal sand miners, showing significant variation across education levels.

5. Conclusion and Recommendations

This study assessed the environmental effects of informal sand mining on artisanal miners' livelihoods in Abuja Municipal Area Council (AMAC). Surface mining was found to be the most common activity, with sites concentrated in rapidly developing areas. Significant environmental impacts were identified, particularly land degradation, water pollution, and habitat destruction. Miners' perceptions of these impacts varied, with most reporting high severity. Education levels correlated with environmental awareness among miners.

The recommendations includes:

1. Increased awareness, education, and enforcement of environmental regulations are necessary to encourage sustainable mining practices.
2. A collaborative approach involving all stakeholders should be adopted to develop sustainable mining practices.
3. Implementing an integrated environmental assessment, management, and monitoring program for sand extraction operations is crucial.

These recommendations can work towards balancing the economic benefits of sand mining with environmental preservation, promoting more sustainable development in the region.

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Impact of Urban Expansion on Agricultural Land in Minna, Niger State, Nigeria

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Abstract

Arable agricultural land has been threatened by many factors among which is rapid rate of urbanization. The study assessed the impact of urban expansion on agricultural land towards sustainable land use policy in Minna, Niger State, Nigeria. Remote sensing data provided useful estimations of agricultural land loss on a regional scale. Satellite data of period from 2000-2020 were collected to analyze the extent of land change dynamics in Minna and to determine the impact of changing pattern of urban expansion on agricultural land in Minna. Remote sensing image processing, supervised classification technique using a Support Vector Machine (SVM) classification algorithm was employed based on five land use (Agricultural land, built-up area, bare surface, Natural vegetation, water bodies) classes. The analysis results reveal a decline in agricultural land and increase in the built-up area indicating an encroachment on agricultural land. The result shows a significant modification in land use landcover observed as agricultural lands underwent noticeable decline by 20.816km2 whereas built up area increased substantially by a value of 37.23km2. The land use landcover projection result revealed that 76% of urban expansion will result in 24% of agricultural land loss by year 2030 in Minna. In conclusion, the urban expansion has significant impact on agricultural land loss in the study area. Overcoming urban encroachment into agricultural lands requires adequate policy formulations amenable to sustainable urban planning and development. The results highlight the need for policy makers and synergies between urban and land management authorities, as well as the Ministry of Agriculture to implement policies to protect agricultural land.

Keywords: Agricultural land loss, Land use landcover, Urban expansion, Urbanization, Spatio-Temporal analysis.

1. Introduction

The consequence of urban expansion on agricultural land is that it brings about loss of agricultural land. The expansion of cities has resulted in the loss of agricultural land, reduction in agricultural land size (Maxwell, 2021). Urbanization leads to the extension of urban socio-spatial morphologies and infrastructure, which encroach on agricultural activities. This has impacted the size and quality of farm lands available in the agricultural sector. Rapid expansion of urban settlements driven by an increase in human population, socioeconomic activities and economic prosperity turns pressure on the surrounding environment (Al-Kofahi *et al*., 2018). The rate of land loss to urbanization in recent times has been a source of concern globally, thus the need for effective monitoring and regulation (Al-Kofahi *et al.*, 2022).

Sequel to the creation of Niger state in 1976 and the increase in its administrative functions, the state has experienced population rise from approximately 3 million in 2006 to a projected 12 million by the end of year 2023 (NBS, 2019). The rapid increase in the population of Niger State is attributed to the inflow of people in search of Job in the state due to the establishment of Gidan Kwano Campus and NECO headquarter office and other institutions. Rapid urbanization and socioeconomic transformation triggers change in land use in the short run, and in the long term it results in the degradation of landscape ecology and the human environment (Brinkhoff, 2021). The consequences of expansion of built-up land in both urban and rural regions is loss of agricultural land (Zhou *et al.*, 2022). The alteration of built-up land in urban and rural areas is a significant determinant of the extent of loss of agricultural land (Zhou *et al.*, 2023).

Given the aforementioned considerations, it is evident that there exists a necessity for obtaining more precise and dependable data pertaining to the preservation of cultivated land and urbanization, particularly within the Minna metropolis. The study assessed the impact of urban expansion on agricultural land towards sustainable land use policy in Minna. This study provides inform data that will assist decision making in agricultural land preservation in the state and Nigeria as whole.

2. Literature Review

2.1 Effect of Urbanization on Agriculture

Agriculture is the backbone of the economy, which provides livelihood to 65 to 70 percent of the total population and employ about 52 percent population of the country (Pramanik and Sarkar, 2021. The urban population of the world will grow by more than billion between 2010 and 2025, whereas the rural population will hardly grow at all (Satterthwaite *et al.,* 2019). Rapid urban population growth because of continue migration results in increase in the demand of land, particularly for housing, water and energy (Pramanik and Sarkar, 2021; Iheke and Ihuoma, 2018). Iheke and Nto (2015) reported that urbanization is an important driving force in migration and community. Urbanization has led to conversion of agriculture land into non-agriculture purposes such as factories, buildings, residential or other commercial use (Liu and Liu, 2021). Ho and Lin (2021) found that the urban population growth was the cause of farmland conversion into coastal cities in Vietnam**.** Han and He (2021) found a significant positive relationship between urban population growth and farmland conversion in to cities. They also found that real estate speculation also results in agriculture land conversion. Land conversion has negative impact on the agriculture land. Assessing the impact of urban expansion on agricultural land in Minna will assist in the dearth data of extent of encroachment on agricultural land and its potential future impacts on agricultural land loss in Niger State. Furthermore, the findings will serve as valuable resources for informing urban-rural development planning, rural revival efforts, and the effective implementation of arable land protection measures.

3. Methodology

3.1 The Study Area

Minna, Niger State administrative capita is located in North Central Nigeria. Minna is located on longitude 9°22'31" to longitude 9°47'59"N and Latitude 6°10'06" to 6°39'15"E (See Figure 1) with a total land area of 6,789 square kilometres (Daniyan & Mohammed, 2018). The land cover of Minna is predominantly built-up area, vegetation, agriculture, outcrops barren land and water body. Minna enjoys a climate typical of the middle belt zone, Guinea savannah with distinct wet and dry seasons. The rainy season starts around April and last till October; it has a mean annual rainfall of about 1334mm (52inches) with September recording the highest rains of about 300mm. The mean monthly temperature is highest in March at 35°C and lowest in August at 22.3°C. The mean monthly relative humidity is highest in August at 60% and lowest in January at 19% respectively (Ojeh *et al*., 2021). This shows that Minna has prefect weather or climate that favours the growth and development of agricultural crops.

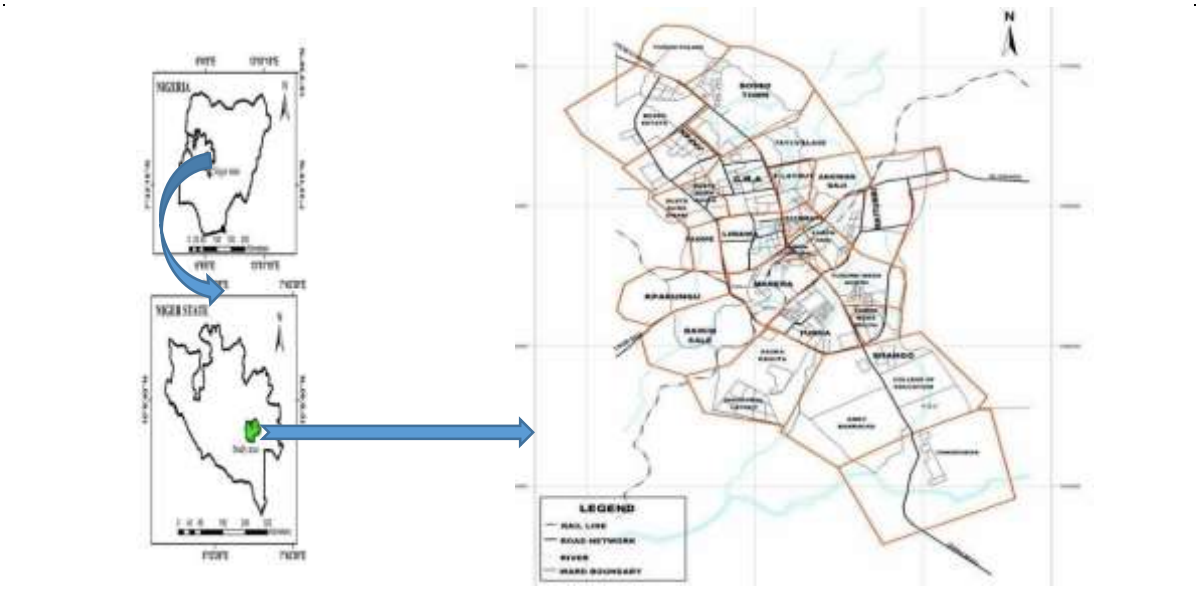

Figure 1. Minna: the study area.

3.2 Methods

Landsat images data with spatial resolution of 30m covering the study area were obtained and downloaded from the Landsat archive of the United State Geological Survey (USGS) earth explorer portal (http://earthexplorer.usgs.gov/) for period of 2000 and 2010 for 2 spatio-temporal periods(200-2010 and 20102020) of 20years(See Table 1).

Table 3.1: Data type specification.

Data	Dates of acquisition	Resolutions	Azimuth
Landsat TM data	2000-01- 29T16:24:59Z	30m	135.92
Landsat-7 ETM+ data 2000	2010-01-04T14:34:24Z	30m	143.34
Landsat8 OLI/TIRS	2020-03-25T14:39:34Z	30m	115.25

3.3 Image processing and Analysis

3.3.1 Image classification

The georeferenced image data obtained were processed first by extracting study area using extract by mask tool in the ArcGIS software mask tool in spatial analyst. Training sampling of the cover features based on the spectral reflectance were digitized and signature file created to enable image classification. This is the process of grouping into segments adjacent pixels that have similar spectral characteristics. Based on the training set of pixels supervised classification using a Support Vector Machine (SVM) classification algorithm on land use classes (Agricultural land, built-up area, bare surface, Natural vegetation, water bodies) derive LULC map.

3.3.2 Spatiotemporal changing pattern of urban expansion in relation to agricultural land use.

The change detection method used in this study is the 'Area Analysis method'. This involves the analysis which highlights the trend of the urban development on agricultural land over the period under assessment. The processes involved are as follows; the geoprocessing was selected and the earlier periods of the year and the observed change of each period of the year i.e. 2000 and 2010, and 2010 and 2020 geometry were calculated and intersected so as to estimate the change. Furthermore, the change detection was done on the attribute by adding new field and renamed change and the type is "Text" and ok was clicked, however the field calculator was activated and a visual basic expression ("Class_2000" & "to "& "Class_2010") was inputted and ok was clicked. After the process was done the output was inferred according to the change that occurred. After the processes, the agricultural land and built-up area from the change detection was executed in the overlay method.

3.3.3 Projection of the land use land cover in 2030 to predict the percentage of Agricultural land loss

The integrated Cellular Automata - Markov Chain (CA-Markov) model was employed to simulate future urbanization by 2030 to predict the percentage of agricultural land loss. CA-Markov allows us to make predictions about the long-term behaviour of the scenario of land use landcover change, and to identify patterns and trends in its behaviour (Tariq *et al*., 2020). The model relies on the interaction between the grid size, cellular space, cell neighbourhood, and transition rules. The equation of a CA-Markov model can be written as:

$$P(t + 1) = T^* P(t) \quad (1)$$

where
P(t) and P(t + 1) represent the state vectors at time t and t + 1, respectively
T = the transition matrix. The transition matrix T specifies the probability of transitioning from each current state to each possible future state.

4. Results and Discussion

4.1 Spatio-temporal Magnitude of Land use landcover Dynamics in Minna (2000 – 2020)

The magnitude of land use landcover lost or gain and the rate of change per decade was examined to determine the extent of agricultural land loss in Minna within the spatio-temporal period studied (2000-2010 and 2010-2020) in the last 20years across the four categories of the land use land cover classes(Built-up area, bare surface, agricultural land and natural vegetation). Figure 2 present the distribution of landuse landcover in the year 2000, 2010, and 2020. The result shows that in year 2000, the agricultural land constitute significant portion of the area with spatial extent of 69.75km^2 (51%), followed by Bare surface which is next covered 30.68km^2 (23%), built-up area occupied 22.01km^2 (16%) and natural vegetation accounted for 13.06 km^2 (10%) of the total area. By the year 2010, The result confirms changes in the landuse landcover including agricultural land which constitute 36%(48.59Km^2) of the total cover, followed by built-up area 33% (44.22Km^2), bare surface 16% (22.19Km^2) and natural vegetation 15% (20.17Km^2). Findings as observed a declined in agricultural land whereas built-up area experienced gain with spatial extent. Furthermore, Land use land cover dynamic in the year 2020 revealed significant increase in the builtup area covering 59.24km^2 (44%), followed by agricultural land 46.03km^2 (34%), and bare surface 23.20km^2 (38.41%) which respectively experienced a decline. Natural vegetation expressed an exponential decrease to 12.384km2 (9%) due to rapid urbanization and human anthropogenic activities. Water bodies also represented slight decrease in surface area with 0.242km2; this could be as a result of change in climate pattern.

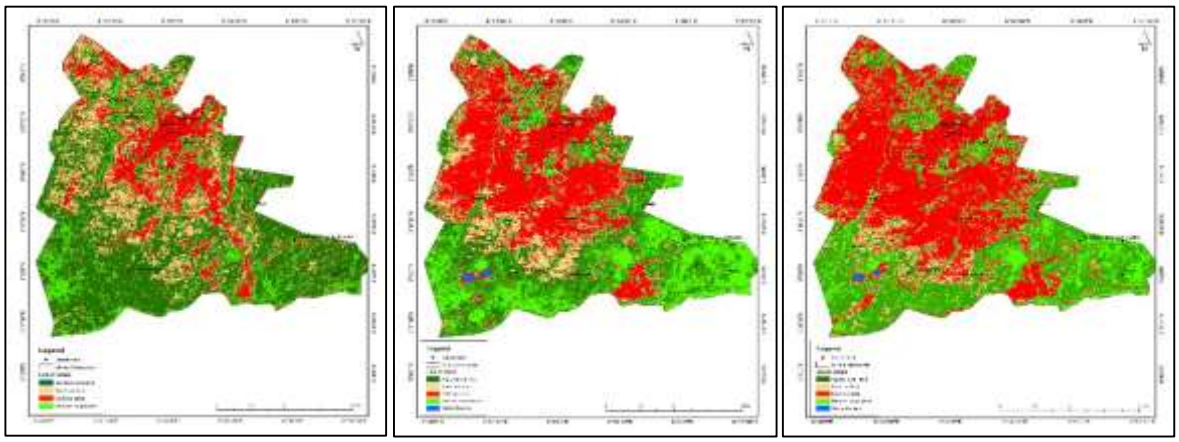

Figure 2: Land use land cover distribution in Minna metropolis in 2000, 2010 and 2020

Table 2 present the spatio-temporal magnitude of change in land use landcover in Minna. Result reveals that within the first decade (2000 – 2010), agricultural land lost 21.16km² and bare surface lost 8.496 km² at the rate of 1.5 and 0.7 respectively. Meanwhile, built-up area gained an extent of 22.213 km² and natural vegetation gained 7.11 km² at the rate of 1.7and 0.5 growth respectively. In the following decade (2010 – 2020) however, all other land use lost their coverages with only built-up area gaining an extent of about 15.02 km² at the growth rate of 1.1 which is about the total area lost by the other land use types. This suggests that the other land use types all transited to built-up area which is an indication of rapid urbanization.

Table 2: Transition probability matrix of the land use land cover (2000 – 2020)

Land use Class	**Spatio-Temporal Landuse/Landcover Change Dynamic**							
	2000 – 2010				**2010 – 2020**			
	Area (km2)	**%**	**Annual rate**	**Inference**	**Area (km²)**	**%**	**Annual rate**	**Inference**
Agricultural land	-21.16	-15	-1.5	Decrease	-2.5	-2	-0.2	Decrease
Bare surface	-8.496	-7	0.7	Decrease	-4.58	-3	-0.3	Decrease
Built-up area	22.213	+17	1.7	Increase	15.02	11	1.1	Increase
Natural vegetation	7.11	+5	0.5	Increase	-7.79	-6	-0.6	Decrease
Water Bodies	Null	Null	Null	Null	-0.081	0	0	Decrease

4.2 Spatio-temporal Changing Pattern of Urban Expansion in relation to Agricultural Land Use

The agricultural land use conversion to built-up area in 2000 – 2010, 2010 – 2020 and overall 2000 – 2020 was mapped and the spatial change analysed as presented in Figure 3. The analysis result has shown substantial agricultural land covering 12.972km² equivalent to 10% were converted to built-up from 2000 to 2010. This agricultural land loss is as a result of 1.7% annual growth rate of urbanization between 2000 and 2010 resulting in 22.313sq km built-up increase (See Table 3). This trend suggests that bulk of cultivatable land in Minna metropolis was consumed by physical development from 2000 to 2010.

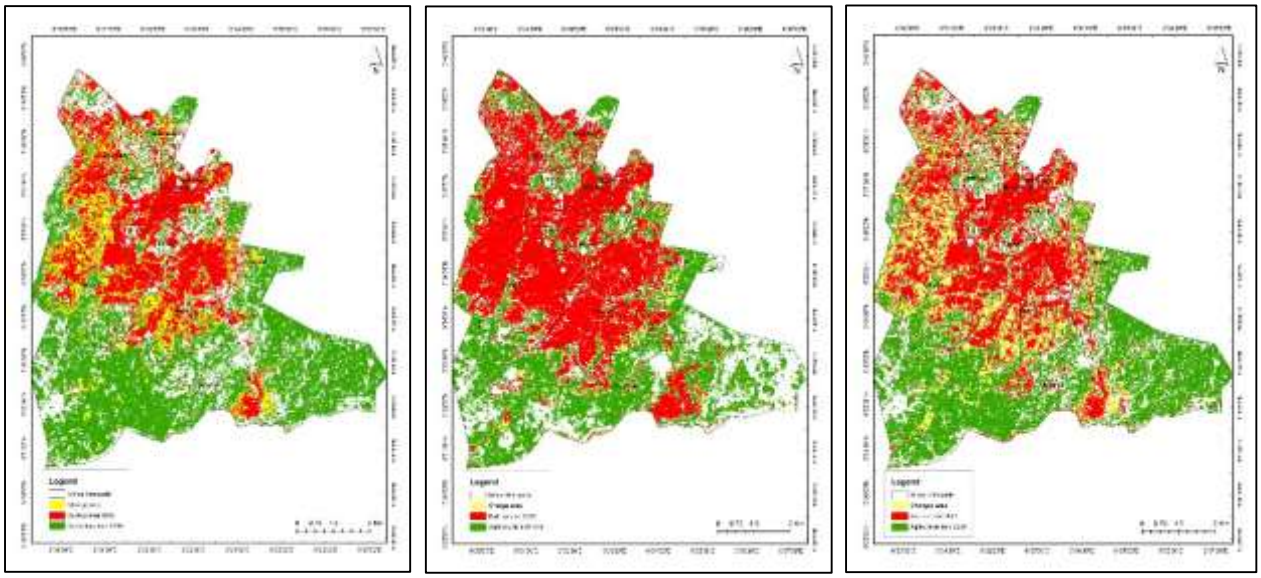

Figure 3: Change Transition in agricultural land loss to built-up area (2000 – 2010 and 2010-2020)

Table 3: Overall Transition of agricultural land to built-up area (2000 – 2020).

Period (Years)	No. Years	Agricultural land – Built-up area		Annual Rate	Built-up
		Area (km²)	%	%	Area km²
2000 – 2010	10	12.972	10	1.7	22.213
2010 – 2020	10	7.844	6	1.1	15.020
2000 - 2020	20	20.816	16	2.8	37.233

4.3 Projection of the land use land cover to predict Impact of Urbanization on Agricultural Land Loss

Table 4 present the result of the analysis of the projected impact of urbanization on agricultural land loss. The result of the projection of landuse landcover from 2020 to 2030 revealed that in the next 10 years, 76% increase in the built-up area will result to 24% of agricultural land loss in Minna (Figure 4). However, this finding provide future insights on urban development expansion pattern and agricultural land loss.

Table 4: Statistic analysis of the projected agricultural land and built-up area in 2030.

S/N	Class in 2030	Area (Km²)	%	Inference
1	Agricultural land	33.124	24	Loss
2	Built-up area	102.368	76	Increase
	Total	135.531	100	

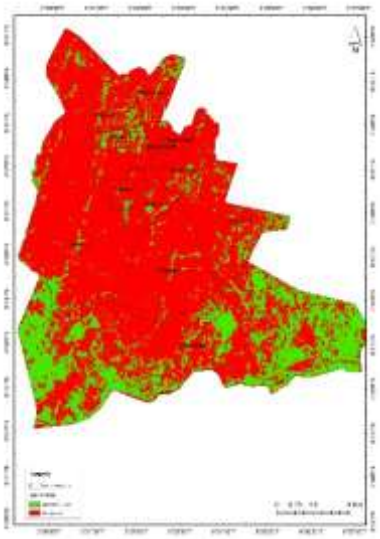

Figure 4: Projected agricultural land and built-up area in 2030

5. Conclusion

Minna is one of the emerging and rapid growing cities. Geospatial satellite imagery provided the essential measuring of spatial and temporal phenomena that are otherwise impossible to try using traditional mapping for the study. The change detected provides the bases for understanding patterns of spatial changes and the importance of addressing the issues arising from such changes. This makes it possible for policy makers to make effective policies.

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Influence of Sustainable Construction Practices on the Building Industry in Abuja, Nigeria

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Abstract

There is an increasing awareness among scientists and scholars regarding the unsustainable rate at which the earth's resources are being consumed, which erodes the earth's support system. This phenomenon is especially pertinent to the construction industry, known as one of the most resource-intensive and environmentally impactful sectors due to its scale, complexity, and resource demands. This study examines the influence of sustainable construction practices (SCPs) on the building industry in Abuja, Nigeria, aiming to optimize SCP implementation. Employing a mixed-method approach, the study gathered data through structured questionnaires completed by building professionals (82.5% response rate) and analyzed using SPSS V21, with findings showing a strong positive correlation (Pearson's r = 0.83; $p = 5.94 \times 10^{-6}$) between awareness of SCPs and their adoption. Key drivers for SCP adoption included addressing cultural resistance to new technologies (MIS = 4.34) and fostering partnerships with government agencies and private firms (MIS = 4.32). Lower adoption was noted in areas such as lifecycle cost analysis during project planning (MIS = 3.58), underscoring a need for policy development and training. Barriers to SCP adoption included insufficient government support (RII = 4.42) and resource constraints (RII = 4.32), while misconceptions about SC costs also hindered progress. The availability of green materials (RII = 4.75), regulatory support (RII = 4.54), and strategic government intervention (RII = 4.58) were highlighted as critical for advancing SCPs. Key productivity drivers included effective site organization (RII = 4.59) and timely project completion (RII = 4.43), though safety integration was lacking (RII = 1.83). The study recommends government policies for financial support, training, and partnerships to boost SCP adoption, with a focus on research and development to bridge technological gaps. Achieving sustainable construction in Abuja requires comprehensive strategies that integrate government support, stakeholder collaboration, and educational initiatives to increase SCP adoption, reduce environmental impact, and enhance productivity in the construction sector.

Keywords: Construction Industry, Productivity, Sustainability, Sustainable Construction Practices.

1. Introduction

The rapid depletion of the earth's resources is weakening the planet's support systems, with the construction industry contributing significantly to this issue. It accounts for about 50% of carbon emissions, 20-50% of resource consumption, and 50% of global solid waste. The industry's impact is most significant during the operational stage, leading to pollution and environmental degradation (UNEP, 2020). While the sector supports economic and social growth, it also exacerbates environmental burdens, consuming freshwater, energy, and contributing to greenhouse gas emissions (IEA, 2023; UNEP, 2023). Sustainable construction aims to optimize resource use and minimize these impacts, promoting well-being (Davies & Davies, 2022; Kreo, 2023). However, developing nations face challenges in adopting sustainable practices due to barriers like financial limitations and outdated frameworks (Toriola-Coker *et al.,* 2021; IFC, 2023). Despite these obstacles, sustainable construction offers opportunities to meet national development goals by fostering resource conservation and healthier living spaces (USGBC, 2023; WGBC, 2023). This study explores how sustainable construction practices influence productivity in Nigeria's building industry.

2. Literature Review

2.1 The Concept of Sustainable Construction

Sustainable Construction (SC) applies sustainable development principles specifically to the building industry, focusing on the planning, design, production, and maintenance of the built environment. This concept involves various stakeholders—including manufacturers, suppliers, clients, contractors, consultants, and end users—working toward environmental, social, and economic benefits (GhaffarianHoseini *et al.,* 2020; Gou and Xie, 2021). SC promotes efficient resource use, improved indoor air quality, reduced greenhouse gas emissions, and enhanced well-being for communities (World Green Building Council, 2023). Emphasizing a Triple-P approach (People, Planet, Profit), SC integrates social, environmental, and economic aspects, fostering sustainable development that aligns with global goals (Larsson and Larsson, 2020). In developing regions, SC implementation faces challenges, such as inadequate

regulations, limited expertise, and financial constraints (IFC, 2023). Nonetheless, as building activities account for significant energy and resource consumption, there is a critical need for sustainable approaches (UNEP, 2023).

2.2 Sustainable Construction Practices in the Building Industry

With buildings contributing significantly to global energy use and emissions, SC practices are essential. The International Energy Agency IEA (2021) and UNEP (2020) report that, without intervention, the building sector's environmental impact will continue to escalate. SC practices aim to mitigate these effects by focusing on efficient resource use throughout the building lifecycle.

2.2.1 Key Sustainable Construction Practices

To effectively reduce environmental impacts, SC incorporates several practices:

1. Energy Conservation: Measures to reduce embodied and operational energy (example, Compressed Stabilized Earth Blocks and energy-efficient building design) can significantly lower a building's energy demand (Reddy and Kumar, 2020; Venkatarama and Manjari, 2021).
2. Use of Environmentally Friendly Materials: Utilizing renewable resources like bamboo and recycled materials helps lower the environmental footprint (Yadav and Mittal, 2021).
3. Recycling Building Wastes: Reusing materials from demolition reduces landfill use and conserves resources (Habert and Schiopu, 2020).
4. Utilizing Renewable Energy Sources: Solar energy adoption, supported by incentives, enhances sustainability (Mondal, 2018).
5. Energy-Efficient Building Techniques: Incorporating passive design, optimal orientation, and energy-efficient appliances supports energy reduction goals (Yao and Short, 2023).

2.3 Level of Adoption of Sustainable Construction Practices

Traditional methods in developing countries often lead to inefficient resource use, which SC seeks to address by promoting a sustainability-oriented mindset (Tingley and Davison, 2021). However, financial limitations, regulatory challenges, and a lack of awareness often hinder adoption. For example, unstable economies and ineffective regulations in developing nations affect SC implementation (Pradhananga *et al.,* 2021).

2.4 Barriers to Sustainable Construction Practices

Barriers to SC adoption include limited awareness, high costs, and a lack of regulatory support. Specifically, in developing countries, inadequate knowledge, cultural resistance, and insufficient government intervention impede progress (Oke and Aigbavboa, 2023).

Table 1: Summary of Previous Studies

S/N	Barriers	Source
1.	Lack of awareness about sustainability issues	Tunji-Olayeni *et al.,* 2018; Aghimien *et al.,* 2018
2.	Lack of business case understanding	Toriola-Coker *et al.,* 2021
3.	No professional role for initiating and leading sustainability	Toriola-Coker *et al.,* 2021
4.	Lack of resources for sustainability supervision	Toriola-Coker *et al.,* 2021
5.	Lack of leadership and professional support institutes	Tunji-Olayeni *et al.,* 2018; Pham *et al.,* 2020
6.	Long payback periods for sustainable practices	Durdyev *et al.,* 2018
7.	Lack of sustainable building materials	Davies *et al.,* 2017; Pham *et al.,* 2020
8.	Lack of capacity for executing sustainable projects	Pham *et al.,* 2020
9.	Lack of incentives for sustainable design	Davies *et al.,* 2017
10.	Operational and end-of-life stages not considered in design	Toriola-Coker *et al.,* 2021
11.	Lack of building codes and regulations	Tunji-Olayeni *et al.,* 2018; Pham *et al.,* 2020
12.	Fear of higher investment costs	Durdyev *et al.,* 2018; Pham *et al.,* 2020
13.	Lack of government support	Tunji-Olayeni *et al.,* 2018; Pham *et al.,* 2020
14.	Lack of sustainability measurement tools and certification	Aghimien *et al.,* 2018
15.	Lack of training on sustainability	Durdyev *et al.,* 2018
16.	Lack of knowledge about sustainability principles	Pham *et al.,* 2020
17.	Client concerns about profitability	Aghimien *et al.,* 2018
18.	Lack of financial resources	Pham *et al.,* 2020
19	Lack of government commitment	Aghimien *et al.,* 2018
20.	Perception that sustainability means more expensive buildings	Toriola-Coker *et al.,* 2021

Identifying and addressing these barriers early is essential for effective SC adoption.

2.5 Sustainable Materials and Techniques in Construction

Sustainable materials, such as recycled steel and bamboo composites, contribute to eco-friendly construction by reducing carbon footprints and aligning with circular economy principles (Ferella *et al.,* 2020). Key sustainable techniques include:

1. Energy-Efficient Design: Passive design strategies and advancements in building envelope technologies optimize energy use (Yun, 2020).
2. Technological Innovations: Building Information Modeling (BIM) and smart systems improve resource efficiency and operational effectiveness (Mahmoud, 2022).

2.6 Impact of Sustainable Construction Practices on Productivity

Sustainable construction (SC) positively impacts productivity and safety, particularly in developing countries like Nigeria, where adoption remains moderate. Studies highlight the need for increased regulatory support and awareness to improve productivity and client satisfaction (Oladokun *et al.,* 2020; Otali & Ujene, 2020). Recommendations for improvement include tax incentives, health and safety compliance, and better access to green materials (Tunji-Olayeni *et al.,* 2020; Otali *et al.,* 2022). SC, a subset of sustainable development, applies to the building industry and involves all stakeholders, from manufacturers to end-users (GhaffarianHoseini *et al.,* 2020; Bilec *et al.,* 2020; Gou & Xie, 2021). It integrates environmental, social, and economic benefits, focusing on prudent resource use and ecological principles to optimize resource use, improve indoor air quality, reduce emissions, and promote well-being (World Green Building Council, 2023). While SC faces challenges in developing countries due to regulatory gaps, expertise shortages, and financial constraints (IFC, 2023), the building industry's significant energy consumption underscores the need for sustainability (UNEP, 2023). The future of SC depends on awareness of its environmental impacts and its alignment with national sustainable development goals, with the Triple-P approach ensuring balanced evaluation of environmental, economic, and social aspects (Larsson and Larsson, 2020).

3. Methodology

The research population for this study consists of construction professionals in both the public and private sectors, as well as property management experts based in Abuja. The participants targeted for this study include registered Architects, Builders, Engineers, and Quantity Surveyors with relevant knowledge of Sustainable Construction Practices (SCPs). Abuja was chosen as the study location due to its dynamic building development activities and a significant concentration of construction professionals (Onyeagam *et al*., 2019). To ensure that the sample accurately reflects the population, a simple random sampling technique was used, giving each professional an equal opportunity to be selected. Using Cochran's sample size formula, the minimum required sample size was determined to be 373 to ensure the data's reliability. The study employs a mixed-methods approach, combining both qualitative and quantitative data to enhance the depth and validity of the findings. The data collection process involved the use of a structured questionnaire, designed to capture both quantitative and qualitative responses. The questionnaire was organized into several sections, focusing on demographic information, levels of awareness and adoption of SCPs, perceived barriers to adoption, and the impact of SCPs on productivity metrics.

The questionnaire consisted of both closed-ended questions for quantitative analysis and open-ended questions for qualitative insights. Likert-scale items were included to assess the levels of adoption of SCPs and the perceived barriers, allowing respondents to indicate their degree of agreement or disagreement. For data analysis, the study utilized the Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics, such as percentages, mean item scores, and relative importance indices (RII), were calculated to identify and rank the key sustainable construction practices, barriers to adoption, and overall adoption levels. Inferential statistics, particularly correlation analysis, were employed to explore the relationship between SCP adoption and awareness across different professional groups. The responses to open-ended questions were analyzed thematically, with key themes identified to provide a deeper understanding of the barriers to SCP implementation and the strategies for overcoming them. This approach allows for a comprehensive analysis, combining numerical trends with qualitative insights to strengthen the study's conclusions.

4. Result and Discussion

This section presents the findings from the quantitative and qualitative research conducted using questionnaires.

4.1 Analysis of the Questionnaires

As of when this research was conducted 308 (82.5%) were retrieved, 15 (4.0%) were not correctly and properly filled and 50 (13.4%) were not returned out of the 373 structured questionnaires that were self-administered to the construction professional at both the public and private organisation within the study area in figure 1.

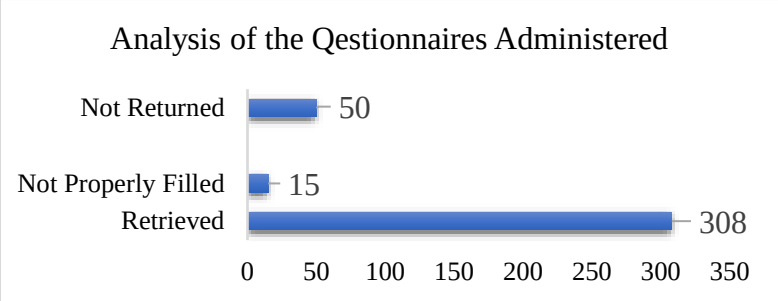

Figure 1: Analysis of the Questionnaires Administered

4.2 Demographic Information of the Respondents

A demographic analysis of the respondents shows that 71.43% of participants are from private organizations, while the remainder comes from public sector organizations. The professionals surveyed represent a diverse range of disciplines, with engineers constituting the largest group (36.04%). The majority of respondents possess substantial experience in the industry, with 46.10% having between 11 to 15 years of experience. Additionally, the majority hold bachelor's degrees (38.64%), reflecting a highly educated group of participants. Importantly, 95.45% of respondents indicated that they have been involved in projects incorporating sustainable construction practices, signaling a high level of engagement with sustainability in their professional activities (Table 2).

Table 2: Demographic Information of the Respondents

Variables	Characteristics	Freq.	Percent (%)	Cumm. Percent (%)
Organisation	Private organisation	220	71.43	71.43
	Public organisation	88	28.57	100.0
	Total	**308**	**100**	
Profession	Builders	74	24.03	24.03
	Architects	85	27.59	51.62
	Engineers	111	36.04	87.66
	Quantity Surveyors	38	12.34	100.0
	Total	**308**	**100**	
Experience	1 to 5 years	48	15.58	15.58
	6 to 10 years	82	26.62	42.21
	11 to 15 years	142	46.10	88.31
	16 to 20 years	22	7.14	95.45
	+Above 20	14	4.55	100.0
	Total	**308**	**100**	
Academic Qualification	OND	9	2.92	2.92
	HND	12	3.89	6.82
	PGD	67	21.75	28.57
	B.Sc/B.Tech	119	38.64	70.13
	M.Sc/M.Tech	89	28.89	96.10
	PhD	12	3.89	100.0
	Total	**308**	**100**	
Professional Membership	MNIOB	75	24.35	24.35
	MNIA	88	28.57	52.92
	MNSE	121	39.29	92.21
	MNIQS	24	7.79	100.0
	Total	**308**	**100**	
Involved in any project where sustainable	Yes	294	95.45	95.45

construction practices where incorporated				
	No	14	4.54	100
	Total	**308**		

Source: Fieldwork 2024

4.3 Level of Adoption of Sustainable Construction Practice on Building Construction in Abuja Nigeria

In Abuja, Nigeria, assessing the adoption levels of these practices among stakeholders is vital for identifying barriers and opportunities for improvement. This section analyzes the findings on stakeholders' adoption of SCPs, as shown in Table 3, which ranks various influencing factors based on their significance according to stakeholder responses.

Table 3: Level of adoption of sustainable construction practice on building construction in Abuja Nigeria

S/N	Factors	VL	L	M	H	VH	N.R	T.S	MIS	RNK	RMK
		1	2	3	4	5					
2.1	Overcoming cultural resistance to new sustainable technologies	4	9	41	78	176	308	1337	4.34	1st	**S**
2.2	Collaboration with government, NGOs, and private sector for SCP	2	1	40	118	147	308	1331	4.32	2nd	**S**
2.3	Sustainable procurement practices	1	4	47	101	155	308	1329	4.31		**S**
2.4	Consumer demand for sustainable building projects	1	0	51	106	150	308	1328	4.31	3rd	**S**
2.5	Health and safety considerations in SCP implementation	1	1	44	118	144	308	1327	4.30	4th	**S**
2.6	Availability and use of locally sourced green building materials	3	2	37	125	141	308	1323	4.29	5th	**S**
2.7	Financial investments in sustainable building practices	0	3	45	120	140	308	1321	4.28	7th	**S**
2.8	Adoption of new technologies and innovations in construction	3	5	45	112	143	308	1311	4.25	8th	**S**
2.9	Government incentives and regulatory support for SCP	1	1	64	96	146	308	1309	4.25	9th	**S**
2.10	Influence of competitive pressure on SCPs adoption	5	9	47	94	153	308	1305	4.23	10th	**S**
2.11	Long-term environmental impact assessments	0	1	56	127	124	308	1298	4.21	11th	**S**
2.12	Training and capacity building programs for sustainable construction	6	6	61	80	155	308	1296	4.20	12th	**S**
2.13	Stakeholder engagement and community involvement in SCP	1	0	64	112	131	308	1296	4.20	13th	**S**
2.14	Awareness and knowledge of SCPs among stakeholders	6	4	69	98	131	308	1268	4.11	14th	**S**
2.15	Adoption of sustainability mindset in project management by real estate developers	14	7	52	99	136	308	1260	4.09	15th	**S**
2.16	Incorporation of waste management and recycling strategies	8	5	75	88	132	308	1255	4.07	16th	**S**
2.17	Perception and preference of SCPs among real estate developers	11	9	60	101	127	308	1248	4.05	17th	**S**
2.18	Integration of sustainability in the building design process	10	12	61	101	124	308	1241	4.02	18th	**S**

2.19	Efficient utilisation of resources (materials, energy, water) in construction	17	27	57	86	121	308	1191	3.86	19th	**S**
2.20	Integration of lifecycle cost analysis in project planning	24	44	60	87	93	308	1105	3.58	20th	**S**
	Means							**1230.66**	**3.99**		
	Std. Deviation							**56.89**	**0.18**		

In Table 3 the most significant factor is "Overcoming cultural resistance to new sustainable technologies" (MIS = 4.34), followed by "Collaboration with government, NGOs, and private sector for SCP" (MIS = 4.32). Other important factors, such as "Sustainable procurement practices" and "Consumer demand for sustainable building projects," both scored above 4.3, reflecting their strong recognition. In contrast, "Integration of lifecycle cost analysis in project planning" scored the lowest MIS of 3.58, indicating a moderate adoption level and identifying it as an area for further development.

4.4 Barriers to the Adoption of Sustainable Construction Practices on Building Construction in Abuja, Nigeria

Table 4 provides a comprehensive overview of these barriers, highlighting the perceptions of various stakeholders involved in the construction sector. The table categorises the barriers based on their significance, as indicated by the relative importance index (RII) and ranks them accordingly. This analysis serves to illuminate the multifaceted challenges that must be addressed to foster a more sustainable construction environment in the region.

Table 4: Barriers to the adoption of sustainable construction practices on building construction in Abuja, Nigeria

S/N	Factors	VL	L	M	H	VH	N.R	T.S	RII	RNK	RMK
		1	**2**	**3**	**4**	**5**					
3.1	Lack of government support	2	8	31	84	183	308	1362	4.42	1st	**S**
3.2	Lack of resources to supervise the realisation of sustainability	1	4	40	111	152	308	1333	4.32	2nd	**S**
3.3	Lack of support from financial institutions	11	19	37	58	183	308	1307	4.24	3rd	**S**
3.4	Lack of education and research	6	14	34	102	152	308	1304	4.23	4rd	**S**
3.5	Long payback periods of sustainable practices	2	9	52	100	145	308	1301	4.22	5th	**S**
3.6	Lack of incentives for designers to facilitate sustainable design	10	8	26	124	140	308	1300	4.22	6th	**S**
3.7	Lack of government commitment	9	5	43	105	146	308	1298	4.21	7th	**S**
3.8	Lack of knowledge about sustainability principles	8	17	47	72	164	308	1291	4.19	8th	**S**
3.9	Different views and conflicts of interest among project players	15	6	39	96	152	308	1288	4.18	9th	**S**
3.10	General perception that sustainability means more expensive buildings	1	4	67	108	128	308	1282	4.16	10th	**S**
3.11	Lack of financial resources	6	8	61	92	141	308	1278	4.15	11th	**S**
3.12	Poor project procurement system	2	6	64	109	127	308	1277	4.14	12th	**S**
3.13	Extensive pre-contract planning	4	16	70	62	156	308	1274	4.13	13th	**S**
3.14	Lack of leadership and professional support institute	12	17	38	94	147	308	1271	4.12	14th	**S**
3.15	Lack of building codes, laws, legal, and regulation	5	11	60	104	128	308	1263	4.10	15th	**S**
3.16	Fear of higher investment cost	12	24	31	97	144	308	1261	4.09	16th	**S**
3.17	Low understanding of economic benefits	11	26	42	85	144	308	1249	4.05	17th	**S**
3.18	Lack of database and information	13	11	46	124	114	308	1239	4.02	18th	**S**
3.19	Poor project organisation structure	12	18	54	96	128	308	1234	4.00	19th	**S**
3.20	Lack of sustainability measurement tools, standards, and certification	12	1	58	144	93	308	1229	3.99	20th	**S**
3.21	Lack of design and construction team	17	8	58	111	114	308	1221	3.96	21st	S

3.22	No professional role for initialising and leading sustainability	17	19	60	84	128	308	1211	3.93	22nd	S
3.23	Lack of accessible guidance about sustainability	20	13	64	92	119	308	1201	3.89	23rd	S
3.24	Lack of training on sustainability	31	9	51	87	130	308	1200	3.89	24th	S
3.25	Integration of sustainability in the building design process	13	11	74	109	101	308	1198	3.88	25th	S
3.26	Lack of sustainable building materials	19	28	61	91	109	308	1167	3.78	26th	S
3.27	Lack of competence of project managers	43	50	18	117	80	308	1065	3.45	27th	S
3.28	Increased documentation	134	16	11	73	74	308	861	2.79	28th	S.N
3.29	Client worries on profitability	97	85	52	26	48	308	767	2.49	29th	S.N
3.30	Lack of capacity for execution of sustainable construction projects	84	112	45	16	51	308	762	2.47	30th	S.N
3.31	Lack of business case understanding	74	142	43	19	30	308	713	2.31	31st	S.N
3.32	Lack of motivation and aspiration values of managers	121	97	16	21	53	308	712	2.31	32nd	S.N
3.33	Lack of strategy to promote sustainability	145	89	64	8	2	308	557	1.80	33rd	S.N
3.34	Operational and end-of-life stages are not considered in design	152	107	45	3	1	308	518	1.68	34th	S.N
	Mean							**1141**	**3.70**		
	Std. Deviation							**240.23**	**0.60**		

Table 4 identifies the barriers to adopting sustainable construction practices in Abuja, Nigeria. The most significant barrier is the "Lack of government support" (RII: 4.42), followed by the "Lack of resources to supervise sustainability" (RII: 4.32), highlighting the need for government involvement and proper oversight. Other key barriers include the "Lack of support from financial institutions" (RII: 4.24) and "Lack of education and research" (RII: 4.23), emphasizing the importance of financial and knowledge resources. Economic challenges, such as "Long payback periods" and "Lack of incentives for designers," were also noted (RII: 4.22). Perceptions that sustainability leads to higher costs (RII: 4.16) and a lack of knowledge about sustainability principles (RII: 4.19) were additional barriers. Lower-ranked barriers, such as "Lack of strategy to promote sustainability" (RII: 1.80) and "Not considering operational stages in design" (RII: 1.68), were seen as less immediate concerns.

Table 5: Correlation analysis between adoption and awareness of SCPs in building industry in Abuja

Metric	**Value**	
	Adoption	**Awareness**
Mean item score (MIS) for Adoption	4.11	
Relative importance index (RII) for Awareness		4.12
Pearson correlation coefficient	0.83	
P-value (significance)	5.94^{-6}	
Interpretation	Strong positive correlation, statistically significant	

Source: Fieldwork 2024

The Table 5 summarises the correlation analysis conducted between the Mean Item Scores (MIS) representing the level of adoption of sustainable construction practices and the Relative Importance Index (RII) representing awareness (or barriers to adoption) of these practices in building construction in Abuja, Nigeria. The Pearson correlation coefficient of 0.83 indicates a strong positive relationship between adoption and awareness. This indicates that as awareness (and understanding) of sustainable practices increases – whether through reducing barriers or fostering a positive perception – adoption levels of these practices also rise. The p-value of 5.94^{-6} indicates that this correlation is statistically significant. This significance implies that the observed correlation is not due to chance, further supporting that awareness levels have a measurable impact on the adoption of sustainable practices.In essence, this table indicates that improving awareness of sustainable practices (and addressing barriers) is likely to encourage greater adoption in the building industry in Abuja.

4. Conclusion and Recommendation

The study investigates the adoption of sustainable construction practices (SCP) in Abuja, Nigeria, highlighting a significant level of engagement with sustainability, with 95.45% of professionals involved in SCP projects. Key factors

promoting adoption include overcoming cultural resistance, fostering stakeholder collaboration, and increasing government support. However, barriers such as a lack of government support, insufficient resources for supervision, misconceptions about costs, and limited knowledge of sustainability principles hinder further adoption. The study also finds a strong positive correlation between awareness and adoption, indicating that increasing awareness can drive wider implementation of SCPs. Recommendations include the establishment of government policies to support sustainability, the creation of educational initiatives to dispel misconceptions, and the promotion of collaboration among stakeholders. Construction firms should integrate sustainability into their core business practices, and further research into sustainable materials and technologies is necessary to overcome current barriers. The study contributes valuable insights into the factors influencing SCP adoption and emphasizes the importance of awareness campaigns. It also suggests areas for future research, such as the long-term effects of government policies, the impact of educational programs, and the role of innovative technologies in promoting sustainability.

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Impact of fuel subsidy removal on building materials in Minna

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Abstract

These instructions comply the subsidization in pump price of fuel subsidy in Nigeria help many Nigerians citizens to petroleum and its products in various ways which make life easy for them. There cent total removal of fuel subsidy has thrown Nigerian to great hardship, making it difficult for an average Nigerian to talk of owning a house of him/herself .This study, Assessment of impact of total subsidy removal on building materials is targeted at investigating the current cost of building materials after the total removal and the cost of building materials before the total removal of fuel subsidy .The study uses market survey to gather the data used for the study. Cost index was used for the analysis of the collected data. The results shows that there is high variation between the cost of building materials before the total removal of subsidy and after the removal of subsidy. The variation in the cost of Reinforcements, Y20, Y16 are #13,900 and #6,800 per length respectively. For Portland cement, the variations are: Lafarge#3,300 per bag, others are#2,700 Wood:2x12 and 2x6 have the highest variation of #500 and #400 per length respectively. The study concluded that the total removal of fuel subsidy has serious impact on the prices of building materials, consequently, high cost of building project and housing development in Nigeria. It was recommended that active price control board be setup by the government to monitor prices of building materials.

Keywords: building materials, economic impact, housing affordability, housing development

1. Introduction

The petroleum sector plays an important role in Nigeria economy, as it is the single largest revenue earner of the country and one of the largest contributors to the gross domestic product (GDP) (Akintola,2018). It is the major regulator of Nigerian economy, a boom in the sector impacts economic growth and affects all sector of the economy including the construction industry. There is a depression in the economy when there is crisis in the oil sector, (Babalola, and Salau,2020). In Nigeria the pump price has made it easy for consumers in Nigeria to buy at a lower price than the market price of fossil fuel (Abdobaidaetal,2020).

The removal of fuel subsidies has significant implications for various sectors of the economy, including the construction industry. Building materials, a critical component of construction projects, are heavily dependent on transportation and energy costs, which are directly affected by fuel prices.

Subsidy was first partially removed in Nigeria in 1986, since then every government that has led since 1986 removes partially a percentage of petroleum subsidy by increasing the pump price. Fuel subsidy removal has been a recurring issue in Nigeria. Successive government in Nigeria have interfaced with the issue as they attempt to reform the Nigerian economy and the petroleum downstream to reduce corruption and waste and make the sector more effective (Harun, etal2018). The total removal of fuel subsidy by the present administration led by Bola Ahmed Tinubu, the president of the federal republic of Nigeria has resulted to very high increase in pump price which has triggered high price of transportation, food items and building materials in the Nigerian market.

The prices of building materials went up more than two times the initial price before the total removal of fuel subsidy which makes it unaffordable by majority of Nigerians particularly the civil servants and the local farmers. Building material is a key item in the construction industry as it is one of the major determinants of the final cost of construction products (Anoosike,2009, Adagunodo,2022). An increase to its cost poses a significant threat to both the housing sector and people aspiring to own a house (BrazilianandOnyei,2012). The rapid inflation in the cost of building materials has been a major constrain in the construction industry. One of the major causes of building materials in Nigeria is the increase in fuel pump price.

Inflation in building materials has a great consequence in the construction industry, as it can result to abandonment of construction project, poor quality product cost overrun as well as delay in project delivery (OkwanyaandMoses,2015). The quality and aesthetics of construction products depend significantly on the type of materials used. When the cost of good quality materials is beyond the reach of the ordinary man, consumers would find alternatives which will result to poor quality of construction products. This paper focus on the impact of total removal of fuel subsidy on the prices of building materials in Minna, Niger State. Nigeria, with the aim of investigating the impact of fuel subsidy removal on

the availability and accessibility of building materials in Minna, Niger state. Nigeria and also the relationship between fuel prices and the cost of building materials in Minna, Niger state, Nigeria.

Minna, the capital city of Niger state, Nigeria was selected as it has a strategic location at the confluence of major highways connecting the northern and southern Nigeria, making it a critical transportation hub. This location increases the city's reliance on fuel-intensive transportation, increasing the potential effects of fuel subsidy removal. Minna has also experienced significant construction activities in recent years, driven by government projects, private investments, and infrastructure development, this growth makes the city an ideal location to study the impact of fuel subsidy removal on building materials.

2. Methodology

This research uses mixed methods to fully and adequately gather data that will provide solutions to the research objectives. It uses market survey as it's quantitative data collection method, where survey questionnaires were administered to building material dealers, builders and contractors and other industry experts. Market survey was also conducted in Minna building materials market to collect data on prices of building materials before and after fuel subsidy removal. This was mixed with in-dept interviews conducted with key stakeholders in the construction industry, building material suppliers, builders and contractors as the qualitative data collections of fuel subsidy removal and the prices of building materials before and after the total removal of fuel subsidy.

The survey questionnaire was designed to collect data on demographics, business operations, perception

The sampling technique used were stratified random sampling for survey questionnaires and purposive sampling for in-dept interviews and case studies.

For the sampling size, 150 respondents of which 60 were building material dealers, 40 were builders and contractors while 50 were industry experts. In-dept interview had 20 respondents, of which 6 were stakeholders, 5 were building material suppliers, 4 were contractors and builders while 5 were industry experts.

The sample size was determined with the sample size formula n=(z^2*0.5^2)/E^2 where n= sample size, Z=Z-score corresponding to desired confidence level (1.96 for 95%) and E = margin of error which is 0.05 with population size of 7000. Using the formula, the recommended sample size is 150.

Cost index was used to analyze the price variations in building materials because it provides a standardized measure of price changes, allowing for comparisons across different materials. Cost index simplifies complex price data into a single easily interpretable value, facilitating analysis and decision making, it also ensured accurate estimates and forecasts.

3. Results and Discussion

Table 1: cost analysis table

Buiding Materials	**Cost before Removal may 2023**	**Cost after removal To date**	**Cost variance**
CEMENT: (ordinary			
Portland cement)	4,500	7,200	2,700
Dangote cement	4,800	7,500	2,700
Bua cement	5,200	8,500	3,300
Lafarge cement	4,300	7,000	2,700
Sokoto cement			
REINFORCEMENT	**Price per length**	**Price per length**	
Y20	18,600	32,500	13,900
Y16	14,200	21,000	6,800
Y12	7,300	11,000	3,700
Y10	5,500	8,000	2,500
WOOD(Timber)	**Price per length**	**Price per length**	
12"x2"	1,500	2,000	500
6"x2"	1,200	1,600	400
4'x2"	750	1,100	350
3"x2"	420	800	380
SAND			
Sharp sand	95,00	150,000	55,000

Fine/plaster	75000	130,000	55,000
Laterite	40,000	75,000	35,000
BLOCK			
6" block	350 per block	450 per block	200 per block
9" block	450 per block	650 per block	200 per block
TILES	**(price per square meter)**	**(price per square meter)**	**price per square meter)**
Viony 400x 400	2,500	4,200	1,700
CDK 400x400	5,200	8,000	2,800
Royal 400x400	3,400	5,500	2,100
STONE	**(price per ton)**	**(price per ton)**	**(price per ton)**
Hard core	4,500	7,500	3,000
Stone dust	5,000	7,500	2,500
chippings	4,500	7,500	3,000

Table one shows the result of the cost of building materials before the total removal of fuel subsidy in May 2023 and after the removal of the subsidy to date. The result indicated that in each of the items shown, there are significant variations in the cost per item and per ton between the cost before the total removal land after the total removal. In most of the items shown, the variations were on a high side. For instance, the variation in cost of sharp sand and fine sand per 20 tons was #55,000 and in high yield reinforcement the variation in Y20 and Y16 are #13,900 and #6,800 per length respectively.

The implication of this findings is that the high increase in the cost of the major building materials as a result of total removal of fuel subsidy in Nigeria has triggered a profound shift and far-reaching effects on housing development in Nigeria. The middle and the lower income earners in Nigeria can no longer afford to own a house of their own as their dream house because of the high cost of building materials that is beyond the reach of an ordinary man in Nigeria and this affect housing development. The study's findings are consistent with the trickle-down economics, which suggests that changes in macroeconomic policies can have a ripple effect on various sectors of the economy. In this case, the removal of fuel subsidy has trickled down to affect the construction industry, leading to increased costs, reduced economic activities and higher inflation.

Furthermore, the study's findings underscore the importance of considering the regional implications of macroeconomic policies. Minna, Niger state, is a region with significant construction activities, driven by government infrastructure projects and private sector investment. The removal of fuel subsidy has disproportionately affected this region, highlighting the need for policymakers to consider regional differences when implementing policies.

Similarly, Babalola and Salau, (2020) examined the effect of petroleum pump price on welfare of Nigerians and concluded that an increase in the pump price of petroleum triggered every other sector of the economy resulting to high cost of transportation, goods and services, building materials and general standard of living. Equally, the findings of this study are in agreement with that of Evansetal, (2023) who investigated the socio-economic effect of subsidy removal in Nigeria and reported that there is a very high relationship between subsidy removal, inflation, high increase in the cost of goods like building materials, food and beverages, services and standard of living in Nigeria.

4. Conclusions

The study concluded based on the findings, that subsidy removal, inflation and high cost of building materials are highly related. The total removal of fuel subsidy in May 2023 in Nigeria led to high inflation which in turn led to devaluation of Nigerian currency, high cost of living standard and accommodation. The study recommended that government should urgently address the rate of inflation and set up price control board to control the prices of goods and services in Nigeria

The findings highlight the need for policy makers to reconsider the timing and implementation of macroeconomic policies, taking into account the potential consequences on valuable sectors of the economy.

To mitigate the effects of fuel subsidy removal, policy makers should consider implementing targeted subsidies for the construction industry to cushion the impact of fuel price increase, invest in alternative energy sources such as solar and wind power to reduce dependence on fossil fuels, enhance transportation infrastructure to reduce logistics cost and increase the efficiency of building material supply chain. Government should also provide financial support and training to small-scale construction businesses to enhance their resilience to macroeconomic shocks.

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Associated Challenges of Parking Facilities at Commercial Banks in Minna, Niger State, Nigeria

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Abstract

Vehicular parking in urban area is a major component of urban transportation system that exhibits the common challenges associated with traffic congestion. With the increase in urbanization rate and the development of commercial banks in large and semi-urban cities, there is an increase demand for parking facilities especially for bank customers, to avoid on-street parking and traffic congestions within banking environment. This study in respect to parking space facilities, thus, examines the locational distribution pattern and capacity of existing parking facilities at commercial banks in Minna core area. Both primary and secondary data were employed for the study. Locational coordinates for all the banks were collected using GPS and the space available for vehicle parking at different banks were mapped. Google earth map was digitized to establish the locational distribution of existing commercial bank in Minna. Based on the assumption of variance of distribution of commercial banks in Minna, quadrant count statistical method was used for the purpose establishing the pattern of distribution of banks. Measurement of inequality of parking areas among banks was analyzed to show the relationship of space acquired for banks and the available space for parking purpose. The study shows a total number of twenty-one (21) banks distributed the major highway of Minna. With reference to the quadrant count analysis, the cluster pattern of the distribution of parking lots in Minna was thereby confirmed. Outcome of the investigation on total land coverage of the bank and the available space for parking shows an expanse of land: UBA 2 (13860m2) and Unity Bank 1 (5954m2), Guarantee Trust Bank (GTB) (900m2), UBA 2 and Union Bank (540m2). Consequently, large portions of the land have not developed for parking purpose. The study concluded that transportation tributary such as parking facility is a vital ingredient integrated to attaining harmony, tranquility and sustainable environment around intense human activity such as banks. It therefore, recommended the provision of adequate parking facility in banks, as the development will go a long way to solving the problem of indiscriminate on-street parking and traffic congestion around banking environment. Hence, advocating for a safe, convenient, efficient and comfortable parking facility is the key to attaining an organized and sustainable society for living and health.

Keywords: Development, Physical, Shopping, Transportation and Urban

1. Introduction

According to Mayer (2016), the economic health and quality of life of a nation's communities depend on a well-functioning and safe transportation system. In such that the accessibility and mobility provided by transportation systems within nation's communities can influence land use and, thus, overtime affect how people live. The relationship between economic development and transportation is founded on the accessibility provided by transportation to every daily social and economic activity within a community. However, one must agree to the fact that this accessibility influences more than just economic development (Mayer, 2006). Parking facilities, an essential component of transportation system; it is an act of manoeuvring a vehicle to a location where it can be left temporarily. At every destination, all vehicles terminate eventually where convenient parking spaces are provided for such purposes, as it is an essential element of the transportation system where business development is promoted.

The need to plan for parking facilities is a trend that arises in other to augment the general transportation system of any environment as well as protecting and sustaining the aesthetics of that environment (Ogar, 2014). Parking facilities as observed by Litman (2023) are major cost to society; conflicts because of parking of vehicles are among the most common problems facing designers, operators, planners and other officials. Joel *et al.* (2022) admitted that parking problems and traffic congestion in Ibadan are apparent within commercial area occurred because of the land use pattern. He further stressed that parking needs to be given adequate consideration in transportation and land use planning, because the commercial land use has a high vehicular and pedestrian traffic generating capacity.

In addition, Litman (2011) conceptualized parking problem in terms of a paradigm shift, which describes a fundamental change in how a problem is perceived, and solutions evaluated. Willson and Shoup (1999) opined that the solution to parking problem can be viewed from the point of shifting from the old paradigm to a new one; in such that the old idea, parking is assumed to be free and abundant at different destinations. This implies that every land use type must provide adequate, sustainable, functional, effective and efficient parking facility to accommodate users need. The

demand for parking is always greater around the central business district area (CBD) hence, the need for adequate parking provision. This has prompted researchers in parking facility aspects, in advocating for planning and development of designated area that is intended for parking within city centre. For instance, most countries where cars are dominant mode of transportation, parking facilities are paramount to areas of intense activities such as shopping malls, commercial banks, sports stadium, and mega places of worship, public institutions, markets and similar venues. In Nigeria, parking facilities is one of the most noticeable problems in most commercial centers, as it is one of the major backdrops in the location distribution of commercial facilities. The planning and designing of parking facilities is however, a challenging task to planners and engineers who are saddled with the responsibility. Urban circulation is one of the most obvious problems and parking facilities seemed to be an overlooked element of transportation planning and development. Vehicles are dominant mode of transportation as transport is the most important tool for social and economic development. The number and use of parking spaces vary widely among activities in each community, reflecting the size, intensity, and location of specific land uses; availability of alternative means of travel; and community attitudes about environmental quality and economic development. Most often, the number of spaces is dictated by local zoning requirements that require minimum amounts of parking for the type and intensity of use at a particular location (Mayer, 2016).

Minna metropolis has been experiencing rapid influx of traffic congestion most especially along the major spine that runs through city. This has been due to the location and distribution different commercial and economic activities along the road. The space allocated for business activities, especially, for banking operations has cause an increase in the rate of on-street parking at different points where the commercial banks are located, along the highway corridor. The shortage of parking space in most of the banks is noticeable and evidently affecting the flow of traffic at different points. Considering the implications of inadequate parking facilities in most urban area that this study, therefore, aim at examining the challenges of parking facilities at commercial banks along the major highway corridor of the city. The study determines the locational and spatial characteristics for parking facility at the commercial banks; the space available for parking of vehicle within the banking premises were analyzed to justify its adequacy in regards to basic standard for parking facility for banking purpose.

2. Study Area

Minna lies between Latitudes 9° 33^{1} and 9° 40^{1} North of the Equator and Longitudes 6° 29^{1} and 6° 35^{1} East of the Greenwich Meridian (Figure 1). The town spanned along the main spine road that separates the city into West and East. This road is from Chanchaga in the South to Maikunkele in the North, covering a distance of about 20km. The West - East pattern, spanned from Gidan-Kwano along Bida axis in the West, to Maitumbi to Gwada axis, in the East, over a distance of 15km (Figure 2).

Figure 1: Map of Niger State

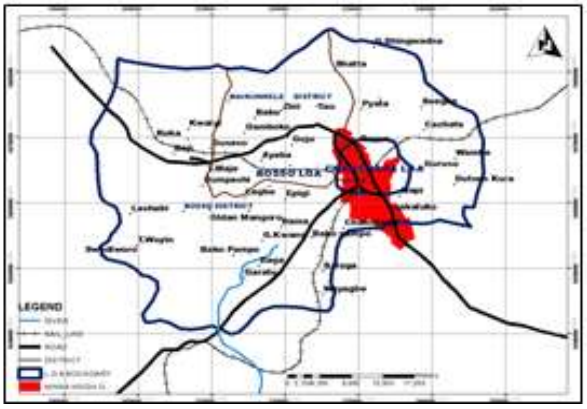

Figure 2: Minna in context of the Local Government Areas.

Commercial facilities in the city are located within the core area of the city, where intense commercial activities are carried out. Considering the area of interest in this study, the study examines the parking facilities for commercial banks that are located along the major highway in Minna.

3. Methodology

Both primary and secondary data were used for the study. The primary data, which were sourced from the field survey consists of the coordinates of location of the banks within Minna metropolis, documentation and mapping of the existing parking areas were also considered. For the secondary data, Google earth map of the town was sourced, to explain the distribution pattern of commercial banks in Minna. Ground Positioning System (GPS) was employed in determining the locations of banks, with the aid of GIS technique; imagery of the town was digitized for location and

distribution of banks to be determined, with the support of quadrant count statistical method. Measurement of inequality of parking areas among banks was analyzed to show the relationship of banks to the available parking lots.

4. Results Discussion

4.1 Locational Distribution Pattern of Commercial Banks in Minna

From the survey conducted, commercial banks are noticeable along the major highway that runs through the city, within Bosso – Mobil- Tunga Road. Table 1 shows the names of banks, its location and their coordinates.

Table 1: Locational Coordinates of Commercial Banks in Minna

S/N	Name of Banks	Location	Coordinates	
			Easting	Northing
1	Zenith Bank	Bosso Road	1061318	0230524
2	Polaris Bank 1	Bosso Road	1064563	0230708
3	Key Stone Bank	Bosso Road	1064771	0230685
4	Stanbic IBTC Bank	Bosso Road	1064363	0230743
5	Access Bank 1	Old Airport Road	1064126	0230700
6	WEMA Bank	Mobil Area	1063788	0230853
7	Unity Bank 2	Mobil Area	1063874	0230836
8	Polaris Bank 2	Old Airport Road	1064128	0230721
9	Eco Bank	Mobil Area	1063730	0230835
10	Union Bank	Paiko Road, Off IBB Road	1063289	0231144
11	Unity Bank 1	Paiko Road, Beside CBN	1063255	0231264
12	UBA 1	Paiko Road, Opposite CBN	1063039	0231446
13	Fidelity Bank	Paiko Road	1062803	0231650
14	FCMB	Paiko Road	1062713	0231729
15	First Bank 1	Behind CBN	1061145	0232683
16	Access Bank 3	Paiko Road, Tunga	1061318	0236110
17	Guarantee Trust Bank	Paiko Road, Tunga	1062384	0232031
18	Access Bank 2	David Mark Road	1062703	0231851
19	Zenith Bank 1	Paiko Road, Tunga	1062925	0231577
20	First Bank 2	Paiko Road, Tunga	1063031	0231580
21	UBA 2	Paiko Road, Beside CBN	1063220	0231323

From Table 1, a total number of twenty-one commercial banks were documented; these bank offices were located within the central area, between Tunga and Government House junction along Bosso Road, as reveals in Figure 3
.

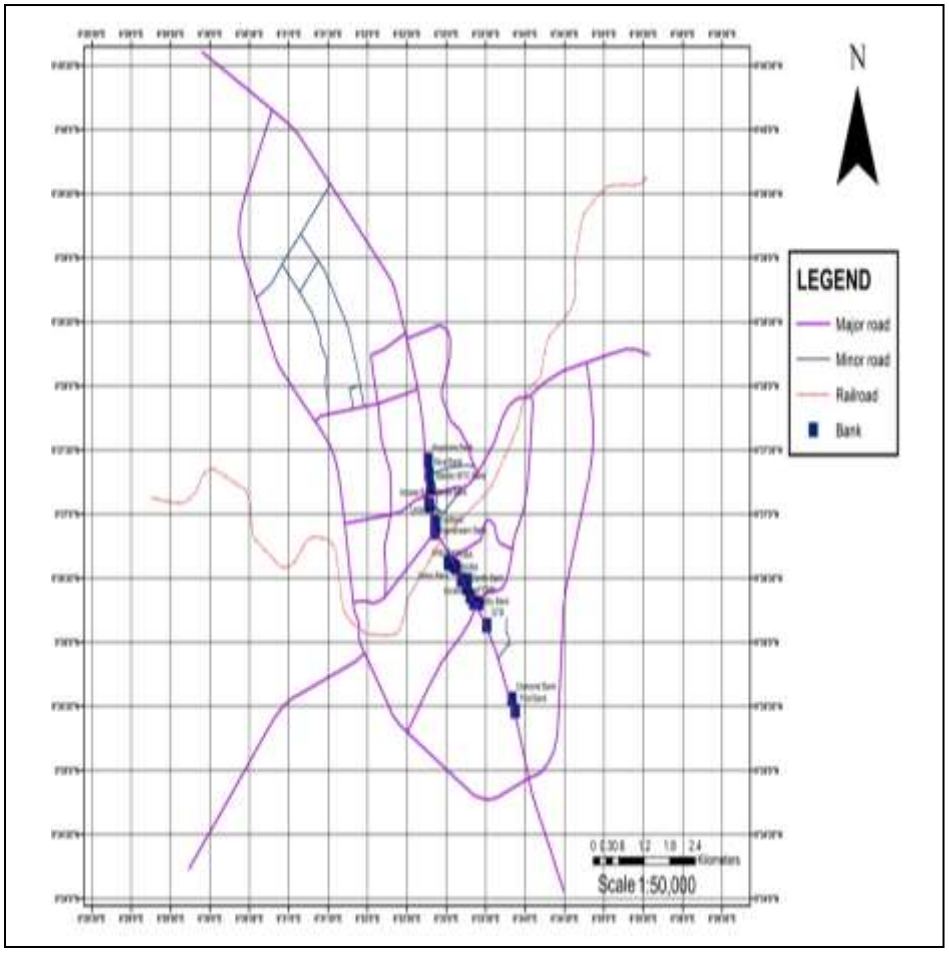

Figure 3: The Distributional Location of Commercial Banks

To further simplify the pattern of distribution of the commercial banks in Minna, Quadrant Count Method of analysis was utilized, based on the assumption of variance of distribution, which stated thus:

Formula:

$$Mean = \frac{No.of\ points\ in\ the\ region}{No.of\ quadrants\ (n)}$$

The Variance of distribution is given by:

$$\boldsymbol{Variance} = \frac{\sum x_i^2 - (\sum x_i)^2}{\boldsymbol{n-1}}$$

Where x_i *= is the frequency of points in each quadrant. The Variance-to-Mean Ratio or VTMR is calculated as;*

$$VTMR = \frac{Variance}{Mean}$$

The Variance-to-Mean Ratio (VTMR) is interpreted as thus:

i. *If VTMR >1, the pattern is clustered. This implies that the data set has one or more groups of points in clusters and large areas of map without points.*
ii. *If VTMR <1, the pattern is regularly dispersed implying the events are distributed more or less regularly over the region.*
iii. *If VTMR = 1, the pattern is random. This implies that the data set has no dominant trend towards clustering or dispersion.*

The study area was partitioned into 7 equal sized quadrants (Table 2) for the purpose of having the quadrant count; for the analysis, mean and variance for the distribution were used to generate the variance-to-mean ratio (VTMR).

Table 2: Quadrant Count Method: Distribution of Commercial Banks in Minna.

Quadrant (n)	Frequency (x_i)	Percentage (%)	$(x_i)^2$
1	4	19.05	16
2	2	9.5	4
3	3	14.3	9
4	7	33.33	49
5	1	4.76	1
6	3	14.3	9
7	1	4.76	1
Total	$\sum x_i = 21$	100	$\sum x_i^2 = 89$

Therefore, from the stated formula, the Variance to Mean Ratio (VTMR) is calculated thus:

$$Mean = \frac{No.of\ points\ in\ the\ region}{No.of\ quadrants\ (n)} = \frac{21}{7} = 3$$

$$Variance = \frac{\sum x_i^2 - (\sum x_i)^2/n}{n-1} = \frac{89-(21)^2/7}{6} = \frac{89-63}{6} = \frac{26}{6} = 4.33$$

$$\boldsymbol{VTMR = \frac{4.33}{3} = 1.44}$$

Consequently, as the value of Variance-to-Mean Ratio (VTMR) is greater than one (>1), this, therefore, confirmed that the pattern of the distribution of commercial banks in Minna is clustered in nature. As observed in Figure 4, the clustering pattern of distribution of the commercial banks is in three areas: (1) within Tunga area (from opposite secretariat and Shiroro Road Junction; (2) within Shiroro Road Junction to IBB Road Junction and (3) within Mobil and Government House Junction.

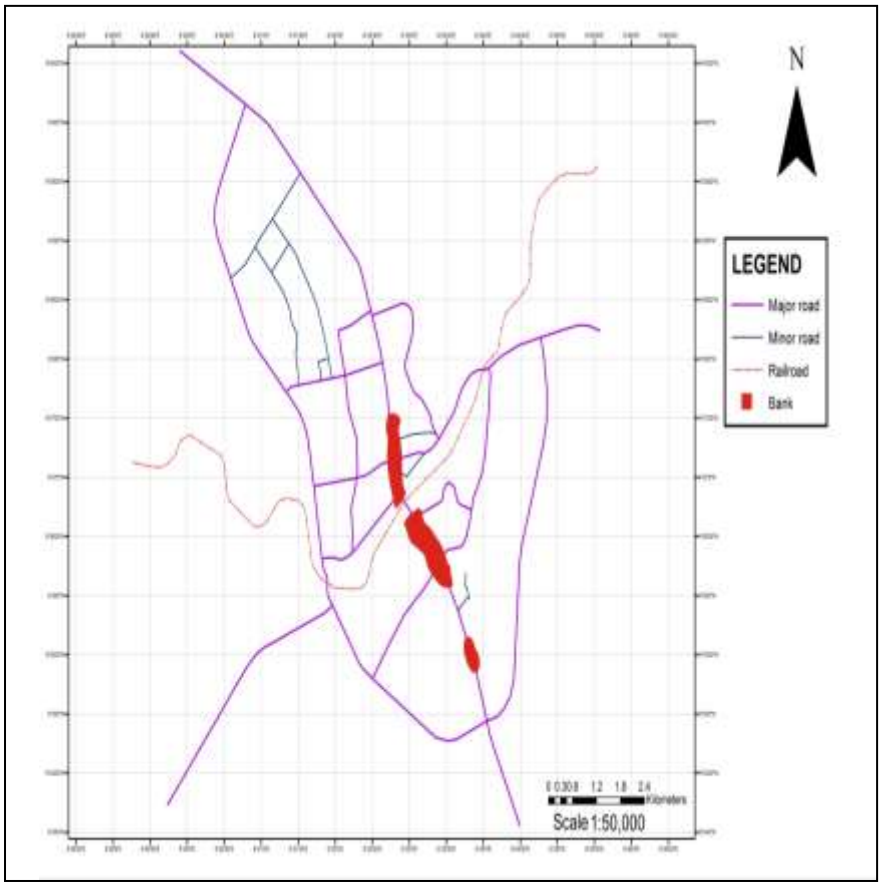

Figure 4: The Distributional Pattern of Commercial Banks

4.2 Existing Space Occupied by Structure and Vacant Space for Parking

Mapping was carried out in order to determine the actual space occupies by structure, to ascertain the actual space meant for parking in each of the bank examined. The survey conducted (Table 3) revealed the total land coverage, the space occupied by structures and the degree of space available for parking of vehicles in all the banks in Minna.

Table 3: Mapping of the Existing Space (m^2)

S/N	Name of Banks	Total Land Coverage (m^2)	Space Occupied by Structure (m^2)	Remaining Vacant Land (m^2)	% of Space occupied
1	Zenith Bank	3,117	409	2,708	13.12
2	Polaris Bank 1	857	337	520	39.32
3	Key Stone Bank	665	327	338	49.17
4	Stanbic IBTC Bank	437	303	134	69.34
5	Access Bank 1	1,488	412	1,076	27.7
6	WEMA Bank	664	138	526	20.8
7	Unity Bank 2	1,846	200	1,646	10.83
8	Polaris Bank 2	383	257	126	67.1
9	Eco Bank	1,931	295	1,636	15.3
10	Union Bank	5,234	775	4,459	14.81
11	Unity Bank 1	8,361	1,687	6,674	20.2
12	UBA 1	1,600	405	1,195	25.31
13	Fidelity Bank	2,049	308	1,741	15.03
14	FCMB	2,634	269	2,365	10.21
15	First Bank 1	3,653	818	2,835	22.4
16	Access Bank 3	637	468	169	73.5
17	Guarantee Trust Bank	4,785	615	4,170	12.9
18	Access Bank 2	659	337	322	51.14
19	Zenith Bank 1	2,433	289	2,144	11.9
20	First Bank 2	2,179	235	1,944	10.8
21	UBA 2	15,620	1,220	14,400	7.81

From the information on the total land coverage and available space in Table 3, the residue of the space occupied and the space for parking were further analyzed Table 4 presents. The analysis shows the remaining unoccupied land for each bank, as well as the extent of the land coverage mainly for parking purpose. The analysis reveals the variations in degree of space available for parking, with UBA 2 (13860m^2) and Unity Bank 1 (5954m^2), having the largest expanse of land unoccupied, while Guarantee Trust Bank (GTB) (900m^2), UBA 2(540m^2) and Union Bank (540m^2) have the largest total area earmarked as parking area.

Table 4: Available Space for parking (m^2)

S/N	Name of Banks	Remaining Unoccupied Land (m^2)	Total land coverage for Parking(m^2)
1	Zenith Bank	2348	360
2	Polaris Bank 1	340	180
3	Key Stone Bank	122	216
4	Stanbic IBTC Bank	42	90
5	Access Bank 1	896	180
6	WEMA Bank	436	90
7	Unity Bank 2	1286	360
8	Polaris Bank 2	0	0

9	Eco Bank	1492	144
10	Union Bank	3919	540
11	Unity Bank 1	5954	720
12	UBA 1	1105	90
13	Fidelity Bank	1345	396
14	FCMB	2185	180
15	First Bank 1	2295	540
16	Access Bank 3	21	216
17	Guarantee Trust Bank	3270	900
18	Access Bank 2	25	324
19	Zenith Bank 1	1604	540
20	First Bank 2	1584	360
21	UBA 2	13860	540

4.3 Measurement of Inequality

This is another statistical method of analysis showing statistically significant correlation between the size of land acquired by banks and the available space for parking.

$$\textbf{Formula } L.Q = \frac{\frac{S1}{S}}{\frac{N1}{N}}$$

Where

S1*= the number of variables*

S*= total value of the variable of facilities in the commercial banks*

N1*= the size of each parking space*

N*= the size of the entire land coverage*

L.Q*= Location quotient*

i. The location quotient of less than one means a condition of inadequate provision of parking facility.
ii. The location quotient of one means a condition of adequate provision of parking facility.
iii. Location quotient of more than one implies a more than enough provision of parking facility.

Table 5: Measurement of Inequality

S/N	Name of Banks	Size of land for Parking (m^2)	Size of Land (m^2)	Ratios	Total
1	Zenith Bank 2	360	3117	0.051/0.052	1
2	Polaris Bank 1	180	875	0.014/0.026	0.5
3	Key Stone Bank	216	665	0.011/0.031	0.4
4	Stanbic IBTC Bank	90	437	7.135/0.013	1.8
5	Access Bank 1	180	1488	0.024/0.026	0.9
6	WEMA Bank	90	664	0.011/0.013	0.9
7	Unity Bank 2	360	1846	0.030/0.052	1.7
8	Polaris Bank 2	0	383	6.25/0	0
9	Eco Bank	144	1931	0.032/0.021	0.7
10	Union Bank	540	5234	0.086/0.078	1.1
11	Unity Bank 1	720	8361	0.137/0.103	1.3
12	UBA 1	90	1600	0.026/0.013	0.1
13	Fidelity Bank	396	2049	0.034/0.057	1.7
14	FCMB	180	2634	0.043/0.026	0.6
15	First Bank1	540	3653	0.060/0.078	1.3
16	Access Bank 3	216	637	0.010/0.031	0.3

17	Guarantee Trust Bank	900	4785	0.078/0.129	1.7
18	Access Bank 2	324	659	0.011/0.047	0.2
19	Zenith Bank 1	540	2433	0.040/0.078	1.1
20	First Bank 2	360	2179	0.036/0.052	1.4
21	UBA 2	540	15620	0.255/0.078	3.3
	Total	**6966**	**61250**		

Table 5 indicates that there are 9 banks without enough parking facilities such as Polaris bank 1 with L.Q 0.5, Keystone bank with L.Q 0.4, Access bank with L.Q 0.9, Mainstream bank with L.Q 0.9, Polaris bank 2 with 0, UBA 1 with L.Q 0.1, FCMB with L.Q 0.6, Access Bank 3 with L.Q 0.3, and Access bank1 with L.Q 0.2 respectively. There are only 11 banks with adequate parking facilities in their location quotient such as Zenith bank 2 with L.Q 1.0, Stanbic IBTC with L.Q 1.8, Unity bank with L.Q 1.7, Union bank with L.Q 1.1, Unity bank with L.Q 1.3, Fidelity with L.Q 1.7, First bank with L.Q 1.3, Guarantee Trust Bank with L.Q 1.7, Zenith bank 2 with L.Q 1.1, and First Bank 1 with L.Q 1.4 respectively. Finally, bank with more than enough parking facility is just one known as UBA 2 with L.Q 3.3.

Table 6: Location/Coverage/Capacity of Parking Lot and Percentages of Parking Space Provided

Name of Bank	**Location**	**Total Land Coverage (m^2)**	**Area for Parking (m^2)**	**Capacity Parking Lot**	**% of Parking Provided**
Zenith Bank	Bosso Road	3117	360	20	11.6
Polaris Bank 1	Bosso Road	875	180	10	20.6
Key Stone Bank	Bosso Road	665	216	12	32.5
Stanbic IBTC Bank	Bosso Road	437	90	5	20.6
Access Bank 1	Old Airport Road	1488	180	10	12.1
WEMA Bank	Mobil Area	664	90	5	13.6
Unity Bank 2	Mobil Area	1846	360	20	19.5
Polaris Bank 2	Old Airport Road	383	0	0	0
Eco Bank	Mobil Area	1931	144	8	7.5
Union Bank	Paiko Road, Off IBB Road	5234	540	30	10.3
Unity Bank 1	Paiko Road, Beside CBN	8361	720	40	8.6
UBA 1	Paiko Road, Opposite CBN	1600	90	5	5.6
Fidelity Bank	Paiko Road	2049	396	22	19.3
FCMB	Paiko Road	2634	180	10	6.8
First Bank 1	Behind CBN	3653	540	30	14.8
Access Bank 3	Paiko Road, Tunga	637	216	12	33.9
Guarantee Trust Bank	Paiko Road, Tunga	4785	900	50	18.8
Access Bank 2	David Mark Road	659	324	18	49.2
Zenith Bank 1	Paiko Road, Tunga	2433	540	30	22.2
First Bank2	Paiko Road, Tunga	2179	360	20	16.5
UBA 2	Paiko Road, Beside CBN	15620	540	30	3.5

Table 6 shows existing space available for parking and the capacity of parking lot in different banks. For instance, Guarantee Trust Bank has the largest space of $900m^2$ with the capacity of 50 parking lots, Unity Bank 1 ($720m^2$ and 40 parking lots), First Bank 1, Union Bank, Zenith Bank 1 and UBA 2 ($540m^2$/ 30 parking lots). Others banks with degree of parking lots are Zenith Bank 2 (20), Unity Bank 2 (20), Fidelity Bank (22), and First Bank 2 (20), while the remaining banks have space less than 20 parking lots. Consequentially, one of the banks Polaris Bank 2 has no parking space

within their premises. Table 6 shows that the banks did not maximally developed the available space for parking lots for their customers, which have increase the rate of on-street parking along the major highways.

Plate I: Parking Facilities at Access Bank, Old Old Airport

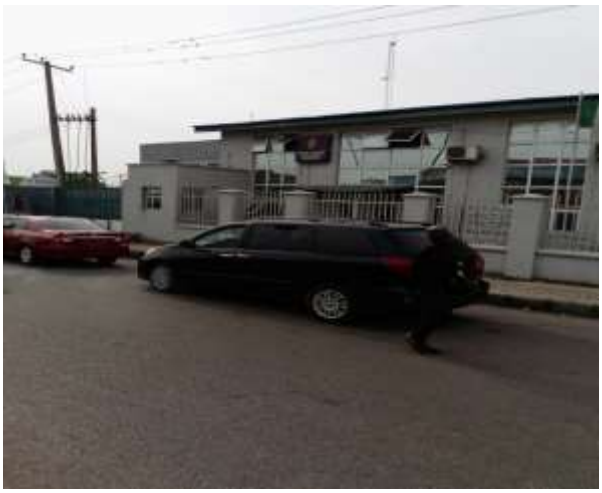

Plate II: Parking Facilities at Polaris Bank II, Old Airport

Plate III: Parking Facilities at Polaris Bank Bosso Road

Plate IV: Parking Facilities at Keystone Bank Bosso Road

Plate V: Parking Facilities at WEMA Bank Mobil

Plate VI: Parking Facilities at Eco Bank Mobil Area, Minna

Plate VII: Parking Facilities at UBA Bank 1. Paiko Road

Plate VIII: Parking Facilities at Zenith Bank 2 Paiko Road,

Plate IX: Parking Facilities at First Bank 2 Tunga,

Plate X: Parking Facilities at Access Bank 3 Tunga,

4.4 Challenges of the Parking Space

The checklist approach was employed to determine the challenges of parking space by respondents who are majorly the customers that patronize with their vehicles, the result in Table: 7 reveals that ten (10) of the commercial bank are perceived to have adequate parking facility, while (6) of the commercial bank have inadequate parking facility, and the parking facility in the remaining (5) banks are considered to be very poor. On the basis of this result, it shows that most of the customers parked their vehicles along the major highways.

Table 7: Respondents Perception on Parking

Banks	Adequate	Inadequate	Very Poor
Zenith Bank 2	√		
Polaris Bank 1		√	
Key Stone Bank		√	
Stanbic IBTC Bank			√
Access Bank 1		√	
WEMA Bank			√
Unity Bank 2	√		
Polaris Bank 2			√
Eco Bank			√
Union Bank	√		

Unity Bank 1	√		
UBA 1			√
Fidelity Bank	√		
FCMB		√	
First Bank1	√		
Access Bank 3		√	
Guarantee Trust Bank	√		
Access Bank 2		√	
Zenith Bank 1	√		
First Bank 2	√		
UBA 2	√		

According to Table 8, 17.6% of respondents based on the inadequate of parking facilities at commercial banks complained of high rate theft of cars, while they parked their vehicle outside the banking premises. Also, 52.9% of respondents admitted on the distruption of their car when parked outside the banking area, while 29.5% with reference to poor parking facilities have experienced theft of valuble things from their vehicle such as ar battery, plate number and extra tyre.

Table 8: Challenges of the Parking Space

Challenges	**Frequency**	**%**
Theft of car	15	17.6
Car Distruption	45	52.9
Theft of car parts	25	29.5
Total	**85**	**100**

From Table 9, the fact remains that only1 bank (UBA 2) out of 21 commercial banks satisfied the required standard of 10,000m^2 for parking space of 30 parking lots. However, six (6) of the banks met up with the parking standard requirements of 30-45 parking spaces (Union, Unity, First Bank 1, GTB and Zenith), while five (5) of the banks did not meet up with the required standard of 10,000m^2 and parking standard requirement of 30-45 parking spaces, but with average parking spaces of 20, 22, and 18 respectively. Finally, nine (9) of the banks did meet not up with the required 10,000m ^{2} neither with the required of 30-45 standard parking spaces for banks.

Table 9: Standard Parking Requirement for Banks in Relation to Existing Parking Provision.

Bank	**Size of Land(m^2)**	**Available Parking**	**Standard Parking Requirement for Banks, 30-45 parking Spaces for 10,000m^2**
Zenith Bank 2	3117	20	Less than 10,000 m^2, with an average of 20 parking spaces below the required standard of 30-45 parking requirement for bank.
Polaris Bank 1	857	10	Less than 10,000m^2 of the required standard with 10 parking spaces below average of required standard of 30-40 parking spaces.
Key Stone Bank	665	12	Less than 10,000m^2 of the required standard with 12 parking spaces below average of required standard of 30-40 parking spaces.
Stanbic IBTC Bank	437	5	Less than 10,000m^2 of the required standard with 5 parking spaces below average required standard of 30-40 parking spaces.
Access Bank 1	1488	10	Less than 10,000m^2 of the required standard with 10 parking spaces below average required standard of 30-40 parking spaces.

WEMA Bank	664	5	Less than 10,000m^2 of the required standard with 5 parking spaces below average required standard of 30-40 parking spaces.
Unity Bank 2	1846	20	Less than 10,000 m^2, with an average of 20 parking spaces below the required standard for bank.
Polaris Bank 2	383	0	Less than 10,000m^2 of the required standard with 0 parking spaces not meeting any of the required standards.
Eco Bank	1931	8	Less than 10,000m^2 of the required standard with 8 parking spaces below average required standard of 30-40 parking spaces.
***Union Bank**	**5234**	**30**	**Less than 10,000m^2 of land but meet the required parking standard of 30 parking spaces.**
***Unity Bank 1**	**8361**	**40**	**Less than 10,000m^2 of land but meeting the required parking standard.**
UBA 1	1600	5	Less than 10,000m^2 of the required standard with 5 parking spaces below average required standard of 30-40 parking spaces.
Fidelity Bank	2049	22	Less than 10,000 m^2, with an average of 22 parking spaces below the required standard for bank.
FCMB	2634	10	Less than 10,000m^2 of the required standard with 10 parking spaces below average required standard of 30-40 parking spaces.
***First Bank1**	**3653**	**30**	**Less than 10,000m^2 of land but meeting the required parking standard of 30 parking spaces.**
Access Bank 3	637	12	Less than 10,000m^2 of the required standard with 12 parking spaces below average required standard of 30-40 parking spaces.
***Guarantee Trust Bank**	**4785**	**50**	**Less than 10,000m^2 of land but above the required parking standard of 30-40 parking spaces.**
Access Bank 2	659	18	Less than 10,000 m^2, with an average of 18 parking spaces below the required standard for bank.
***Zenith Bank 1**	**2433**	**30**	**Less than 10,000m^2 of land but did not meet the required parking standard of 30 parking spaces.**
First Bank 2	2179	20	Less than 10,000 m^2, with an average of 20 parking spaces below the required standard for bank.
***UBA 2**	**15620**	**30**	**Above required standard of 10,000m^2 of land with 15620m^2 and meeting the required standard of 30 parking spaces respectively.**

Note: (*) indicates the banks that the available parking facilties are between 30 and above

5. Conclusion and Recommendations

The study revealed the distribution of twnty-one (21) commercial banks along the major highway in Minna, as well as the capacities of its parking facilities. From the study, six (6) of the banks have above the required standard that required for 30 parking spaces. This implies that the over 70% of the commercial banks in Minna are characterized with different degree of inadequate parking facility. Therefore, the provision of adequate parking facility in banks will go a long way to solving the problem of indiscriminate on-street parking and traffic congestion around banking environment. Hence, advocating for a safe, convenient, efficient and comfortable parking facility is the key to attaining an organized and sustainable society for living and health. Recommendation include establishment of car park policy measures for banks against the miss-use of parking facilities. In addition, provision and implementation of sustainable

physical planning for off-street parking facility around commercial corridors in order to integrate and foster tranquility, harmony and sanity in the transportation network system, development of integrated safe and convenient parking facility in relation to the land use types to reducing traffic congestion.

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Impact of Logistics Management Practices on Construction Firms' Performance in Abuja, Nigeria

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Abstract

Construction projects are characterized by a unique element of temporariness as production is carried out at the final place of consumption with new production sites in each new project. This uniqueness indicates that logistics in construction needs to be managed in a more dynamic way to and from sites. Unfortunately, the Nigerian construction industry faces challenges of corporate logistics leading to delayed and inaccurate information, incomplete services, slow and inefficient operations, and a high product damage rate. The study therefore assessed the impact of a set of logistics activities on construction firms' performance in Abuja with a view to enhancing project delivery. The study adopted a quantitative research approach using the survey research design. Structured questionnaires were used to collect data from 327 logistics officers of construction firms registered with Corporate Affairs Commission, Abuja at a response rate of 30.58%. Analysis of data was undertaken using descriptive statistics such as percentage, frequency counts and Mean Item Score (MIS); and inferential statistics such as Spearman Rank (rho) correlation analysis with the aid of IBM 23.0 SPSS software. The study identified thirteen (13) logistics management activities, of which ones adopted the most were "Order Processing" (MIS = 4.48), "Replenishment" (MIS = 4.40) and "Dispatching" (MIS = 4.40). The logistics management activities adopted the least were "Tracking" (MIS = 3.62) and "Transportation" (MIS = 3.48). The study also identified nine (9) Key Performance Indicators required in testing logistics management practices, out of which the most important ones were "Quality" (MIS = 4.53) and "Serviceability" (MIS = 4.50). It was also revealed that there exists a strong, positive and significant relationship between the adoption of combined logistics management activities and construction firms' performance in Abuja ($r = 0.568$; $p = 0.000$). The study concludes that the impact of a set of logistics activities on construction firms' performance in Abuja is significant and can enhance the delivery of construction projects. It was therefore recommended that in order to enhance the level of adoption of logistics management practices, construction firms should develop a mechanism that will be based on reduced delays in material delivery, minimization of disruptions caused by material shortages or logistical bottlenecks and maintenance consistent progress on construction projects.

Keywords: construction firms, impact, logistics management, performance, practices

1. Introduction

Completing construction projects in a timely manner with their numerous constrains requires the skillful integration of many aspects. One of these aspects, which plays a crucial role in ensuring that construction projects are completed successfully, is labour productivity. Construction project sites are impacted by several factors that affect the efficiency of a workforce by reducing their overall productivity. Such a loss of efficiency interferes with the performance of an entire project, and reduces management's chances of meeting project quality, budget, and time objectives (Oluwajana *et al*., 2022). Conversely, by increasing overall productivity through improving labour force productivity, construction companies would reap many more benefits from their projects. One of the most obvious causes of lost productivity is the poor management of materials, equipment, and tools—or "logistics management". Hence, construction logistics can be defined as "the management of the flow of materials, tools, and equipment (and any related object) from the point of discharge to the point of use or installation (Almohsen and Ruwanpura, 2013). Bringing together and coordinating the management of these three vital components between the project's principal parties would increase productivity substantially. On a construction site, these components must be properly managed in order to ensure a project's success (Almohsen and Ruwanpura, 2013). Ineffective management, on the other hand, will result in conflicts between these aspects. These conflicts will ultimately cause project delays, and cost overruns.

Furthermore, construction projects are characterized by an element of temporariness as production is carried out at the final place of consumption (Ekeskär and Rudberg, 2016), with new production sites in each new project. This differs from other industry contexts where the place of consumption is decoupled from the place of production and the production facilities are, to a greater extent, fixed in their location. These differences indicate that logistics in construction needs to be managed in a more dynamic way as the project conditions will dictate how logistics is carried out on-site (Spillane *et al*., 2013; Spillane and Oyedele, 2017) as well as to and from sites (Ghanem *et al*., 2018; Ying *et al*., 2021). At the same time, construction is material intensive and according to Scholman (1997), 60%–80% of the

gross work involves purchased materials and services and approximately 40% of the project cost is made up of logistics costs (Jang *et al*., 2003). Therefore, this suggests that logistics management should be a priority in the construction industry. However, according to Petter and Mats (2023), logistics management has traditionally been approached in an ad hoc manner by construction projects and not as an opportunity to improve the construction projects' performance. Instead, construction projects have solved their daily logistics activities on a day-to-day basis (Ying *et al*., 2018; Petter and Mats, 2023). Hence, the need for new technological approach.

The need to develop and utilise new technology globally has made the construction industry undergo fundamental transformations, in order to raise the levels of firms' performance and to compete globally (Mohammed and Ali, 2016; Preidel and Borrmann, 2015). The logistics technology used in order processing operations in the Nigerian construction industry is outdated, ineffectual, and often overlooked, due to its weak contributions to project performance (Yahaya *et al*., 2020). According to Bengtsson (2019), these technologies are required at every stage of the logistic process, in order to increase the efficiency and effectiveness of the process, so that projects will be completed within budget, schedule and the anticipated quality. Dim *et al*. (2015) believed that some design teams, contractors and suppliers have little knowledge of recent technologies and logistics tasks in construction. Therefore, identifying the appropriate tasks and their relevant technologies in the construction industry would help integrate and facilitate the processes of logistics management practices (Polacco, 2016).

Unfortunately, in the construction industry, the general problems that arise in corporate logistics include delayed and inaccurate information, incomplete services, slow and inefficient operations, and a high product damage rate. The consequences are an inability to provide inter-linked services, high operating costs, a rate of high inaccuracy, and a lack of flexibility in responding to changing demand requirements (Appiah, 2021). This is due to the fact that logistic technologies for effective and efficient 'order processing operations' in the areas of tracking, shipping, replenishment, dispatching and holding of inventory are deficient in the Nigerian construction industry, when compared to manufacturing and retailing sectors (Isah *et al*., 2021). Thus, the research problem statement is "the construction firms suffer poor performance in the project delivery due to inefficiencies and ineffectiveness in current logistics management practices". This is confirmed to have a significant effect on the performance of the construction sector.

In addition, previous studies have made lots of efforts to improve logistics management practices in the construction sector both internationally and locally. In line with the international domain, it has been reported that the current on-site construction process is hampered by inefficiencies and limited in terms of opportunities for technological innovation in Finland (Barkokebas *et al*., 2015). In addition, Adelwini *et al*. (2023) reported that poorly managed logistics have been found to lock up almost 70% of a company's entire current assets, impacting both its operational and overall performance. It could also open large gaps in internal controls, exposing manufacturing organisations to financial risks, such as theft and fraud schemes, production and delivery delays, numerous faulty products, and wasteful product shortages in Nigeria (Ogah *et al*., 2022; Orobia *et al*., 2020). Furthermore, in the Nigerian context, researches conducted by Fadiya (2012) and Bhandari (2014) on logistics management have focused on transportation, forecasting, effectiveness or efficiency in logistics supply chain and so forth in Nigeria. There is, however, hardly any focus on logistics technology, especially in the use of order processing technology for improving construction logistic processes. This therefore leaves a wide gap in the Nigerian construction logistics processes (Dim *et al*. 2015; Fatnani and Malik, 2015; Polacco, 2016). Impliedly, the technological aspect of construction logistics, especially the order processing, is over-looked, and little is understood in the Nigerian construction industry. In order to fill this gap. This study sets out to assess the impact of a set of logistics activities on construction firms' performance with a view to enhancing project delivery using Abuja as the study area. Abuja was chosen as the study area because it is the capital city of Nigeria where both indigenous and multinational construction companies execute most of their projects in Nigeria (Kadiri *et al*., 2014). This is because a reasonable number of construction activities take place in Abuja. This was due to the fact that Abuja experiences rapid population increase and new developmental projects daily as a result of rapid urbanisation and rural-urban migration. This leads to constant increase in demand for shelter for both residential and commercial purposes.

In view of the above backgrpound, it is necessary to assess the impact of a set of logistics activities on construction firms' performance in Abuja with a view to enhancing project delivery. In order to achieve this aim, this study examined the current level of adoption of logistics management activities by construction; barriers to the adoption of logistics management activities for improved performance of construction firms; drivers for enhancing the adoption of logistics management activities for improved performance of construction firms; and relationships between a set of logistics activities and construction firms' performance in Abuja.

In the light of the fourth objective of this study, as well as review of related literature relating to it, the following pair of hypotheses have been formulated in order to address the problem and achieve the aim of the study:

H_0: *Logistics activities do not have a significant relationship with construction firms' performance in Abuja.*

H_A: *Logistics activities have a significant relationship with construction firms' performance in Abuja.*

2. Literature review

2.1 Adoption of logistics management activities by construction firms

Logistics can be defined as the process of planning, operating and controlling and managing of resources of supply chain, from original point to the point of destination, such as raw material gathering and distribution for example delivering goods to the correct location at the right time, in a right amount of quantity and quality and at a reasonable price (Mohd *et al*., 2018). In addition, Lundesjo (2015) added that there are five elements ("five right") that needed to be considered to define logistics that are right place, time, quality, quantity and price. Therefore, to define logistics is seen to vary. However, the fundamental of logistics is concerning on goods movement and storage, that includes the information flow throughout the supply chain.

In addition, logistics management can be defined as the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders (Kabadurmuş, 2019). Unfortunately, over the last years, construction industry's performance, especially in developing nations, has deteriorated in the Logistics Performance Indicators. According to Kabadurmuş (2019), firms in the logistics industry are worried about global economic recession as it affects the volume of trade and thus performance of the sector. Moreover, they also see technological advancement and improvement in infrastructure as the most important factors that can contribute to their competitive position.

Managing construction projects requires an integrated process to ensure that they are completed on time, within budget, and according to the contract specifications. Labour force productivity enhancement, which typically reduces costs and increases productivity, requires key activities for a successful and efficient logistics management. In view of this, Appiah (2021) provided a brief account of and described the key activities involved in logistics management. These key activities are: Network Design; Order Processing; Procurement; Materials Handling; Inventory Management; Packaging and Labeling; Storage/Warehousing; and Transportation.

Before the COVID-19 virus, the logistics sector and most other industries were slowly or gradually adopting new technologies. Due of the strong restrictions placed on the movement of people and commodities, the pandemic severely impacted the operations of logistics companies. Technology adoption in the sector was accelerated to encourage the development of a robust and effective supply chain system to address the issues brought on by the epidemic. Adopting new technology helps with global logistics management by improving supply chain productivity, lowering operational costs, and decreasing errors (Orji *et al*., 2020; Tu, 2018).

In line with the findings of past studies, Isah *et al*. (2021) found that logistic technologies for effective and efficient 'order processing operations' in the areas of tracking, shipping, replenishment, dispatching and holding of inventory are deficient in the Nigerian construction industry, when compared to manufacturing and retailing sectors. This suggests low-level adoption of logistics management activities in the construction sector.

The logistics management is in charge of ensuring that materials arrive on time and in the correct quantities for the construction project (Lundesjö, 2015). One of the major functions of construction logistics is material and resource deliveries to and from site. The other important function of construction logistics management amongst others is to ensure the efficiency of construction projects' on-site operations by managing logistics activities such as planning, storage, materials tracking, waste management, and managing on-site processes related to physical flows (Ghanem *et al.*, 2018; Ying *et al*., 2018). This is supported by Jang *et al.* (2003) and Thunberg *et al*. (2017) who found that construction logistics can be a catalyst to manage on-site issues and enhance communication and collaboration amongst construction supply chain partner.

2.3 Barriers to adoption of logistics management activities on performance of construction firms

Improving logistics management in construction project is becoming more challenging as the construction industry is getting more complex than what we have had then. However, the construction industry is left behind as compared to other industry such as manufacturing and retail industry. The logistics issues in construction project have hindered its performance thus the construction project goals (time, cost, and quality) cannot be achieved (Mohd *et al*., 2018).

The major problems of construction logistics, according to Isah *et al*. (2021), include the following challenges: technology, standard, patent, cost, infrastructure, and Return on Investment (RoI). These challenges can adversely affect the performance of construction projects. Therefore, managing the flow of materials, assuring their quality, checking the quantity, allocating the storage areas, coordinating the overall process, triggering the orders, and updating the participants are major obstacles in construction logistics management.

Appiah (2021) revealed that the failure in adoption of new and emerging technological approach as well as integrating it into the logistics management system is the most contributing factor affecting logistics management in the construction industry. On a general level, Appiah (2021) identified five (5) factors serving as barriers to the adoption of logistics management in the construction industry. These barriers are: Inefficient Planning, Scheduling and

Procurement process; Communication and flow of information; Ineffective Inventory management; Failure to adopt new and emerging Technology; and Ordering Process.

Appiah (2021) described these barriers further from the viewpoint of the fact that the failure in adoption of new and emerging technological approach as well as integrating it into the logistics management system is the most contributing factor affecting logistics management in the construction industry. With regards to the survey conducted, findings from the study therefore accentuate that the integration and incorporation of new and emerging Technology in logistics management in the construction industry goes a long way to have impact or influence on all the other factors enumerated in the analysis. Technology facilitates communication and the flow of information among the various personnel's and stakeholders involved in logistics management and its supply chain. Information technology integration enhances quality, reduces time and costs, enhances competitiveness and generates future growth. Information technology sharing also aids in swift and smooth accomplishment of inventories aiding in fast decision making. Technology also promotes and facilitates more frequently the Planning, Scheduling, Procurement and Ordering processes which contribute to effective and timely supply logistics in the construction industry. Technology also helps managers in redesigning of strategy to add more value to resources when the need arises.

Adekunle and Isokpan (2021) focused their research on antecedents and obstacles relating to the use of technology in logistics management and draw appropriate business implications. The rationale for focusing on logistics is motivated by the high logistics costs associated with transporting items to their destination, which can be reduced using the appropriate technology. According to Pimentel *et al*. (2022), with growing environmental concerns, reverse logistics (RL) assumes a significant role in the sustainability of the construction industry to the extent that it can contribute to mitigating some of the negative environmental impacts related to its activity. However, there are several barriers hindering the adoption of logistics management. These barriers, according to Pimentel *et al*. (2022) are: lack of financial incentives to incorporate recycled materials, lack of knowledge about RL, lack of technical support, standard codes and regulations in favor of using recycled materials, lack of information sharing, cooperation and coordination among entities of the supply chain, current buildings have not been designed for deconstruction, and lack of construction and demolition waste management and recycling infrastructures.

Rabiu (2023) emphasized that logistic management is an essential component of any construction site. The challenges that the construction industry faces are primarily related to poor logistics management, which has a variety of effects on the project. Some of these barriers are highlighted as: Transportation cost; Late delivery of materials and components; and Storing materials on site. Stressing further Rabiu (2023) reported that most of the materials used on construction sites are not manufactured on site but are procured from other places and transported to site. Transportation is a key factor that affects the efficiency of material logistics. Late delivery of materials and components could be as a result of several factors including people, policies and procedures. It could also be as a result of lack of experience of the procurement officer or inability to understand specification in vendor's quotation. Storing material on site can also have some negative impact on project outcomes. Materials can be damaged by weather, moving equipment or people. Efficient material logistics will require the use of innovative techniques like Just in Time (JIT) in order to minimize the negative impacts of storing materials on site.

2.4 Drivers for adoption of logistics management activities on performance of construction firms

According to Chileshe *et al*. (2016), to facilitate the development of an indexing system, thus enabling the retrieval and coding of interview data, there are several logistics management drivers required to be put into consideration. These drivers have been grouped into six categories. These are: Economic, Product and technology, Legislation, Customer, Industry and market, and Corporate citizenship. El Korchi and Millet (2011) grouped logistics management drivers into three categories, such as: Economic, Environmental and Social. Many economic drivers of logistics management adoption have been reported in past studies (Aidonis *et al*., 2008; Hiete *et al*., 2011). Cost savings due to less usage of virgin materials; reduced transportation and disposal costs; and revenue generated by the sale of salvaged materials were among the main economic drivers (Saghafi and Teshnizi, 2011; Hiete *et al*., 2011).

According to Lundesjo (2011), consolidation centres have much advantage for construction sites. Such as: reduces freight traffic to site by up to 70%, increases productivity of site labour by 30 minutes per day leading to a 6% productivity gain and reduces onsite waste by 7-15% through less material damage and shrinkage. As it was stated here; efficient logistics management in construction projects can be achieved by applying construction consolidation center and through this, site congestion reduction, increase of productivity and reducing of material wastage; will be achieved. Demand smoothing is a way of looking on the project activities in the entire chain and identifying whether the performance can be "smoothed" to decrease transport resourced, materials and labour needed to carry out the activity. It helps to identify peaks and gaps in the materials needs over a time period (Lundesjo, 2011).

The major environmental driver of logistics management implementation is the possibility of reversing the negative impacts of construction activities on the environment (Chileshe *et al*., 2016). Implementation of logistics management complies with environmental regulations and makes organisations self-compliant (Densley and Davison, 2012). It

encourages the usage of less virgin raw materials in buildings and less energy for the transport of goods, and generates less waste (Denhart, 2010). In addition, logistics management diverts construction and demolition waste from landfill so they can be more appropriately used (Bleek, 2013). A recent study by Bouzon *et al*. (2015) showed that the salience of environmental, social and regulatory drivers is on the rise; however, they are not yet considered important in countries with restricted regulations.

With regard to social drivers for logistics management implementation, new jobs could potentially be created due to deconstruction. Local communities could become involved in the logistics management supply chain, also benefiting from improved health conditions due to less pollution (Chileshe *et al*., 2016). Companies implementing logistics management practices would improve their image, a crucial point for the construction industry which currently suffers from a poor public image. However, the motivation of companies to meet environmental requirements and enhance their green image largely rests on local circumstances and the social values prevalent in the community.

In order to ensure that the logistics in construction project is more efficient, it should be designed in the most efficient way to meet the client's requirements (Mohd *et al*., 2018). To achieve this, it should be targeted to focus on the following factors: Number of suppliers; Involvement of supplier at the design stage; Communication; Tracking facilities on site; Performance measurement; and Cost transparency. Reporting further, Mohd *et al*. (2018) stated that the number of suppliers should be rationalized by decreasing its number. This will ensure that the delivery material will be more efficient. Rationally, a chain with a fewer number of suppliers is easier to manage thus logistical barrier can be reduced. In addition, a clear understanding of implication of design, components and choices of material is very crucial. The success of the logistics in construction holistically indicates the success of each phase in logistics management. Technology has brought changes in construction industry that improves previous construction industry practices and method of construction that acquires large amount of labour, time consuming, prone to error. Proper performance measurement should be implemented to benchmark and maintain the performance of construction logistics (Mohd *et al*., 2018).

In the contribution of Rabiu (2023), it was reported that the drivers are factors that promote successful logistics management practices in construction industries for effective construction projects. In the light of this, Rabiu (2023) identified several drivers for adoption of logistics management, such as: Information and Communication Technology (ICT) Systems; Just-In-Time delivery (JIT); Construction Consolidation Centre (CCC); Demand smoothing; On-site marketplaces; Pre-assembled and offsite fabrication; Third party logistics; and Applying integrated/systematic construction logistics. Reporting further Rabiu (2023) submitted that ICT Systems are used to keep track and monitor materials through entire supply chain process (starting from production place until it is used or installed onsite). Tag systems was used to manage material deliveries with the help of different sort of information technology (bar code). Then Radiofrequency identification (RFID) is used for reading of tags or barcode of that material on site for checking the material. The tag system, having relatively low cost, allows the monitoring of material to the point of final use and can offer detail information about how is it going on site. It helps to know easily how much material was used and how much material is left in the store.

The JIT logistics were developed by the Japanese automobile manufacturer system Toyota as an essential part of The Toyota Production System. The basis of this system is the absolute elimination of waste (Rabiu, 2023). It is the mechanism of continuous supply of right quantity of material at right quality, in right time and at right place. In this case there is no as such onsite storage is needed. Therefore, risk of material damage and loss, site congestion and safety issue will be minimized.

On-site marketplaces method is the way allowing the trade worker to bring their products on construction site and stored daily used materials (such as screw, bolts, drill bits, nuts, saw blades and etc. in a temporary ware house. Prefabrication is a good method for smoothing construction logistics. Because of all the components used for building construction is produced in factory and transported to the construction site for assembly. It ensures better quality, less material wastage, minimizes labour force cost, reduces onsite congestion and reduces construction time, lower amount of errors and decreases transport cost (Rabiu, 2023). Third party logistics is a way of involving the third person, rather than supplier and consumer in the logistics system for making better logistics system. The main purpose of such companies is to create safe, clean and work-efficient working place by efficient and better planed logistics. A systematic approach to construction logistics has led to the emergence of a dedicated logistics contractor who assumes the single point responsibility to integrate all the essential support services associated with construction project (Sullivan *et al*., 2010).

2.5 Relationships between logistics activities and construction firms' performance

Several studies have analyzed the relationship between factors influencing logistics activities and critical success factors of construction project delivery and came up with varying propositions. According to Chileshe *et al*. (2016), implementing logistics management in construction could yield approximately 85 per cent of the materials used in a project through salvaging materials from old buildings destined for demolition. Similarly, the cost savings of a project

as a result of using salvaged materials is in the range of 30-50 per cent. Nevertheless, the initial cost of deconstruction would be approximately 21 per cent higher than that of traditional mechanical demolition. In addition, Chileshe *et al*. (2016) reported that the revenue from reuse and resale of salvaged materials and the reduction of disposal cost would make construction 37 per cent cheaper.

Thote *et al*. (2017) claimed that the construction industry contributed to the economic growth of the nation. Proper logistics can minimize disruptions caused by material shortages or logistical bottlenecks. This can contribute to maintaining consistent progress on construction projects, supporting critical success factors like maintaining continuous workflow and preventing project delays.

Appiah (2021) identified several effects of logistics activities on the performance of construction firms. These effects are as follows:

i. Logistics management results in cost reduction and profit maximization; this is primarily due to improved material handling, Safety, speedy and economical transportation, optimum number and convenient location of warehouses.
ii. Inbound logistics helps in the efficient flow of manufacturing operations, due to on-time delivery of materials, proper utilization of materials and semi-finished goods in the production process;
iii. Logistics provide, maintain and sharpen the competitive edge of an enterprise by increasing sales through providing better customer service, arranging for rapid and reliable delivery and also avoiding errors in order processing;
iv. Logistics management helps in developing effective communication system for continuous interface with suppliers and rapid response to customer enquiries; and

Appiah (2021) stressed further that the above effects are a by-product of logistics management. A major headache of production management and financial management is how to ensure effective sound inventory management but such headache is cured by logistics management. Logistics management therefore helps to drive up revenue, improves customer service, and adds to the company's good reputation and brand, which in turn creates new and more business. With more visibility into the supply chain there is the opportunity to save costs in operations, by controlling inbound funds, keeping inventory at the right level and organizing the reverse flow of goods. Therefore, there is a significant and positive relationships between logistics activities and construction firms' performance.

Rabiu (2023) observed that effective logistics system can impact the success of construction projects by ensuring timely and efficient material delivery, inventory management, and supply chain coordination can influence project timelines and costs, thereby aligning with critical success factors like on-time completion, cost control, and quality assurance. It was suggested further that efficient logistics management can contribute to cost control in construction projects. Proper coordination of transportation, inventory, and procurement can lead to cost savings by reducing waste, minimizing stockpiling, and optimizing resource allocation. Logistics activities play a crucial role in ensuring that construction materials are delivered to the project site on time. Delays in material delivery can lead to project schedule disruptions, which in turn might impact critical success factors such as meeting project deadlines and milestones (Rabiu, 2023).

3. Research methodology

This study adopted a survey research design. In view of this, the quantitative research approach was adopted for the study. The study did this by using structured questionnaire for data collection. The study's population is composed of the construction firms registered with the Corporate Affairs Commission (CAC) with Abuja's business address. In view of this, the study considered the construction professional in-charge of logistics management in each of these construction firms. These construction professionals are: Architects, Builders, Civil Engineers, Services Engineers and Quantity Surveyors. From the list of CAC, the total number of the construction firms registered with CAC and operate in Abuja is 2219 (CAC, 2024). This study adopted the simple random sampling technique for the selection of 327 respondents based on Krejcie and Morgan (1970) Table. Therefore, the sample size for the study was 327 which is the representative sample size from a population size of 2219 as suggested by Krejcie and Morgan (1970) Table. Structured questionnaire was adopted for collecting data in this study from professionals based on a five-point Likert scale format. The questionnaire contained five (5) sections (A - F). The first section (Section A) of the questionnaire collected data relating to respondents' profile. The other sections (A - E) addressed issues relating to the objectives of the study respectively. The questionnaires were distributed to 327 logistics officers of construction firms registered with CAC in Abuja, out of which 100 copies of questionnaires were returned and used for data analysis. This gives a response rate of 30.58%. This is perhaps due to the fact that logistics management practice among construction professionals is rare. Howevere, the response rates for past studies in construction related subject matters are within the range of the response rate achieved by this study. Ankrah (2009) who had a response rate of 15.42% reported that the response rate norm for postal questionnaire surveys is 20 – 30%. Others are Kheni (2008) and Ikpe (2009) with response rates of 32.42% and 15.8% respectively. In addition, 15.72% was the response rate in the study of Agumba and Haupt where

questionnaires were both self – administered and administered by mail. This justifies that the response rate in this study is adequate.

A reliability test was undertaken to validate the research instrument before the main data analysis was done. This was done with the use of Cronbach's Alpha reliability test. According to Pallant (2013), the Cronbach's Alpha of values above 0.700 and this suggests very good internal consistency reliability for the scale. This is considered acceptable for data to be reliable. Therefore, it was observed that the Cronbach's alpha coefficient was 0.805 which was greater than 0.70 recommended (Pallant, 2013). Most of the Inter-Item Correlation Matrix values were above 0.50 which falls within the threshold of 0.2 to 0.4 suggested by Pallant (2013). In view of this, the research instrument and the data collected were valid and reliable.

After conducting the reliability test, analysis of data was carried out using descriptive statistics such as percentage, frequency counts and Mean Item Score (MIS); and inferential statistics such as Spearman Rank correlation analysis. Frequency counts and percentage were used to analyse respondents' profile while MIS and Spearman Rank (rho) correlation analysis was used to analyse data with respect to the study's objectives. The formula used for calculating MIS values for data analysis is expressed as Equation 1 while the decision rule adopted for the MIS analysis are summarized in Table 1.

$$MIS = \frac{\Sigma W}{N} \quad (1)$$

Where: Σ = Summation, W = Weight, and N = Total

MIS is being ranked from 1.00 to 5.00

Table 1: Decision rule for MIS analysis

Scale	MIS Cut-Off Point	Interpretation			
		Level of Importance	Level of Adoption	Level of Severity	Level of Significance
5	4.01 - 5.00	Extremely Important	Very High	Extremely Severe	Extremely Significant
4	3.01 - 4.00	Very Important	High	Very Severe	Very Significant
3	2.01 - 3.00	Important	Fair	Severe	Significant
2	1.01 - 2.00	Less Important	Low	Less Severe	Less Significant
1	0.01 - 1.00	Least Important	Very Low	Least Severe	Least Significant

Source: Adapted and Modified from Shittu *et al*. (2021) and Shittu *et al*. (2022)

For the Spearman Rank correlation, the decision rules for the nature of correlation state that if coefficient of correlation (r) = 0.10 to 0.29, then there is small amount of correlation; if r = 0.30 to 0.49, then there is medium amount of correlation; and if r = 0.50 - 1.0, then there is large amount of correlation between the variables, as opined by Pallant (2013).

4. Results and discussion

4.1 Respondents' profile

The profile of these respondents is presented in Table 2. It is shown in Table 6 that the respondents comprise of a mix of all professionals relevant in decision-making in logistics management with the required level of academic qualifications; professional qualification; and years of experience in construction projects logistics management practices.

Table 2: Respondents' profile

PROFILE	STATISTICS	
Profession of Respondents	Frequency	Proportion (%)
Architects	15	15
Builders	17	17
Civil Engineers	34	34
Services Engineers	29	29
Quantity Surveyors	5	5
Respondents' Highest Academic Qualification	Frequency	Proportion (%)
Higher National Diploma (HND)	7	7
Bachelor's Degree (BSc/BTech)	54	54
Master's Degree (MSc/MTech)	34	34
Doctoral Degree (PhD)	5	5
Respondents' Professional Qualification	Frequency	Proportion (%)
MNIA/ARCON	7	7
MNIOB/CORBON	54	54
MNSE/COREN	34	34
MNIQS/QSRBN	5	5

Respondents' Years of Experience	Frequency	Proportion (%)
1-5 Years	8	8
6-10 Years	35	35
11-15 Years	38	38
16-20 Years	14	14
Above 20 Years	5	5
Involvement of Respondents in Construction Projects Logistics Management Practices	Frequency	Proportion (%)
Yes	87	87
No	13	13
Total	100	100

4.2 Adoption of logistics management activities by construction firms

The results presented in Table 3 revealed that the logistics management activities adopted the most were "Order Processing" (MIS = 4.48), "Replenishment" (MIS = 4.40) and "Dispatching" (MIS = 4.40). The logistics management activities adopted the least were "Tracking" (MIS = 3.62) and "Transportation" (MIS = 3.48). In addition, it was shown that the logistics management activities that were very high ranged from "Order Processing" to "Packaging and Labeling' (MIS = 4.48 – 4.12), while the logistics management activities that were high ranged from "Inventory Management" to "Transportation' (MIS = 3.93 – 3.48). On the average, the level of adoption of all the logistics management activities by construction firms in Abuja were very high (average MIS = 4.04).

Findings from past studies differ from the findings of this study in this area. This is because past studies found that over the last years, construction industry's performance, especially in developing nations, has deteriorated in the Logistics Performance Indicators (Kabadurmuş, 2019; Orji *et al*., 2020). In addition, Isah *et al*. (2021) also found that logistic technologies for effective and efficient 'order processing operations' in the areas of tracking, shipping, replenishment, dispatching and holding of inventory are deficient in the Nigerian construction industry, when compared to manufacturing and retailing sectors. This suggests low-level adoption of logistics management activities in the construction sector as reported by past studies. In view of this, adopting new technology will help with global logistics management by improving supply chain productivity, lowering operational costs, and decreasing errors.

Table 3: Adoption of logistics management activities adopted by construction firms

Code No.	Logistics management activities adopted by construction firms	MIS	Rank	Interpretation
B2	Order Processing	4.48	1st	Very High
B10	Replenishment	4.40	2nd	Very High
B11	Dispatching	4.40	2nd	Very High
B1	Network Design	4.35	4th	Very High
B4	Materials Handling	4.12	5th	Very High
B6	Packaging and Labeling	4.12	5th	Very High
B5	Inventory Management	3.92	7th	High
B7	Storage/Warehousing	3.82	8th	High
B3	Procurement	3.70	9th	High
B9	Tracking	3.62	10th	High
B8	Transportation	3.48	11th	High
	Average MIS	***4.04***		***Very High***

4.3 Examining the barriers to adoption of logistics management activities on performance of construction firms

The results highlighted in Table 4 revealed that the most severe barriers to adoption of logistics management activities on the performance of construction firms were "Transportation Cost" (MIS = 4.32) and "Scheduling and Procurement Process" (MIS = 4.30). The least severe barriers to adoption of logistics management activities on the performance of construction firms were "Return on Investment (RoI)" (MIS = 3.79) and "Late delivery of materials and components" (MIS = 3.69). In addition, it was shown that the barriers to adoption of logistics management activities on the performance of construction firms that were extremely severe ranged from "Transportation Cost" to "Lack of communication, information sharing, cooperation and coordination among entities of the supply chain" (MIS = 4.32 – 4.06), while the barriers to adoption of logistics management activities on the performance of construction firms which were very severe ranged from "Patent" to "Late delivery of materials and components" (MIS = 3.99 – 3.69). On the average, all the barriers to adoption of logistics management activities for improved performance of construction firms in Abuja were extremely severe (MIS = 4.06).

In line with the findings of this study, past studies have discovered that major problems of construction logistics are more challenging as the construction industry is getting more complex than what we have had then. However, these problems serve are barriers which makes the construction industry to be left behind as compared to other industries

such as manufacturing and retail industry. In the long-run, these logistics barriers in construction projects have hindered its performance thus the construction project goals (time, cost, and quality) cannot be achieved (Mohd *et al*., 2018; Appiah, 2021; Adekunle and Isokpan, 2021; Isah *et al*.; 2021; Pimentel *et al*., 2022; Rabiu, 2023). Therefore, efficient material logistics will require the use of innovative techniques like Just in Time (JIT) in order to minimize the negative impacts of storing materials on site.

Table 4: Barriers to adoption of logistics management activities on performance of construction firms

Code No.	Barriers to adoption of logistics management activities on performance of construction firms	MIS	Rank	Interpretation
C12	Transportation Cost	4.32	1st	Extremely Severe
C8	Scheduling and Procurement Process	4.30	2nd	Extremely Severe
C6	Lack of financial incentives to incorporate recycled materials	4.27	3rd	Extremely Severe
C1	Failure to adopt new and emerging technology	4.25	4th	Extremely Severe
C4	Infrastructure	4.25	4th	Extremely Severe
C2	Lack of technical support, standard codes and regulations in favour of using recycled materials	4.16	6th	Extremely Severe
C10	Ineffective Inventory management	4.09	7th	Extremely Severe
C9	Lack of communication, information sharing, cooperation and coordination among entities of the supply chain	4.06	8th	Extremely Severe
C3	Patent	3.99	9th	Very Severe
C14	Storing materials on site	3.93	10th	Very Severe
C7	Inefficient Planning	3.88	11th	Very Severe
C11	Lack of knowledge about logistics management	3.87	12th	Very Severe
C5	Return on Investment (RoI)	3.79	13th	Very Severe
C13	Late delivery of materials and components	3.69	14th	Very Severe
	Average MIS	*4.06*		*Extremely Severe*

4.4 Examining the drivers enhancing adoption of logistics management activities on performance of construction firms

The results summarised in Table 5 indicate that the most significant drivers for the adoption of logistics management activities on the performance of construction firms were "Demand smoothing" and "Reduced transportation and disposal costs" (MIS = 4.58 respectively). The least significant drivers for the adoption of logistics management activities on the performance of construction firms were "Applying integrated/systematic construction logistics" (MIS = 3.60) and "Adoption of performance measurement" (MIS = 3.48). Furthermore, it was shown that the drivers for the adoption of logistics management activities on the performance of construction firms that were extremely significant ranged from "Demand smoothing" to "Effective communication" (MIS = 4.58 – 4.12), while the drivers for the adoption of logistics management activities on the performance of construction firms which were very significant ranged from "Involvement of supplier at the design stage" to "Adoption of performance measurement" (MIS = 3.92 – 3.48). On the average, all the drivers for the adoption of logistics management activities on the performance of construction firms in Abuja were extremely significant (MIS = 4.04).

Findings from past studies support the findings of this studies in this case. In line with this, past studies revealed that in order to ensure that the logistics in construction project is more efficient, it should be designed in the most efficient way to meet the client's requirements by putting certain drivers into consideration (Bouzon *et al*., 2015; Chileshe *et al*., 2016; Mohd *et al*., 2018). In addition, Rabiu (2023) reported that these drivers promote successful logistics management practices in construction industries for effective construction projects. Therefore, this will ensure that the delivery material will be more efficient.

Table 5: Drivers for adoption of logistics management activities on performance of construction firms

Code No.	Drivers for adoption of logistics management activities on performance of construction firms	MIS	Rank	Interpretation
D13	Demand smoothing	4.58	1st	Extremely Significant
D2	Reduced transportation and disposal costs	4.48	1st	Extremely Significant
D14	On-site marketplaces	4.43	3rd	Extremely Significant
D10	Information and Communication Technology (ICT) Systems	4.40	4th	Extremely Significant
D11	Just-In-Time delivery (JIT)	4.40	4th	Extremely Significant
D12	Construction Consolidation Centre (CCC)	4.40	4th	Extremely Significant
D1	Cost savings due to less usage of virgin materials	4.35	7th	Extremely Significant
D4	Designing in the most efficient way to meet the client's requirements	4.12	8th	Extremely Significant
D6	Effective communication	4.12	8th	Extremely Significant

D5	Involvement of supplier at the design stage	3.92	10th	Very Significant
D7	Tracking facilities on site	3.82	11th	Very Significant
D3	Revenue generated by the sale of salvaged materials	3.70	12th	Very Significant
D16	Third party logistics	3.66	13th	Very Significant
D15	Pre-assembled and offsite fabrication	3.63	14th	Very Significant
D9	Cost transparency	3.62	15th	Very Significant
D17	Applying integrated/systematic construction logistics	3.60	16th	Very Significant
D8	Adoption of performance measurement	3.48	17th	Very Significant
	Average MIS	*4.04*		*Extremely Significant*

4.5 Determination of relationship between adoption of logistics management activities and construction firms' performance

In order to determine the relationship between the adoption of logistics management activities and construction firms' performance in Abuja, three different analyses were undertaken. Firstly, MIS was used to rank the perception of respondents on the level of importance of the key performance indicators (KPIs) required in testing logistics management practices. Secondly, MIS was also used to rank the opinion of respondents on the perceived effects of logistics activities on construction firms' performance. Thirdly, Spearman Rank Correlation (rho) analysis was used to determine the relationship between the adoption of logistics management activities by construction firms and the combination of KPIs required in testing logistics management practices (representing construction firms' performance) in Abuja. However, before conducting the Spearman Rank Correlation (rho) analysis, the suitability of the data for Spearman Rank (rho) correlation was tested.

4.5.1 Key performance indicators required in testing logistics management practices

The results of the MIS analysis used to rank the opinion of respondents on the KPIs required in testing logistics management practices by construction firms in Abuja are presented in Table 6. The results in Table 6 revealed that the most important KPIs required in testing logistics management practices were "Quality" (MIS = 4.53) and "Serviceability" (MIS = 4.50). The least important KPIs required in testing logistics management practices were "Cost Efficiency" (MIS = 4.17) and "Conformance" (MIS = 4.16). On the average, all the KPIs required in testing logistics management practices by construction firms in Abuja were extremely important (average MIS = 4.35).

Table 6: Key Performance indicators required in testing logistics management practices

Code No.	Key performance indicators required in testing logistics management practices	MIS	Rank	Interpretation
E1.1	Quality	4.53	1st	Extremely Important
E1.6	Serviceability	4.50	2nd	Extremely Important
E1.15	Consistency	4.48	3rd	Extremely Important
E1.16	Use of assets	4.47	4th	Extremely Important
E1.9	Effectiveness	4.46	5th	Extremely Important
E1.2	Time	4.45	6th	Extremely Important
E1.10	Availability	4.44	7th	Extremely Important
E1.11	Productivity	4.39	8th	Extremely Important
E1.12	Utilization	4.33	9th	Extremely Important
E1.14	Agility	4.31	10th	Extremely Important
E1.8	Flexibility	4.27	11th	Extremely Important
E1.13	Outcome	4.27	11th	Extremely Important
E1.3	Reliability	4.22	13th	Extremely Important
E1.5	Technical Durability	4.20	14th	Extremely Important
E1.7	Cost Efficiency	4.17	15th	Extremely Important
E1.4	Conformance	4.16	16th	Extremely Important
	Average MIS	*4.35*		*Extremely Important*

4.5.2 Perceived effects of logistics activities on construction firms' performance

The results in Table 7 revealed that the most significant effect of logistics activities on construction firms' performance was "Delays in material delivery can impact critical success factors such as meeting project deadlines and milestones" (MIS = 4.55). The least significant effect of logistics activities on construction firms' performance was that "There is a significant and positive relationships between logistics activities and construction firms' performance" (MIS = 3.96). It was further revealed that the effects of logistics activities on construction firms' performance which are extremely significant ranged between "Delays in material delivery can impact critical success factors such as meeting project deadlines and milestones" and "Effective logistics system can impact the success of construction projects by ensuring timely and efficient material delivery" (MIS = 4.55 and 4.05), while the effects of logistics activities on construction

firms' performance which are very significant ranged between "Logistics management results in cost reduction and profit maximization" and "There is significant and positive relationships between logistics activities and construction firms' performance" (MIS = 3.99 and 3.96). On the average, all the identified effects of logistics activities on construction firms' performance in Abuja were extremely significant (average MIS = 4.24).

Table 7: Perceived effect of logistics activities on construction firms' performance

Code No.	Perceived effect of logistics activities on construction firms' performance	MIS	Rank	Interpretation
E2.13	Delays in material delivery can impact critical success factors such as meeting project deadlines and milestones	4.55	1st	Extremely Significant
E2.1	Proper logistics can minimize disruptions caused by material shortages or logistical bottlenecks	4.51	1st	Extremely Significant
E2.2	Proper logistics can contribute to maintaining consistent progress on construction projects	4.51	1st	Extremely Significant
E2.3	Proper logistics supports critical success factors like maintaining continuous workflow and preventing project delays	4.42	4th	Extremely Significant
E2.12	Delays in material delivery can lead to project schedule disruptions	4.34	5th	Extremely Significant
E2.11	Inventory management, and supply chain coordination can influence project timelines and costs, thereby aligning with critical success factors	4.31	6th	Extremely Significant
E2.7	Inbound logistics helps in the efficient flow of manufacturing operations	4.18	7th	Extremely Significant
E2.9	Logistics management helps in developing effective communication system for continuous interface with suppliers and rapid response to customer enquiries	4.16	8th	Extremely Significant
E2.8	Logistics provide, maintain and sharpen the competitive edge of an enterprise by increasing sales through providing better customer service, arranging for rapid and reliable delivery and also avoiding errors in order processing	4.13	9th	Extremely Significant
E2.10	Effective logistics system can impact the success of construction projects by ensuring timely and efficient material delivery	4.05	10th	Extremely Significant
E2.6	Logistics management results in cost reduction and profit maximization	3.99	11th	Very Significant
E2.4	Implementing logistics management in construction could yield approximately 85 per cent of the materials used in a project through salvaging materials from old buildings destined for demolition	3.98	12th	Very Significant
E2.5	There is significant and positive relationships between logistics activities and construction firms' performance	3.96	13th	Very Significant
	Average MIS	*4.24*		*Extremely Significant*

4.5.3Relationship between a set of logistics activities and construction firms' performance

The reliability test carried out between the adoption of logistics activities on construction firms' performance in Abuja shows no evidence of outliers with a scatterplot with the data points spread all over the place, suggesting a very high correlation. This shows that the data set is fit for Spearman Rank correlation analysis. Figure 1 shows the graph of the scatterplot of the relationship between the adoption of logistics management activities and construction firms' performanc**e**.

Figure 1: Scatterplot between the adoption of logistics management activities and construction firms' performance

Twelve (12) Spearman Rank (rho) correlation analyses were undertaken here. Correlation Analysis 1 – 11 were used to determine the relationship between each of the identified Logistics Management Activities adopted by construction firms and Construction Firms' Performanc**e**. The twelfth (12^{th}) correlation analysis was used to determine the relationship between a combination of the Logistics Management Activities adopted by construction firms and Construction Firms' Performanc**e**. The results of the Spearman Rank Correlation Analysis are presented in Table 8. In line with this, it was found that "Network Design", "Order Processing", Procurement; Materials Handling; Inventory Management; Storage/Warehousing; Transportation; and tracking (Correlation Analyses 1, 2, 3, 4, 5, 7, 8 and 9), each, have a positive and significant relationship with construction firms' performance in Abuja. The coefficient of correlation (*r*) value observed from the analyses ranged from 0.260 – 0.426. This shows that the strength of the correlation between the logistics management activities and construction firms' performance ranged between weak and slightly strong. Hence, there is a range of small and medium correlation between the variables in each of the analysis concerned (Pallant, 2013). The observed Probability (p) values ranged from 0.000 – 0.009 which were all less than the study's level of significance of 0.01. These indicates that each of these logistics management activities has significant relationship with construction firms' performance. Hence, the null hypothesis is hereby rejected, while the alternative hypothesis is accepted.

Also, in the results presented in Table 8, it was found that "Packaging and Labeling", "Replenishment", and Dispatching (Correlation Analyses 6, 10 and 11), each, have a positive and non-significant relationship with Construction Firms' Performance in Abuja. The coefficient of correlation (*r*) value observed from the analyses ranged from 0.111 – 0.158. This shows that the strength of the correlation between the logistics management activities and construction firms' performance is very weak. Hence, correlation between the variables in each of the analysis concerned is small (Pallant, 2013). The observed Probability (p) values ranged from 0.116 – 0.271 which were all greater than the study's level of significance of 0.01. These indicates that each of these logistics management activities in this case has a non-significant relationship with construction firms' performance. Hence, the null hypothesis is hereby accepted, while the alternative hypothesis is rejected.

In the twelfth analysis, as shown in Table 8, it was observed that there exists a strong, positive and significant relationship between the adoption of combined logistics management activities and construction firms' performance in Abuja. The positive correlation indicates that improvement in the adoption of logistics management activities by construction firms will result in the improvement in the performance of the construction firms. The correlation coefficient (*r* value) observed was 0.568 indicating strong degree of association between the variables. Hence, the correlation between the variables is large (Pallant, 2013). The probability (P_{value}) value of 0.000 observed was less than the level of significance adopted for the study (0.01). This implies a significant relationship between the variables. Therefore, the effect of the adoption of logistics management activities on construction firms' performance in Abuja is significant. Hence, the null hypothesis is rejected, while the alternative hypothesis is accepted. The results of the Spearman Rank correlation analysis are summarised in Table 8. The analyses showing significant relation between the variables indicate that the KPIs (i.e., "Packaging and Labeling", "Replenishment" and "Dispatching") related with construction firms are usually given little attention.

Table 8: Relationship between adoption of logistics management activities and construction firms' performance

Analysis No.	VARIABLES		OBSERVATIONS			INFERENCES	
	X_1	X_2	*r*	LOS	P_{value}	Strength of Relationship	Remark
1	Network Design	Construction Firms' Performance	0.426	0.01	0.000	Slightly Strong	SS
2	Order Processing	Construction Firms' Performance	0.260	0.01	0.009	Weak	SS

3	Procurement	Construction Performance	Firms'	0,475	0,01	0.000	Slightly Strong	SS
4	Materials Handling	Construction Performance	Firms'	0.330	0.01	0.001	Weak	SS
5	Inventory Management	Construction Performance	Firms'	0.389	0.01	0.000	Weak	SS
6	Packaging and Labeling	Construction Performance	Firms'	0.158	0.01	0.116	Very Weak	NS
7	Storage/Warehousing	Construction Performance	Firms'	0.395	0.01	0.000	Slightly Strong	SS
8	Transportation	Construction Performance	Firms'	0.403	0.01	0.000	Slightly Strong	SS
9	Tracking	Construction Performance	Firms'	0.370	0.01	0.000	Weak	SS
10	Replenishment	Construction Performance	Firms'	0.122	0.01	0.227	Very Weak	NS
11	Dispatching	Construction Performance	Firms'	0.111	0.01	0.271	Very Weak	NS
12	Adoption of Combined Logistics Management Activities	Construction Performance	Firms'	0.568	0.01	0.000	Strong	SS

KEY:
SS = Statistically Significant
NS = Not Significant
r = Correlation Coefficient
LOS = Study's Level of Significance
P_{value} = Calculated Probability Value

Findings from past studies agree with the finding of this study here. This is because past studies revealed that implementing logistics management in construction could yield approximately 85 per cent of the materials used in a project through salvaging materials from old buildings destined for demolition (Chileshe *et al*., 2016; Appiah, 2021; Rabiu, 2023). Similarly, it was revealed that the cost savings of a project as a result of using salvaged materials is in the range of 30-50 per cent (Chileshe *et al*., 2016; Appiah, 2021). Therefore, effective logistics system can impact the success of construction projects by ensuring timely and efficient material delivery, inventory management, and supply chain coordination can influence project timelines and costs, thereby aligning with critical success factors like on-time completion, cost control, and quality assurance.

5. Conclusions

It was found that "Order Processing", "Replenishment", "Dispatching", "Network Design", and "Materials Handling" are the logistics management activities mostly adopted, while the level of adoption of these logistics management practices by construction firms in Abuja is very high. It can therefore be inferred that construction firms in Abuja currently adopt logistics management practices in their organisation in order to meet their customer needs and sustain their performance. However, the major finding from the study revealed that the most significant perceived effects of logistics activities on construction firms' performance are "Delays in material delivery can impact critical success factors such as meeting project deadlines and milestones", "Proper logistics can minimize disruptions caused by material shortages or logistical bottlenecks" and "Proper logistics can contribute to maintaining consistent progress on construction projects". It was also shown that there exists a strong, positive and significant relationship between the adoption of combined logistics management activities and construction firms' performance. Therefore, effective logistics system can impact the success of construction projects by ensuring timely and efficient material delivery, inventory management, and supply chain coordination can influence project timelines and costs, thereby aligning with critical success factors like on-time completion, cost control, and quality assurance. The study therefore concludes that the impact of a set of logistics activities on construction firms' performance in Abuja is significant and this impact can enhance the delivery of construction projects.

The following recommendations were made based on the results and findings from the data analysis carried out for this study:

i. The construction firms in Abuja should focus more attention to making policies that will enable the organisation to give more priority to the order processing, replenishment, dispatching, network design, and materials handling while carrying out logistics management activities. This will enhance construction firms' level of adoption of effective logistics management practices.
ii. In order to mitigate the barriers to the adoption of logistics management practices, construction firms in Abuja should come up with proactive measures that will avoid high transportation cost, ineffective scheduling

and procurement process, lack of financial incentives to incorporate recycled materials, failure to adopt new and emerging technology and poor infrastructure.

iii. The management of construction firms in Abuja hould focus more attention on making policies that will empower workers to carry out their tasks to achieve effective demand smoothing, reduced transportation and disposal costs, competitive-advantaged on-site marketplaces, effective ICT systems, efficient JIT approach and effective construction consolidation centre.

iv. In order to enhance the level of adoption of logistics management practices, construction firms in Abuja should develop a mechanism that will be based on reduced delays in material delivery, minimization of disruptions caused by material shortages or logistical bottlenecks and maintenance consistent progress on construction projects. This will help to continuously enhance the positive and significant effect of logistics activities on construction firms' performance for effective project delivery.

v. In view of the limitations of this research, this paper recommends a further study to assess the impact of logistics management practices on individual performance indicators of construction firms/workers' productivity in Abuja.

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Assessment of Challenges against Business Continuity Planning in Construction Micro, Small and Medium Enterprises Competencies for in Abuja, Nigeria

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Abstract

The aim of this study is to assess the challenges militating against business continuity planning (BCP) in construction micro, small and medium enterprises (CMSMEs) in Abuja, Nigeria, with a view to improve the competence of BCP MSMEs. This study relied on a quantitative approach to obtain the data needed to answer the research objectives. This was done through the administration of questionnaires in a survey of selected members of the population. The target population for this research was the owners/management staff of the CMSME organizations within the study area. They constitute the major stakeholders of SMEs within the construction industry who make the decision regarding the day to day running of the CMSMEs that the study is interested in. Therefore, the sample size for the study was 223. A simple purposive sampling procedure were used to select the participants involved in construction work in the study area. Descriptive statistics such as Mean Score and standard deviation was used to assess the challenges militating against business continuity planning (BCP) in construction micro, small and medium enterprises. The findings revealed that the most important challenges militating against business continuity planning (BCP) in construction micro, small, and medium enterprises (CMSMEs) in Abuja is little government support (MIS = 4.27). On average, all 32 challenges militating against business continuity planning (BCP) in construction micro, small, and medium enterprises (CMSMEs) in Abuja, Nigeria, were important (MIS = 4.16). To enhance the competencies of construction Micro, Small, and Medium Enterprises (MSMEs) in Abuja for effective business continuity planning (BCP), the following recommendations are proposed: Government agencies, construction associations, and educational institutions should organize targeted training programs to educate MSMEs on the importance of BCP.

Keywords: Business, Competencies, Construction, Continuity, Enterprises Micro, Small and Medium Planning

1. Introduction

Micro, Small and Medium Enterprises (MSMEs) have a strategic role in national economic development, because apart from playing a role in economic growth and employment, they also play a role in the distribution of development outcomes (Mardikaningsih, 2022). As a form of business that is able to survive during the financial crisis, MSMEs have received the attention of all parties. In the recent economic crisis that occurred in several countries, where many large-scale businesses stagnated and even stopped their activities, MSMEs proved to be more resilient in facing the crisis (Darmawan, 2021). This resilience is considered not excessive if the development of the private sector is focused on MSMEs, moreover this business unit is often neglected just because its production is on a small scale and has not been able to compete with other business units. Business continuity planning capabilities have thus become a need for every business operating in this unpredictable environment.

Business continuity plans or guidelines are required to sustain operations amidst periods of crisis. The majority of the MSMEs business continuity plans focused on new ways of conducting day to day operations, risk assessment, and impact analyses. Aremu *et.*al. (2015) noted that, 70 percent of small-scale enterprises in Nigeria failed within the first five years of operation. Kato and Charoenrat (2018) concluded that there is a failure in developing a Business Continuity Plan (BCP) among SMEs. In 2019 Business Continuity Benchmark Survey revealed that only 9% of participants indicated that their business continuity programs were “very mature.” Furthermore 27% was “mature” and 33% was “reasonably mature,” indicating that their approach to BCP varied in terms of the sound implementation of BCP-related activities and therefore reflected on the outcomes of the process (Continuity Central, 2019).

The latest International Organization for Standardization (ISO)22301:2019 reflected the significant developments taking place in the field of business continuity that are aimed at helping organizations respond to, and recover from, disruptions effectively (ISO, 2019). BCP is applicable to all organizations, regardless of size, sector or type of business; yet, according to many researchers in the field, there is still limited “empirical” research on BCP adoption, practices and effectiveness in some business areas and countries, which triggers the need for further investigation (Azadegan *et al.,*

2020; Ferguson, 2019; Sawalha and Meaton, 2012). Even after the worst of the COVID-19 pandemic had passed, many micro, small and medium-sized firms (MSMEs) have found it difficult to maintain operations, putting such businesses at risk of closing permanently (McCloskey and Heymann, 2020). The presence of this challenge may be attributed to the insufficient competency of MSMEs in properly implementing business continuity planning (Wong, 2020; Ombongi and Long, 2018). Therefore, MSMEs in Nigeria lack the competencies needed to carry out BCP effectively.

2. Literature Review

2.1 The concept of business continuity

Business continuity is a business philosophy defined as the processes, procedures, decisions and activities that ensure an organization can continue to function through eternity (Tuana and Aslıhan, 2021; Păunescu and Agartu, (2020). It involves planning so as to help prevent operational interruptions, crises and environmental changes happening so as to assist the organization quickly return to a state of business as usual should any of these events occur (Dana, 2019). Once it has been prepared, the business continuity plan must be tested and exercised to ensure that it will perform as anticipated, so that the organization experiences the minimum possible day to day disruption (Jorrigala, 2017).

Business continuity achieves various things for organizations, with the degree of success in each area dependent on the amount of effort, skill, resource and commitment, provided by the organization for business continuity activities (Tuana and Aslhan, 2021). Proactive measures are designed for the prevention of interruptions to organizational activities.

Business Continuity is the process of developing preventive and recovery strategies to cope with possible dangers to a business. Păunescu and Agartu (2020) define business continuity as the expected consequence of successful execution of both business continuity planning and catastrophe recovery. It appears to imply a comprehensive strategy for continuing to operate the company solution even in the event of a distressing event ('Tuana and Aslhan, 2021). The organizational ability to respond to critical contingencies is crucial for businesses and involves a five-level framework that encompasses operations, customer, workforce, leadership, and community-related responses (Margherita and Heikkilä, 2021).

2.2 Business Continuity Planning (BCP)

Business Continuity Planning programs includes plans for the reactive measures that will be taken should the proactive measures that are in place fail or become overwhelmed by some unforeseen and unexpected crisis (Naser *et al.,* 2022; Schmid *et al*., 2021). Reactive measures enable the organization to return to an acceptable level of operations within a desired timescale following an interruption, disaster or crisis. Culture change plays a role in Business Continuity Planning programs it involves an exploration of organizational culture (Venclova and Urbancova, 2013).

The essence of good Business continuity planning is the identification and implementation of measures which can be put in place to proactively prevent operational interruptions taking place, and to prevent crises and disasters occurring (Naser *et al.,* 2019). Business continuity management, at its highest level, is about keeping organizations operating at their maximum capability while reactive measures are designed for recovery from interruptions to organizational activities.

More than half of new businesses fail during the first year; approximately 20% of new businesses fail during the first two years of being open, 45% during the first five years, and 65% during the first 10 years. Only 25% of new businesses make it to 15 years or more (Prieto *et al.,* 2022). However, Business Continuity Institute (2018) indicate that through developing proactive measures to deal with possible hazards to a company, business continuity policies can enhance an organization's resilience (Punla, 2017). Thus, managing business continuity, in particular, is one of the most important factors that would enhance a company's ability to withstand risks and survive disasters (Naser and Khalifa 2019). Recently, Siriporananon and Visuthismajarn (2018) challenged the dominant classification of disaster types, stating that a disaster can be classified according to the cause of the disaster, and proposed three types of disasters, namely natural disasters such as floods, human-inflicted disasters, and disasters caused by technology failure. Business Continuity Planning (BCP) must take all of these types of disasters into consideration when a business continuity plan is being developed.

2.3 Concept of competence in relation to SMEs

The concept of competence in relation to SMEs is complex; Woodruffe (1971) contrasts areas of competence as aspects of the job that an individual can perform, with the term competency referring to an individual's behaviour that supports a competent performance. Thus, competence refers to functional areas and behavioural areas. Thus, a holistic model of individual competence will include both 'functional competence' and 'behavioural competency'; this will be a combination of knowledge, understanding, functionality, mental and applied skills, behaviours, attitudes and learning to learn (Delamare-LeDeist and Winterton, 2005). Competencies in any firms have a positive or negative effect on the firms' performance. The human resources in SMEs are usually limited; in Europe micro, small and medium-sized

enterprises employ, on average, four people (Lukacs, 2005). Therefore, the effect of employees' skills and competencies is significant for any firm's performance. The small number of employees means a low structure in the organisation.

2.4 Section Challenges Militating against Business Continuity Planning (BCP) in Micro, Small and Medium Enterprises (MSMES)

Across the globe, small and medium enterprises (SMEs) make enormous contributions towards economic growth and active employment in both the developing economies and the developed economies (Ogundana, 2022). OECD (2018) opined that SMEs embody about a totality of global businesses, accounting for about 70% of all employments and generating an average range of 50% to 60% of value-added. In Africa, SMEs support economic growth through job creation in different sectors of endeavours, improve means of livelihood, industrial production upturn, and export, social enrichment as well as governmental constancy and they serve as a mainstream revenue generation in many of these economies, including in Nigeria (Tehseen & Ramayah, 2015). Entrepreneurial competencies and SMEs business success: The contingent role of external integration. Mediterranean journal of social sciences, 6(1), 50-61. and Ramayah, 2015; Ifekwem and Adedamola, 2016; Ogundana *et al*. 2018). However, they also must deal with challenges that pertain to sustaining their performance and continuity. For example, the informality of the substantial African SMEs industry poses a problem as to multiple taxations, unaccountable levies and little government support on the SMEs industry. The informal nature of the SMEs industry in Nigeria, with little regulations and support from the Government, forces the industry operators to secure their means to business survival and growth (Madichie *et al*., 2017; Ingenbleek, 2019). Consequently, the challenges that Nigerian SMEs face include securing funds, competing with their foreign counterparts and with other large firms in related industries (Jevwegaga *et al*., 2018). Other challenges include lack of managerial experience, skills, and individual characteristics, as well as unfriendly financial conditions, misguided business plans, and asset starvation; these are the main reasons why new SME firms fail.SMEs are confronted with BCP implementation challenges from various angles, including: regulation and legislation, historical legacies and strategic planning (Elliot *et al*., 2010). Other challenges include: inadequate understanding of data recovery following disaster; adoption of unsuitable BCP implementation approach; and lack of commitment on the part of senior management (Chuang and King, 2013).Moh and Wong (2015) highlighted obstacles to implementation of BCP by SMEs, including: lack of understanding of business continuity management; BCP professionals do not share the message outside large corporations; misconceptions about the importance of BCP; BCP process bottlenecked due to overshadowed and complicated methodology; and too expensive to implement. Lack of understanding and misconceptions about the importance of BCP may be in form of underestimation of impact; inappropriate scenario assumptions; time and manpower resource affordability; living outside disruptions comfort zone; and lack of sense of urgency (Moh and Wong, 2015). In order to enhance the capabilities of SMEs in coping with these and other challenges, entrepreneurial competencies appear to be a viable tool to engage. According to Gwadabe and Amirah (2017) the failure of SMEs in Nigeria has increased due to a hostile operating environment and increased competition. Entrepreneurial competencies enable competitive advantage in business through proper management of relationships (Tehseen & Ramayah, 2015). Entrepreneurs are also able to identify opportunities for the success of the firm (Ibidunni *et al*., 2017). According to Zizile and Tendai (2018), the survival and success of SMEs have been positively affected by entrepreneurial competencies.

3. Methodology

This study relied on a quantitative approach to obtain the data needed to answer the research objectives. This was done through the administration of questionnaires in a survey of selected members of the population. The target population for this research was the owners/management staff of the CMSME organizations within the study area. They constitute the major stakeholders of SMEs within the construction industry who make the decision regarding the day to day running of the CMSMEs that the study is interested in.

According to Kotler (2012), sample size determination formular is for the study A sample is a small proportion of a population selected for observation and analysis. The sample size of the respondents was calculated using a simplified formula proportion as illustrated by Glenn (2013).

$$n = \frac{N}{1 + N(e)^2} \quad (3.1)$$

Where;

n = Sample size

N = Population size in the sample unit

e = Level of precision which is + 5% (0.05)

$$n = \frac{506}{1 + 506(0.05)^2} = 223$$

The CMSMEs listed in the national survey of micro small &Medium Enterprises (MSME)and an estimated sample size of 223 respondents was arrived at a respondent from a firm. Therefore, the sample size for the study was 223. A simple purposive sampling procedure were used to select the participants involved in construction work in the study area. The CMSME organizations within the study area was visited in turn, and data collected from them. Descriptive statistics such as Mean Score and standard deviation was used to assess the challenges militating against business continuity planning (BCP) in construction micro, small and medium enterprises.

4. Findings and Discussion

The findings revealed the challenges militating against business continuity planning (BCP) in construction micro, small, and medium enterprises (CMSMEs) in Abuja, Nigeria, as shown in Table 1. All thirty-two challenges were important, ranging from little government support (MIS = 4.27) to asset starvation support (MIS = 4.05). Based on the ranking, the most important challenges militating against business continuity planning (BCP) in construction micro, small, and medium enterprises (CMSMEs) in Abuja are little government support, lack of commitment on the part of senior management, securing funds, strategic planning, lack of managerial experience, skills, and individual characteristics (MIS = 4.27, 4.26, 4.24, 4.23, and 4.23), respectively. The least challenges militating against business continuity planning (BCP) are too expensive to implement and asset starvation (MIS = 4.07 and 4.05), respectively. On average, all 32 challenges militating against business continuity planning (BCP) in construction micro, small, and medium enterprises (CMSMEs) in Abuja, Nigeria, were important (MIS = 4.16). This study aligns with Moh and Wong's (2015) that highlighted obstacles to the implementation of BCP by SMEs, including a lack of commitment on the part of senior management. SMEs face challenges in securing funds, planning strategically, receiving minimal government support, comprehending business continuity management, feeling urgency, and formalizing BCP activities.

Table 1: Challenges militating against business continuity planning (BCP)

Challenges militating against business continuity planning (BCP)	Mis	Sd	Rank
Little government support	4.27	0.71	1st
Lack of commitment on the part of senior management	4.26	0.80	2nd
Securing funds	4.24	0.77	3rd
Strategic planning	4.23	0.77	4th
Lack of managerial experience, skills, and individual characteristics	4.23	0.79	4th
Hostile operating environment	4.21	0.77	6th
Lack of understanding of business continuity management	4.20	0.74	7th
Lack of sense of urgency	4.18	0.78	8th
Formalization of BCP activities	4.18	0.81	8th
Centralization of BCP activities/regulation	4.18	0.79	8th
Unfriendly financial conditions	4.18	0.81	8th
Living outside disruptions comfort zone	4.18	0.75	8th
Misguided business plans	4.17	0.73	13th
Misconceptions about the importance of BCM	4.17	0.81	13th
Adoption of unsuitable BCM implementation approach	4.17	0.81	13th
Unaccountable levies	4.17	0.80	13th
Complexity of SME operations/economy	4.16	0.82	17th
Industry operators forced to secure their business survival	4.16	0.86	17th
Increased competition	4.16	0.88	17th
Multiple taxations	4.15	0.85	20th
Inadequate understanding of data recovery following disaster	4.15	0.84	20th
BCM process bottlenecked due to overshadowed and complicated methodology	4.15	0.74	20th
Time and manpower resource affordability	4.13	0.83	23rd
Underestimation of impact	4.12	0.74	24th
Competing with their foreign counterparts	4.12	0.87	24th
Regulation and legislation	4.11	0.81	27th
BCM professionals do not share the message outside large corporations	4.11	0.83	27th
Informality of the substantial African smes industry	4.09	0.83	29th

Historical legacies	4.09	0.90	29th
Too expensive to implement	4.07	0.91	31st
Asset starvation	4.05	0.81	32nd
Average MIS			***4.16***

5. Conclusion and Recommendation

This study aims to assess the challenges militating against business continuity planning (BCP) in construction micro, small and medium enterprises (CMSMEs) in Abuja, Nigeria, with a view to improve the competence of BCP MSMEs in Abuja. Based on empirical findings the study concludes that the five major challenges to CMSMEs in Abuja, are little government support, Lack of commitment on the part of senior management, securing funds, Strategic planning, Lack of managerial experience, skills, and individual characteristics, compound the difficulty of implementing effective BCP strategies.

In order to enhance the competencies of construction Micro, Small, and Medium Enterprises (CMSMEs) in Abuja for effective business continuity planning (BCP), the following recommendations are proposed: Government agencies, construction associations, and educational institutions should organize targeted training programs to educate CMSMEs on the importance of BCP. These should cover areas such five (5) major identified challenges as well as the remaining twenty-seven (27) identified challenge which are also though important for business continuity planning. Provide entrepreneurship development programs that focus on financial management, strategic planning, and leadership skills to empower CMSME owners and managers with the knowledge to sustain their businesses through crises. Financial institutions and the government should develop loan programs with low interest rates specifically designed to help CMSMEs invest in risk mitigation strategies, infrastructure upgrades, and technology.

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Integrating Biophilic Principles in Resort Design: a Case Study of Abuja, Nigeria.

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Abstract

This study explores the integration of biophilic design principles in Abuja resorts, aiming to enhance guest well-being and sustainability. Using an explorative qualitative approach, data were collected via interviews and analyzed through inductive thematic analysis. Findings indicate positive professional perceptions of biophilic design but highlight significant implementation barriers, including space, cost, and limited stakeholder awareness. Recommendations include awareness campaigns, scalable design solutions, and policy support for biophilic urban planning in Nigeria.

Keywords: Adoption, Biophilia, Implementation, Reintegrate, Resort, Sustainability, Urbanization, Well-being.

1. Introduction

Urbanization and industrialization have led to a growing disconnect between people and nature, resulting in urban areas becoming "concrete jungles." Despite this, humans have an inherent need to connect with nature, a connection rooted in evolutionary history rather than built environments (Abah, 2019). The design approach influenced by biologist Edward O. Wilson's concept of "Biophilia," promotes the integration of natural elements into architecture to improve occupant well-being. This concept has gained prominence in architecture, revolutionizing how we interact with our surroundings. This natural affinity for nature is reflected in people's preferences, such as seeking homes with scenic views, enjoying park walks, and drawing inspiration from natural surroundings. These behaviours demonstrate the deep connection between humans and nature (Abbas and Jawwid, 2017). Biophilic design aims to reintroduce nature into built environments to enhance well-being and performance. People desire more than functionality in their spaces; they want environments that provide comfort, inspiration, and energy. In response to environmental concerns, the field of architecture has increasingly focused on biophilic design, although questions remain about how to conceptualize and apply 'nature' in both research and practice (Zhong *et al*., 2021). Sustainable development principles, including biophilic design, emphasize the efficient use of resources and materials, contributing to cost-effectiveness and environmental responsibility (Pranjale1 and Hejiib, 2020). The incorporation of natural elements in urban settings not only improves environmental performance but also fosters a connection between humans and nature. This connection is especially important in cities, where people spend much of their time in compact, stressful environments, contributing to stress-related illnesses (Terrapin Bright Green, 2017). Kellert *et al*.'s (2018) work on biophilic design provides a comprehensive guide to implementing these principles, emphasizing the importance of creating spaces that resonate with humans' innate affinity for nature. In design of resorts, biophilic principles are particularly important as these spaces offer a refuge from urban life. The integration of natural elements in resorts enhances the guest experience, fostering well-being through sensory connections with nature (Kellert and Calabrese, 2017). This approach not only improves aesthetics but also contributes to a sustainable and ecologically conscious design, making resorts exemplars of biophilic architecture.

Studies such as Ulrich's (2004) groundbreaking work on the therapeutic effects of nature views further support the benefits of biophilic design in resort environments. The incorporation of nature into resorts can reduce stress, improve mood, and provide guests with a transformative experience. The multisensory engagement provided by biophilic elements, such as water features, greenery, and natural materials, enhances guests' overall well-being (Browning *et al*., 2014). Thus, biophilic design in resorts meets the evolving expectations of guests seeking both physical and emotional rejuvenation. Urbanization and industrialization have significantly transformed natural landscapes, creating a notable disconnect between humans and nature (Kellert *et al*., 2008). This disconnect is particularly evident in urban environments dominated by concrete and artificial structures (Beatley, 2011). Abuja, the rapidly growing capital city of Nigeria, exemplifies this trend. As the city expands, it becomes increasingly important to incorporate natural elements into its urban design, especially in leisure and hospitality sectors like resorts (United Nations, 2019; Nigeria National Tourism Development Corporation, 2020).

Biophilic design, which integrates natural elements into built environments, offers a promising solution (Terrapin Bright Green, (2014). Applying biophilic principles can enhance guest well-being, promote sustainability, and create aesthetically pleasing environments that foster a deeper connection with nature (Heerwagen, 2000; WHO, 2016). Despite these recognized benefits, there is limited research on biophilic design's application in resort development in Abuja, Nigeria (Africa *et al*., 2019). This study seeks to assess the level of familiarity and application of these Biophilic design Principles as well as it's barriers and perceived impact.

2. Literature Review

2.1 Biophilia in Architecture

The term Biophilia was introduced by Edward O. Wilson in 1984, who coined it to describe an innate human desire to connect with nature. This concept has significant implications for psychology, architecture, and urban planning, emphasizing the need to reconnect with nature to enhance well-being and reduce stress. Rapid urbanization since the Industrial Revolution has distanced humans from natural environments, which ancient architecture integrated harmoniously (Sinharay *et al*., 2022). Sustainable architecture, particularly through biophilic design, seeks to reintroduce natural elements into modern buildings, promoting health and well-being by incorporating natural light, air, water, plants, and views of nature (Hidalgo, 2015, Söderlund and Newman, 2015). Biophilic design is crucial in contemporary architecture for enhancing human well-being, promoting sustainability, and creating aesthetically pleasing environments. Its adoption in resorts worldwide, including in Nigeria, demonstrates its effectiveness in improving guest experiences by reconnecting them with nature.

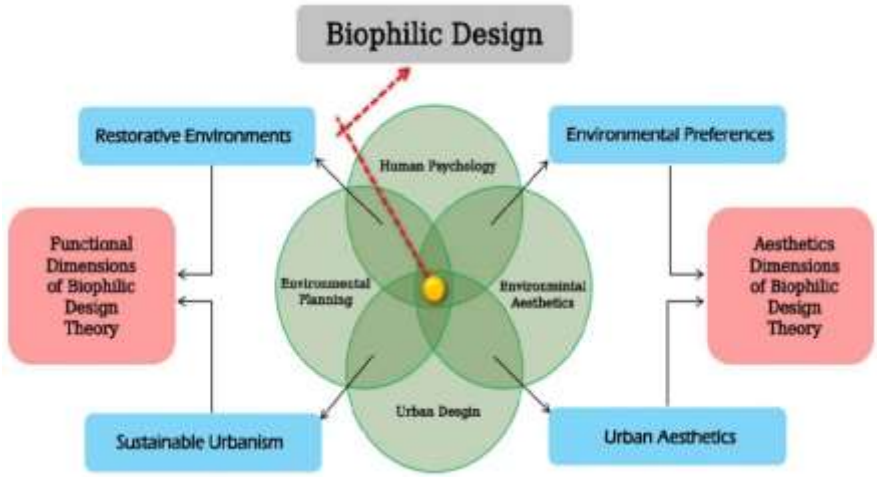

Figure 1: An illustration of the concept of biophilia in Architecture
Source: ResearchGate (2023)

2.2 Biophilic Principles

Biophilic design principles include Direct experiences of nature, Indirect experience of Nature, and Experience of Space and Time characterized by elements such as natural light, fresh air, water features, plants, and natural materials (Ryan *et al*., 2014; Soderlund, 2019). These elements improve mood, productivity, and cognitive function while reducing stress (Kellert *et al*., 2008).

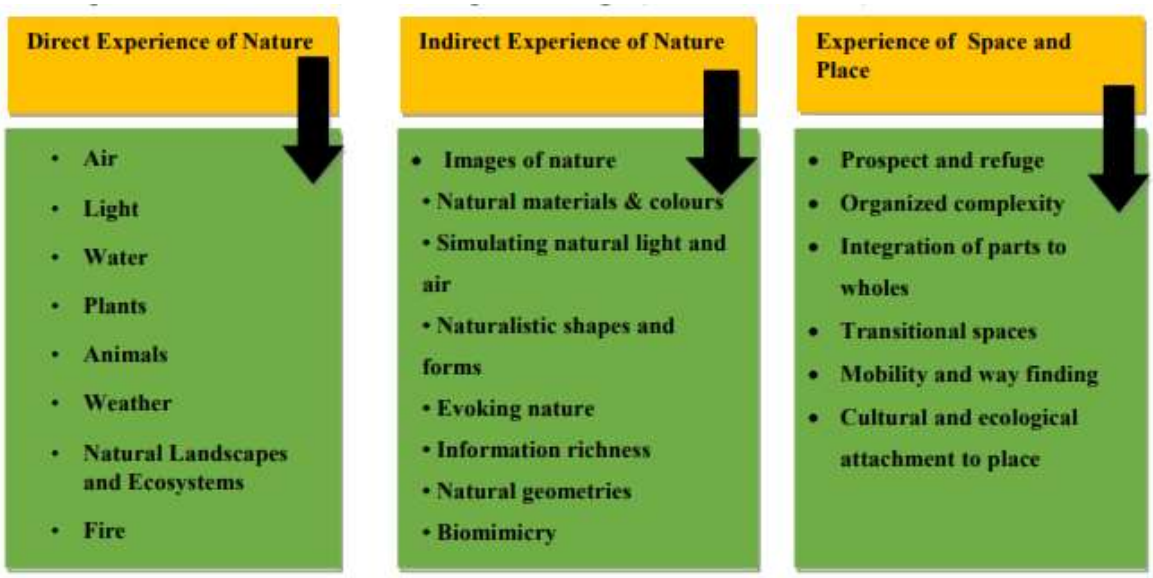

Figure 2.2: Characteristics of the three principles of Biophilic Design
Source: The practice of Biophilic design (Kellert, 2015).

2.2.1 Direct Experience of Nature

Direct Experience of Nature in Biophilic design refers to the incorporation of natural elements that people can physically interact with or directly observe within built environments. This principle is grounded in the idea that exposure to natural stimuli can enhance human well-being, reduce stress, and improve cognitive function. The direct experience of nature includes elements such as natural light, air, water, plants, animals, and natural landscapes (Pranjale1 and Hejiib 2020). It is the incorporation of plants, water, and animals into the built environment, especially with movement (Söderlund and Newman, 2015). The principle of Direct Experience of Nature in biophilic design involves the intentional integration of natural elements and processes directly into the built environment. This approach leverages human affinity for nature (biophilia) to improve well-being, enhance environmental quality, and promote sustainability. The elements involved in direct experience can include natural light, vegetation, water features, natural landscapes, and the use of natural materials" (Ryan *et al*., 2014; Soderlund, 2019).

Platee 3: Plate an interior of the Changi Airport showing the rain vortex at the core of the building with a lot of vegetation and natural elements

2.2.2 Indirect experience of nature

The principle of indirect experience of nature in biophilic design involves integrating natural elements that evoke a connection to nature within built environments. This is achieved using natural materials like wood and stone, nature-inspired colors, patterns, and shapes such as fractals or biomorphic forms, as well as visual representations of nature.

These design features, such as leaf-mimicking flooring or tree bark-like wall textures, create a calming atmosphere, promoting mental relaxation

Plate 2: The use of Bamboo and wood to make a Bar at Ulaman Retreat (Hotels and Tourism)
Source: ArchiDaily (2024)

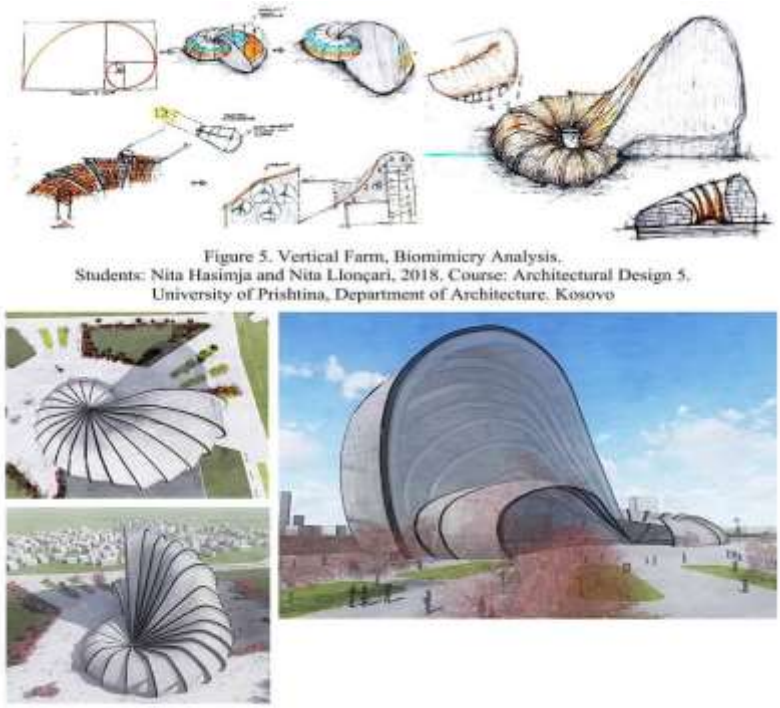

Plate 3: A student project adopting the concept of Biomimicry in Biophilic Design
Source: Pinterest (2024)

2.2.3 Experience of Space

The principle of Experience of Space and place in biophilic design emphasizes the importance of creating environments that foster a connection to the surrounding space and the unique characteristics of a place. This principle is based on the idea that humans have an innate desire to connect with their environment in meaningful ways, which can enhance well-being, comfort, and a sense of belonging (Kellert *et al*, 2013; Salingaros, 2015). This is achieved through various design strategies:

i. **Spatial Variability:** Incorporating a mix of open and enclosed spaces mimics natural environments, offering areas for socializing, reflection, and engagement. The Salk Institute in California exemplifies this with its open courtyard and ocean views that enhance the connection to the surrounding landscape (Kellert *et al*, 2013).
ii. **Place-Based Design:** Reflecting the cultural and ecological context of a location fosters a sense of community and identity. The High Line in New York City, an elevated park built on a former railway line, exemplifies this by blending industrial history with green space for public enjoyment (Lindsey, 2013).

iii. **Prospect and Refuge:** Providing views (prospect) alongside sheltered, intimate spaces (refuge) enhance psychological comfort. Frank Lloyd Wright's Fallingwater house balances openness with enclosed spaces, offering both views of nature and private areas

iv. **Wayfinding and Orientation:** Clear sightlines, intuitive layouts, and strategic use of lighting and landmarks make spaces easier to navigate, reducing anxiety. The Seattle Public Library by Rem Koolhaas achieves this through color-coded floors and transparent elevators (Weisman, 2014).

v. **Transition Spaces:** Gradual transitions between indoor and outdoor spaces, such as courtyards and atriums, blur boundaries and enhance the spatial experience. The Chandigarh Capitol Complex in India, designed by Le Corbusier, uses large open spaces and transitional zones to connect different buildings harmoniously (Jencks, 2015).

Plate4: A plate showing a part of Changi Airport interior giving visitors an awesome experience of space
Source: Google images

Globally, resorts like Alila Villas Uluwatu in Bali and Six Senses Qing Cheng Mountain in China integrate biophilic principles to enhance guest experiences and well-being (Kellert, 2018; Terrapin Bright Green, 2014). In Nigeria, resorts like Obudu Mountain Resort and La Campagne Tropicana Beach Resort incorporate natural landscapes and materials to promote relaxation and connection with nature (Ogunbiyi and Balogun, 2019). Biophilic design in architecture leverages natural elements to foster human well-being, reduce stress, and promote sustainability. By incorporating features like natural light, ventilation, water elements, plants, and natural views, biophilic architecture creates healthier and more aesthetically pleasing environments. This approach is increasingly adopted in global and Nigerian resorts, demonstrating its practical benefits and potential for enhancing urban living spaces.

3. Methodology

For this study, Explorative qualitative research approach is employed to provide a deep understanding of the subject through observations and Semi-Structured Interviews with architects, resort developers/urban planners, and government officials will provide detailed accounts of the familiarity, perceived impact, barriers, and application. A purposive sampling technique was adopted in which case, the participants were selected based on their participation, experience and expertise in Resorts development.

3.1 Sample size

The sample size was focused on depth rather than breadth, whereby approximately 20–30 participants are to be selected to participate in this study ensuring a manageable yet diverse pool of respondents. Qualitative research often emphasizes the depth of insights over sample size, a smaller, well-targeted sample can provide in-depth data essential for understanding the awareness and implementation of biophilic architecture (Gentles *et al*., 2015).
Architects: 10– 15 participants.
Resort Developers/Urban Planners: 5–10 participants
Government Officials/Regulatory Agencies: 3–7 participants

3.2 Data Collection

The data for this research will be collected through a literature review, and Semi-structured interviews. The semi structured interviews will allow the flexibility in interviewing the participants. The Questions were developed from the objective of the study and were validated by experts in the field to ensure that the required data would be achieved based on their lived experience. For this study, questions would likely start broadly and become more specific, aiming to elicit participants' experiences, beliefs, and challenges regarding biophilic principles in architecture. These questions cut across variables as follows:

a. Awareness/familiarity with Biophilic design
b. Perceived impacts/Benefits of applying Biophilic Principles
c. Barriers to implementation of biophilic design
d. Application of biophilic principles (e.g., green spaces, water features)

3.3 Data analysis

Thematic Analysis was used to analyse the data collected. An inductive thematic analysis is often chosen for research when the aim is to derive themes directly from data rather than imposing pre-existing frameworks or theories, making it ideal for exploratory studies. This method allows researchers to uncover rich, nuanced insights from participants' perspectives, especially in qualitative research, as it enables themes to emerge from raw data without prior assumptions (Braun & Clarke, 2006). By not predetermining themes, researchers can identify patterns that may reflect the unique experiences and perceptions of participants, making it suitable for analyzing complex, subjective topics like perceptions of biophilic design.

4. Results and Discussion

4.1 General information

The dataset contains a total of 23 survey responses from a proposed (20-30 participants). The survey Has 14 Architects, 5 urban planners and 4 other stakeholders. Respondents provided constructive feedback and concerns regarding biophilic design.Some comments emphasized the need for greater awareness and education among the Architects and general public and within the architecture/construction industry to promote the benefits of biophilic design. A few respondents highlighted the cultural shift required to embrace more natural elements in urban spaces, suggesting that public demand for biophilic design could drive its adoption more effectively. While some felt that while biophilic design is beneficial, it needs to be practical and scalable to different types of projects, from large-scale developments to smaller personal spaces. The qualitative analysis reveals a positive perception of biophilic design among professionals, particularly in architecture and urban planning. However, significant barriers exist that limit its implementation in practice. These barriers are primarily related to space, cost, and a lack of awareness among clients and stakeholders. While there's a strong understanding of the health and well-being benefits of biophilic design, more efforts are needed to bridge the gap between theory and application. Educating clients, increasing public awareness, and finding cost-effective ways to implement biophilic principles could enhance its adoption in the built environment.

4.2 Familiarity with Biophilic Design

Most respondents have a moderate to high level of familiarity with biophilic design. Several respondents (mostly architects and urban planners) reported being "very familiar" or "somewhat familiar" with the concept of biophilia. The majority 63% of these respondents were introduced to biophilic design through academic studies, indicating that formal education plays a crucial role in disseminating knowledge about this design principle, 19% through media (TV, magazines, online articles) and 18% through independent research or professional experience showing that awareness extends beyond formal education, though to a lesser degree.

4.3 Perception Impact

Respondents generally perceive biophilic design as beneficial, particularly for well-being. Many respondents highlighted the therapeutic and well-being benefits of biophilic design as ascertained by (Kellert & Calabrese, 2017) indicating an understanding that these principles have positive effects on health and psychological comfort. A few mentioned that while they believed in the potential of biophilic design, its impact is often overlooked due to the emphasis on cost-efficiency and functionality in most projects. Some comments reflected the view that biophilic design could create more sustainable environments which is in alignment with the claim of (Pranjale1 & Hejiib, 2020), and a few participants expressed frustration over its lack of broader adoption despite its known benefits.

4.4 Barriers

Numerous barriers inhibit the practical application of biophilic design in resort development projects in the study area, several respondents cited the fact that Cost is a great barrier owing to about 35%, the perception that biophilic design requires more resources than traditional design approaches. space limitations are also a barrier which is a peculiar phenomenon in urban environments, taking about 30%. This is a common theme among urban planners and architects working in densely populated areas. Another significant barrier is lack of sufficient awareness and understanding of the long-term benefits of biophilic design, particularly among clients standing up to about 27.5 Other barriers included regulations, technical difficulties, and sometimes the lack of support from the broader design and construction community holding up to about 2.5%.

4.5 Application

The application of biophilic design is limited, but interest is strong. A majority of respondents indicated that they had incorporated or would consider incorporating biophilic design principles in their work or personal spaces. This shows a positive attitude towards its application when possible. However, the practical use of these principles seems to be more limited due to the aforementioned barriers. While interest exists, actual implementation varies. Some respondents reported feeling constrained by project limitations that prevented them from fully applying biophilic elements, even if they were personally inclined to do so. While biophilic design is embraced in theory, its practical application is often constrained by external factors, suggesting a gap between intent and execution. More education and advocacy may be needed to overcome these barriers.

5. Conclusion

The qualitative analysis of the dataset reveals a positive perception of biophilic design among professionals, particularly in architecture and urban planning. However, this familiarity has remained largely theoretical in resort development in Abuja with minimal application limited to greens. Also, Significant barriers exist that limit its implementation in practice. These barriers are primarily related to space, cost, and a lack of sufficient awareness among clients and stakeholders.

While there's a strong understanding of the health and well-being benefits of biophilic design, more efforts are needed to bridge the gap between theory and application in resort development in Abuja.

This implies that there are no strong regulatory policies enough to enforce the implementation of Biophilic principles in the design of resorts in Abuja, Nigeria. It is now left in the hands of developers, and other stakeholders to choose as whether to embrace it or not which makes the concept of Biophilia more of theory rather than practical in the urban context of Abuja.

6. Recommendation

i. Develop scalable solutions**:** Creating more adaptable biophilic design strategies for different project sizes and budgets.
ii. Partnership with local government agencies to integrate biophilic design policies into urban planning will create a pathway for increased adoption and application of Biophilic Design Principles in resort designs in Abuja, Nigeria.

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Evaluation of The Performance of Residential Building Fabrics: A Design and Specifications Approach

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Abstract

The performance of residential building fabrics is dependent on the quality of the manufactured product and design concept which can enable it to withstand the intended use and associated climatic conditions. This paper measured the present condition of building fabrics quantitatively using methods ranging from a non-destructive technique and method based on indices for assessing the quality of the fabrics. The study on a residential estate within Minna, Niger State, Nigeria is discussed. It emphasized the pivotal role of standards and codes, such as ASTM D559-03, ASTM C97-02, and NIS 87-2006, in ensuring both short-term and long-term performance predictability. The influence of conceptual design solutions, focusing on layout optimization to enhance the performance of building fabrics are discussed. Through adherence to standards, the performance of building fabrics in building projects can significantly enhance its life cycle costs.

Keywords: Building fabrics, Mohs' kit, Surface Hardness, specifications

1. Introduction

1.1 Performance of building fabrics

In enhancing the performance of building fabrics used in the construction of buildings, a set of standards are primarily employed as a guide for achieving quality products. Adherence to these standards or codes is intended to ensure building fabrics that meets both short and long-term performance. This obviously, would enhance the performance on exposure to use, weather and climatic conditions. These codes predict the performance in terms of minimum strength requirement, percentage of eroded particles, percentage of moisture absorbed (ASTM D559-03, ASTM C97-02, NIS 87-2006). These expected performances are predictable irrespective of whether the building fabrics are with or without additional protective coatings or finishings (Alao and Ogunbode, 2019; Riahinezhad, 2021; Alao and Apeh, 2023). The life cycle cost of these building fabrics can therefore be predictable with adherence to these codes thereby enhancing its performance.

1.2 Enhancing the performance of building fabrics using technological process and conceptual design

Enhancing the performance of building fabrics can be achieved using new materials from enhanced technological processes. These include the use of modifying agents or additives that can enhance performance of manufactured products, thus improving greater strength and durability when exposed to climatic factors and other agents of deterioration, (Nilimaa and Zhaka, 2023; Lachheb *et al*., 2023). The use of protective coatings cannot therefore be regarded as a singular solution.

Similarly, architectural conceptual design process is also conceivable which are capable of enhancing performance of building fabrics and cost in use which can considerably reduce deterioration of building fabrics (Alao and Ogunbode, 2019). A conceptual design process primarily refers to an intuitive and knowledge-based reasoning for allocating and maximizing space for functionality, aesthetics and efficiency of an architectural or structural layout. A structural conceptual design process permits an overall development of adequate resistance to strong wind loads, avoids undesirable stress distribution, thereby ensuring robustness of the building. It can also be explored in redirecting load paths aimed at overall optimal structural efficiency while avoiding concepts that creates maintenance concerns (Alao and Ogunbode, 2020; Ruan, 2023).

1.3 Effect of environmental stress on performance of building fabrics

Deterioration factors on building fabrics associated with the effect of climatic conditions are often referred to as environmental stress (Heathcote, 2002; Phillipson *et al*., 2016; Alao and Adedeji, 2020; Barrelas, 2023). This environmental stress can have a considerable effect on the fabrics particularly where adherence to minimum specification requirements normally prescribed in the bill of quantities for building construction works are ignored.

Property owners could incur considerable cost of maintenance over the life cycle not only associated to its use but because of exposure of the fabrics to environmental stress. These environmental stress elements include humidity, cycles of drying and wetting seasons including environmental pollution effects.

2. Methodology

2.1 Testing methods on building fabrics

Resilience of building fabrics when exposed to use and climatic conditions can be determined with the use of some series of tests. Each of the fabrics has its unique characteristics and hence, a method adaptable to one material cannot be generalized for others. Building fabrics characterized by onsite manufacturing process, according to (Heathcote, 2002) can be divided into indirect, simulated and accelerated tests. The methods which measure erodibility of the particles of the fabrics include Wire Brush tests, Spray tests and Surface hardness tests. Others include indirect tests for measuring the performance in service such as Drip tests, Permeability/slake tests and strength tests (Wet/Dry strength Ratio). Each of the fabrics can also have specific behavioural characteristics when in service. A good example can be an unrendered wall of laterite-cement bricks which are usually associated with reversal of stabilization because of moisture intrusion (Heathcote, 2002). These methods of tests are recognized by relevant standards, (ASTM C97-02, ASTM D559-03, NIS 87-2006). These methods are essentially employed to achieve a strength level usually represented by minimum cement required in other to resist field weathering and other environmental conditions.

2.2 Rating methods of building fabrics conditions

Indices are also explored for measuring the condition of building fabrics. There are established standardized procedure adopted by countries for measuring condition of buildings and fabrics essentially to enable establishment of current condition of the building. The Facility Condition Index (FCI) is estimated as the total cost of needed building repairs and renewals divided by the current cost of replacing the fabric. These scores (expressed in ratio or percent) reflect the current condition of the building. The expression and rating as good, fair, poor, or critical are presented in Equation (1) and Figure (1) respectively.

$$\frac{\text{ECRR}}{\text{RV}} \text{ x } 100 = \text{FCI} \qquad (1)$$

Where:
ECRR = Estimated Cost of Repair and Replacement
RV = Replacement Value

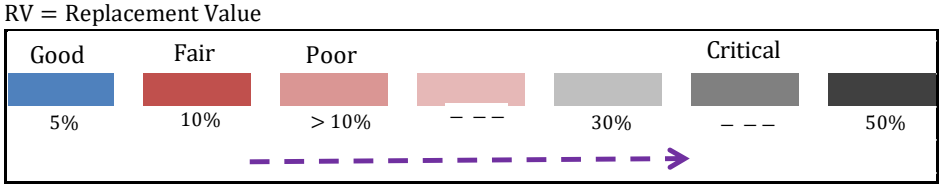


Figure 1: Facility condition index rating

There are similarities in many of the practice procedures. Most of the developed methods centered on building of ratings scale for necessary improvements required including associated costs. Checklists are generally used for the assessments of the building fabrics and indoor environmental quality (Brandt and Rasmussen, 2002; Dejaco *et al*., 2017; NIOB, 2002; Salim *et al*., 2002; ASTM E2018-08, 2008; ASTM E3035-15, 2015). A multicriteria rating method known as Office Building Rating Methodology for Europe (ORME) was also developed by Roulet *et al*. (2002). It is capable of measuring parameters such as energy use for heating, cooling and other appliances, including its impact on external environment, indoor environment quality and cost.

2.3 Measuring percentage of eroded particles using non-destructive testing

A method of non-destructive measurement of erodibility of building fabrics associated with on-site produced finishing materials and products is the Surface hardness test. In contrast to Wire Brush and Spray tests which are carried out on specimen samples, the surface hardness test can be carried out on-site and also on specimen samples. Resistance to rising dampness, avoiding spalling of rendered surfaces, efflorescence, avoiding erodibility problems in the short and long term can be measured indirectly using this method (Rajesh, 2020; Alao and Apeh, 2023). The instrument commonly used is the Mohs' hardness test kit which measures the resistance to scratching on a hardness scale. It is an indirect method of determining the minimum amount of resistance adequate to resist field weathering. Primarily, for concrete composites like cement-sand finishings, the quality of the material is greatly influenced by the quantity of cement which have effects on the long-term performance of the material such as strength, water absorption, capillary movement.

2.4 Rating of hardness on the Mohs' hardness scale

The Mohs' hardness kit is an instrument that can be used to test the resistance to abrasion of an initially smooth surface by scratching when a pressure of approximately 13.3N force is exerted. Diamond, being the hardest mineral can only be scratched by another diamond and is therefore rated highest on the Mohs' hardness scale, and is assigned number 10. Talc is the softest of the minerals on the hardness scale, and is assigned number 1. Minerals above quartz on the hierarchy, are considered hard materials and are commonly used as a reference level with assigned hardness scale number 7. The hierarchy of the hardness scale is depicted in Figure (2) and the handy test kit is shown in Figure (3)

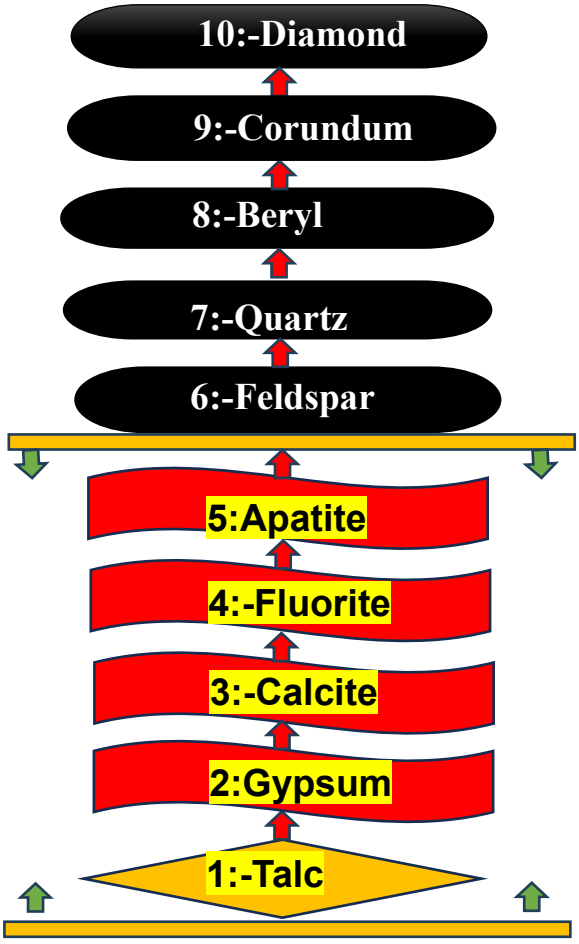


Figure 2: Hardness indices on Mohs' hardness scale

Figure 3: Mohs' Hardness test kit

2.5 Description of the study area

The following are the list of Residential Estates within Minna in Niger State, Nigeria:

i) Talba Housing Estate Bida Road, Minna has 2 bedrooms of 300 units and 3 bedrooms of 200 units.
ii) M.I Wushishi Housing Estate, Western Bye-pass Minna has 2 bedroom of 500 units and 3 bedroom of 46 units.
iii) Shehu Ahmed Musa, Bosso Road Minna
iv) Tunga Low-cost Housing Minna has a total of 288 housing units of both 2 and 3-bedroom housing designs.
v) Bosso Estate, Minna has 500 units of both 2 and 3-bedroom designs
vi) Bosso Low-cost, Minna has a total of 500 housing unit of both 2 and 3-bedroom designs.

In order to examine the variation of building fabric quality for the selected residential buildings, the walls were divided into three levels. They are:

i. Top level (the roof)
ii. Middle level (the wall fabric of buildings)
iii. Lower level (the foundation)

The top level consists of the building cover (roof material), the middle level comprises all the components of the wall fabric (doors, window, wall material, finishing and ceiling cover). The lower level focuses on the building foundation. The roof is the topmost part of a building structure designed to shield the structure from effects of climate variables. Observations within the study showed that three major roofing materials were employed within the study area. They

are: corrugated aluminium, zinc sheets and roofing tiles. Results showed, that of the 200 buildings investigated, 141 made use of corrugated aluminium, 47 made use of zinc sheet and 12 made use of roof tiles.
According to Adesogan (2018), there are eleven primary categories of roof failure, which includes rust, leakage, tearing-off, open lap, truss damage, nail withdrawal, wood decay, sagging, ponding, discoloration, and blown-off. The research identified four common roof failures with the study area: rust, leaks, nail withdrawal, and blow-off. Within the study sample, 134 residential buildings suffered various roof defects most of which were buildings roofed with corrugated aluminium finish. In addition to the identified roof failures within the study area, most of the aluminium sheets were also noticed to gauge between 0.45mm to 0.55mm throughout the study area. The presence of heavy yet fluctuating rainfall readings within the North Central was established to be one of the main cause-effect of the large number of defects and damages on building roofs. Other affecting factors include: building's topography, location, roof geometry, issues with the design, poor installation and construction techniques, a lack of maintenance and age.

3. Results and discussion

3.1 Deterioration Index of the building fabrics

The Facility Condition Index (FCI) was used to characterize the deterioration index of the building fabrics within the study area. It is the total cost of needed building repairs/renewals divided by the current cost of replacing the building fabric. The result is presented in Table (1) for Bosso Estate and Bosso low-cost Estate in Minna, North Central, Nigeria. Table (1) revealed that the finishings of houses in Niger State are fair in terms of ceiling and external walls while finishings are good. In the same vein, the doors and windows fittings are fairly well rated in terms of external doors and windows with poor anti-burglary bars. However, the roof structure and coverings are fair with specific reference to facial board and roof coverings while for the building landscape, the presence of trees to serve as wind breakers and sunshade is fairly well rated with presence of water drains around buildings. Building orientation to wind direction, window sizes and orientation to wind direction are rated good.

Table 1: Conditions of Major building fabrics in residential building designs in Minna, Niger State, North Central Nigeria

S/No	Building fabrics	Rating			
		Good	Fair	Poor	Critical
1	**Finishing**				
	Ceiling	0	50	0	0
	External Walls	0	50	0	0
	Slab Soffits	50	0	0	0
	Floor Finishing	50	0	0	0
2	**Doors and Window Fittings**				
	External Doors	0	50	0	0
	Windows	0	50	0	0
	Anti-Burglary Bars	0	0	50	0
3	**Roof Structure and Coverings**				
	Facial Boards	0	50	0	0
	Roof Coverings	0	50	0	0
4	**Building Landscape**				
	Presence of Trees (Serving as Wind Breakers and Sunshade	0	50	0	0
	Presence of Water Drains Around Buildings	0	50	0	0
	Building Orientation to Wind Direction	50	0	0	0
	Window Sizes	50	0	0	0
	Orientation of Windows to Wind Direction	50	0	0	0

3.2 Deterioration frequency of wall fabrics using severity index

Table (2) reveals that all the defects highlighted are frequently experienced on buildings within the study area, however, the indicators of peeling of paints, flaking of mortar and blistering of paint (formation of bubbles in the exterior decorative paint film) are more rampant when expressed using scales of Very high (VH-5), High (H-4), Average (AVG-3), Low (L-2) and very low (VL-1).

Table 2: Wall Defects and Frequency of Occurrence in Buildings Within the Study Area

S/N	Defect	5	4	3	2	1	Total	Mean	Mean2	Std D	(SI)	Rank
1	Peeling of paints	120	50	20	6	4	200	4.38	20.04	3.957272	87.6	1st
2	Blistering of paints	66	84	30	12	8	200	3.94	16.6	3.558089	78.8	2nd
3	Flaking of mortar	30	120	40	6	4	200	3.83	15.29	3.385262	76.6	3rd
4	Biological growths	20	30	116	24	10	200	3.13	10.65	2.742262	62.6	4th

Table (2) presents data on wall defects and their frequency of occurrence in buildings within the study area. The table includes information such as the number of occurrences for each severity level, total occurrences, mean severity ratings, mean squared severity, and standard deviation. The data shows that the most prevalent defects are peeling of paints and flaking of mortar, while biological growths and blistering are relatively less common. The severity ratings indicate the average level of damage, with peeling of paints having the highest severity. The standard deviation values suggest some variability in the severity ratings within each defect category. The table provides an insight into the types of wall defects and their distribution in the study area

The table presents several columns, including the defect type, mean severity rating, standard deviation, and ranking. The data reveals that peeling of paints is the most severe defect, with a mean severity rating of 4.38, ranking it first among the defects analyzed. Blistering follows closely behind with a mean severity rating of 3.94, ranking it second. Flaking of mortar has a mean severity rating of 3.83, placing it in the third position. Biological growths have the lowest mean severity rating of 3.13, ranking them fourth. The standard deviation values indicate the variability in severity ratings within each defect category. Studies have highlighted biological growth as a factor in the development of architectural flaws (Bortolini and Forcada, 2018)**.** It provides valuable insights into the severity levels and rankings of different wall defects observed in the study area while the severity indices of the symptoms associated with wall defects was computed in Table 4.19.

3.3 Deterioration rating of cement-sand wall fabrics using mohs' hardness indices

The defect patterns resulting from the scaled readings were measured based on Table (3) at heights of 0.0 – 1.0m, 1.0 – 2.1m and 2.1 – 3.0m in the survey. It showed the relationship of compressive strength, ratio of cement-sand mortar, and the corresponding hardness values of cement-sand mortar cubes. The results indicate the need for quality cement-sand mortar mixes to achieve a sustainable and durable cement-sand mortar finish. This is to prevent basic wall finishes defects as well as to prevent excessive rising/capillary movement into walls surfaces.

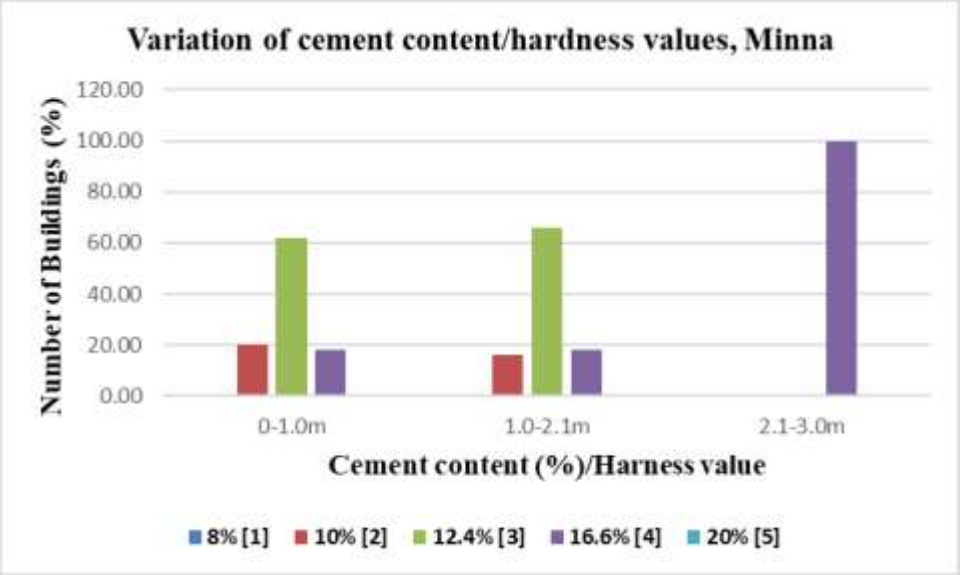
Table 3: Relationship of Compressive strength, Ratio of cement-sand mortar, Percentage cement content and Mohs' hardness value

S/No	Compressive Strength fc(N/mm²)	Ratio of Cem:Sand	Cement (%)	Mohs' Value	Categorical/ Likert Scale Value
(1)	(2)	(3)	(4)	(5)	(6)
1	3.24	1:12	8.0	1	1
2	5.60	1:10	10.0	2	2
3	7.80	1: 8	12.4	3	3
4	10.8	1: 6	16.6	4	4
5	12.7	1: 4	20.0	5	5

*Columns (2), (3) and (5): Adapted from Alao and Apeh (2023)

The Mohs' laboratory hardness value was computed and established (Alao and Apeh, 2023). The field measurements of hardness values of the cement-sand plaster finishes, representing the sampled representative buildings for the 50 units within the government residential estate is shown in Figure (4) for Minna. The hardness scale, the corresponding cement content (%) are as shown.

The values in columns (4) and (5) of Table (3) were used for plotting the chart.



3.4 Measuring economic loss using Mohs' hardness scale

In assessing the economic loss and significant deviation from base line standards from expected quality of cement-sand mortar building fabrics, a simple estimation of the quantity of constituent primary material was used. The Absolute Volume Method of the materials was estimated for typical samples of building units within the sample frame. It represents an estimation of the quantity of constituent materials. The result is shown in Table (4).

Table 4: Economic loss of significant deviation from baseline standards for cement-sand plastered block walls

S/N	Ratio of cement-sand (C:S) mortars	Quantity of Cement/m^3 of mortar (kg)	No of Cement bags/m^2 of plastered wall	No of required Cement bags/400m^2 (2 B/R)	No of required Cement bags/600m^2 (3 B/R)
1	1:4	393.05	0.1179	47.16	70.74
2	1:6	302.34	0.090702	36.2808	54.4212
3	1:8	245.65	0.073695	29.478	44.217
4	1:10	206.85	0.062055	24.822	37.233
5	1:12	178.65	0.053595	21.438	32.157

It can be shown that any significant reduction in quantity of binder, cement reduces the strength and thus the life cycle cost or replacement cost of the fabrics

4. Conclusion

The paper underscores the significance of adherence to performance standards, utilization of advanced technologies, comprehensive testing methods including the use of non-destructive measurement techniques in optimizing the performance and longevity of building fabrics in construction projects. The rating employed will enable a measurement of the durability of building fabrics and also as a measure of its performance and decision or a choice for replacement options in the study area.

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Factors Influencing Implementation of Safety Measures Against Scaffolding Accidents on Construction Sites in Abuja, Nigeria: Systematic Review

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Abstract

Scaffolding accidents are one of the leading causes of injuries and fatalities on construction sites. This systematic review assesses the factors influencing the implementation of safety measures to prevent scaffolding accidents. The review draws on a comprehensive search of scholarly databases, including PubMed, Google Scholar, and others, to identify relevant studies published between [2011] and [2023]. The review concludes that while safety regulations exist, economic and organizational barriers often hinder their effective implementation. Recommendations for improving compliance and prioritizing safety on construction sites are discussed. total of 56 studies met the inclusion criteria, covering various aspects such as regulatory and policy issues, economic constraints, awareness and training, cultural and behavioral factors, quality of safety equipment, and management practices. The findings reveal that regulatory enforcement gaps, insufficient worker training, financial limitations, and negative safety attitudes are the primary barriers to effective implementation of scaffolding safety measures. The review concludes by recommending policy enhancements, improved training programs, economic incentives for compliance, and cultural shifts towards prioritizing safety. These recommendations aim to mitigate scaffolding-related accidents and foster a safer construction environment in Abuja. Further research is suggested to evaluate the impact of targeted interventions on safety outcomes.

Keywords: Accident, Construction Sites, Implementation, Safety Measures, Scaffolding,

1. Introduction

According to Enshassi and Shakalaih (2015), scaffold erection has been defined as a variable that combines all components related to scaffolding safety. Scaffolding is a dynamic process, during the design phase through the construction. Unfortunately, it has been reported that every year, there are several thousand occupational accidents on Polish construction sites, many of them are related to the use of scaffolding (Nowobilski and Hoła, 2023). In addition, falls through roof surfaces were linked to lack of OHS compliance to scaffolds (Enshassi and Shakalaih, 2015).

Working on these work stations is burdened with a high occupational risk, and the possible consequences of an accident are usually very serious. In line with this, it was reported that accidents involving scaffoldings in the Taiwanese construction industry constitute up to 30 % of all fatal accidents in the construction industry (Nowobilski and Hoła, 2023). The causes for the high scaffolding accident rate in the construction industry can be traced to low occupational safety culture, factors directly related to the construction site, factors related to the time when the accident occurred, the organisation of the construction enterprise and its size (Nowobilski and Hoła, 2023).

Analysis of the fatal accidents involving scaffolding in Malaysia revealed that there were about 20 fatal accidents reported to Department of Health and Safety (DOSH) from 2010-2020) out of the cases reported 19 cases (95%) was due to fall from scaffold whereas 1case (5%) was to due collapse of scaffold (DOSH, 2020).

The leading cause of building site accidents in Nigeria include falls from unsafe working conditions and scaffolding (Douglas and Adeloye, 2016). In the same vein, Sanni-Anibire *et al.* (2022) reported that about 40% of all the proportion of industrials accidents in Nigeria come from scaffolding in the construction sector, making it the most perilous industry in the country. In line with this, the most important reason of occupational accidents is unsafe behaviour with a rate of 75%, although the necessary occupational accidents statistics are not well documented in Nigeria (Eguh and Adenaiya, 2020).

According to Kadiri *et al.* (2014), negligence is the main cause of accidents on construction sites, labourers are also the major victims of these site accidents, loss of time in project execution is one of the major effects caused by these accidents in project execution. In addition, lack of awareness and understanding of H&S significantly hinders compliance to H&S, it is therefore pertinent to use enforcement in form of incentives-based approach to take care of the challenges to H&S compliance in Nigeria (Emma-Ochu *et al.,* 2021).

Also, it has been confirmed that the major cause of building accidents is unsafe working conditions and scaffolding due to lack of framework to properly guide workers on safe execution of scaffolding works and lack of compliance to H &S standards on workplace activities (Ogundipe *et al.,* 2018; Adeagbo *et al*., 2019; Adebiyi *et al.,* 2020; Mayanja *et al.,* 2022). The leading cause of building site accidents in Nigeria include falls from unsafe working conditions and scaffolding (Douglas and Adeloye, 2016). In the same vein, Sanni-Anibire *et al*. (2022) reported that about 40% of all the proportion of industrials accidents in Nigeria come from scaffolding in the construction sector, making it the most perilous industry in the country. In line with this, the most important reason of occupational accidents is unsafe behaviour with a rate of 75%, although the necessary occupational accidents statistics are not well documented in Nigeria (Eguh and Adenaiya, 2020).

There is also dearth of literature on ways of addressing accidents resulting from fall from heights, of which scaffolding accidents is a major type. Efforts made in this direction are for developed countries where there are well established laws on H&S on construction sites. Also, Occupational Safety and Health Administration (OSHA), proposes the need for consistent training of artisans and managers about workplace hazards and control in order to ensure safety and productivity (Adeagbo *et al.,* 2019). Training, in this context, is to provide workers and managers with a greater understanding of H&S policies and practices for them to work safely and ensure that their actions and inactions do not harm any other person. These suggestions from other studies carried out in developed nations can be used as a basis for the Nigerian domain to come up with a framework for implementation of safety measures against scaffolding accidents as contained in the OSH law of construction. The construction industry in Abuja, Nigeria, has experienced rapid growth, driven by urban development and infrastructure expansion. However, this growth has been accompanied by a rising incidence of workplace accidents, with scaffolding-related accidents being particularly prevalent. Scaffolding is widely used on construction sites, but inadequate safety practices often result in falls, injuries, and fatalities, posing significant risks to workers' health and safety. Despite the existence of safety regulations and guidelines designed to mitigate these risks, the implementation of scaffolding safety measures on many construction sites remains inconsistent and suboptimal. Various factors, including regulatory enforcement, economic challenges, cultural attitudes, and management practices, may influence the degree to which safety measures are adopted and maintained. These gaps in safety implementation not only endanger workers but also lead to legal and financial repercussions for construction companies. Addressing this problem is critical for improving occupational safety in Abuja's construction sector. There is a need to systematically identify and understand the factors that hinder or facilitate the implementation of scaffolding safety measures on construction sites. This review seeks to explore these factors, providing insights that can inform strategies to enhance safety standards and reduce scaffolding-related accidents in Abuja.

2. Methods

Bennet *et al.* (2015) conducted a systematic literature review to identify, analyse, and evaluate theoretical and empirical studies pertaining to a certain topic or phenomenon. Furthermore, its classification as secondary study is predicated on its aggregation of previously conducted primary studies. This research adheres to the framework established by Fortich (2013), including the following elements: a structured overview, contextual information, objectives of the review, search methodology, selection criteria for resources, findings, and analysis of the results. This paper presents the authors' conclusive results and recommendations. Likewise, the manuscript adhered to the protocols set out by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework; nevertheless, it did not include a meta-analysis. The approach included certain criteria to ascertain the inclusion or exclusion of materials. This facilitated the procurement of the necessary quantity of articles for the systematic review (Hutton *et al.,* 2016). The names of the papers were chosen as the focus for examining passive cooling strategies to streamline the analytical process. This method was used to avoid the complications that would emerge from evaluating the whole article with an excessive word count. A thorough search was conducted across many scientific databases, including Emerald, Scopus, Web of Science, ProQuest, and Scielo. The selection criteria for the present research were evaluated, focussing on publications published during the last fourteen years, namely from 2011 to 2023, for inclusion in the databases. The second requirement was the source; the articles must only derive from academic publications indexed in the aforementioned scientific databases. The final limitation was to the publication language, limiting downloads to English content alone. Conversely, the article omitted grey literature, including conference proceedings, project reports, theses, undergraduate or graduate capstone projects, and dissertations, from our analysis. This conclusion was reached since the study concentrated on downloading articles from esteemed and indexed scientific publications. Files from unreliable sources and those written in languages other than English were also eliminated. Upon acquiring the compilation of included articles, duplicate entries were eliminated to consolidate the material, since there were instances of the same file being detected across many databases. A comprehensive evaluation was performed to analyse both the summary and the whole text, ensuring that the inquiry concentrated on the variables influencing the adoption of safety measures against scaffolding accidents on construction sites. This transpired due to the observation that several papers used the variables in their titles and abstracts. Upon additional analysis of the

remaining material, it was determined that either there was no evidence of these variables or that other factors differed from those first presented.

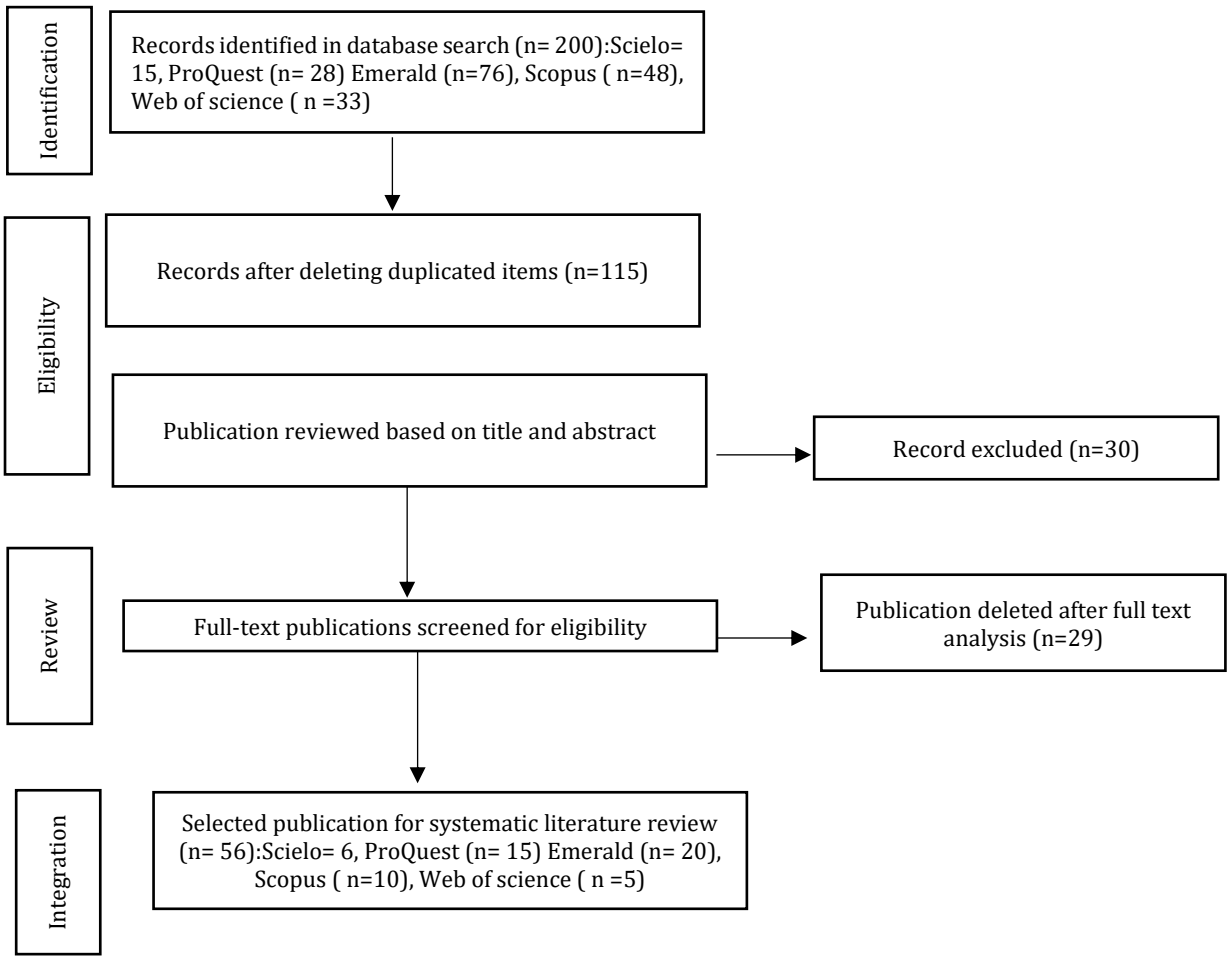

Figure 1: Review Process
Source : Authors (2024)

Finally, 200 items were pulled from the various databases by using the predetermined integration and exclusion criteria. After removing duplicates and going over titles, abstracts, and content, the number of files drastically dropped during the course of the review process (see Figure 1). Eventually, there were only 56 files remaining. Following that, these 56 files were reviewed and then examined in further depth in this paper.

3. Results and Discussion

3.1 Place of origin of publications

A study was undertaken to identify the continents where the majority of studies on the subjects were performed. For pragmatic purposes and enhanced comprehension, they were categorised by continents (see to Table 1). The European continent comprises the majority, with 21 articles out of a total of 56, followed by the Asian continent with 15 publications. Table 1 illustrates a significant disparity in the percentages of documents between the continent with the lowest (America) and the continent with the greatest (Europe) count. The continent with the lowest percentage of scientific studies published on factors influencing the implementation of safety measures against scaffolding accidents on construction sites over the past twelve years is America, with a mere 8% productivity.

Table 1: Place of origin of publications

Continents	Publication
Africa	12
america	8
asia	15
Europe	21
Total	56

Source: Authors (2024)

In summary, research examining the factors influencing the implementation of safety measures against scaffolding accidents on construction sites has been approached from multiple perspectives (individual, organisational, business, financial, and non-financial, among others); however, some studies were excluded due to merely referencing the variables in their titles without offering additional information or evidence of their execution. In a similar manner, the study identified more papers that examined the topic independently throughout the database search; however, it opted not to include them into the current evaluation due to a specific criteria necessitating the consideration of both perspectives.

3.2 Studies by year

This article calculated the yearly number of publications and the corresponding percentages for each year, as shown in Table 1, to discover trends in productivity and determine the years of greatest and lowest output. The aim of this research was to examine the temporal trend in publications and ascertain if there has been an increase or decline. The research sought to determine if the issue has increased in relevance and popularity over the previous decade or whether there has been a fall in interest among academics and professionals.

Table 2: Published studies per year

Year	Studies	Percentage
2011	**2**	**3.6%**
2012	4	7.1%
2013	3	5.4%
2014	5	8.9%
2015	2	3.6%
2016	6	10.7%
2017	3	5.4%
2018	4	7.1%
2019	4	7.1%
2020	2	3.6%
2021	7	12.5%
2022	8	14.3%
2023	6	10.7%
Total	56	100.0%

Source: Authors (2024)

After analysing the results (see Table 1), it was not possible to identify an evolution or a continuous growth of publications in the established period, as expected. Specifically, the number of articles did not increase or decrease as the years went by; they varied without any clear sequence. However, it is possible to observe that the year with the highest number of articles was 2022, with 8, which equals 14.3%. Year 2021 finished in second place with 7 publications 12.8 %,y. On the contrary, 2011,2014, and 2020 was the year with the lowest number of publications, since only two publication was found in that year respectively, which is equivalent to 3.6% of the total.

This systematic review identified a total of [56] studies that met the inclusion criteria and provided insights into the factors influencing the implementation of scaffolding safety measures on construction sites in Abuja, Nigeria. The studies covered various aspects of construction safety, regulatory frameworks, and industry practices. The key findings are organized into the following categories:

1. **Regulatory and Policy Issues**

   Weak Enforcement of Safety Regulations: Liy *et al.,* (2016); Nor Haslinda *et al.,* (2020) highlighted the inadequate enforcement of existing safety regulations in Abuja. Insufficient inspections and penalties for non-compliance were common, leading to inconsistent implementation of scaffolding safety measures. Ogundipe *et al*., (2021),

noted that the safety standards in use were either outdated or not comprehensive enough to cover modern construction practices, resulting in loopholes that allow for substandard safety practices.

2. **Awareness and Training**
   Many construction workers in Abuja lack sufficient knowledge of safety protocols, including proper scaffolding setup and the use of personal protective equipment (PPE). This gap in awareness was attributed to limited safety education and training. The review found that training programs, when available, were often infrequent or not comprehensive enough to cover the necessary safety practices. Workers and site supervisors were not consistently provided with updated training on evolving safety standards (AbdulLateef *et al*. 2021; Darshana, 2017)
3. **Economic Constraints**
   Hamdan and Awang (2015); Deepak *et al.* (2019); Kavya and Pradeep (2019); Zakaria *et al.* (2021) indicated that construction companies often prioritize cost-cutting measures over safety investments. Financial constraints led to the use of substandard scaffolding materials and inadequate provision of PPE. Companies were found to allocate minimal funds for safety management, making it challenging to implement safety measures effectively, especially in smaller or informal construction projects.
4. **Cultural and Behavioral Factors**
   A culture of accepting risks as part of the job was prevalent among workers, which undermined the enforcement of safety measures. Workers often viewed safety practices as secondary to completing tasks quickly. Some workers exhibited resistance to following safety protocols, often due to a lack of understanding of their importance or misconceptions about safety equipment being uncomfortable or hindering productivity (Asumeng *et al.* 2015; Deepak *et al*. 2019; Hammond 2019; Kavya and Pradeep 2019)
5. **Quality of Safety Equipment**
   The review found that substandard or poorly maintained scaffolding was frequently used, contributing to a higher risk of accidents. This was often due to cost-cutting measures or lack of quality control. There was a noted scarcity of essential safety gear on some construction sites, and workers were sometimes required to share equipment, compromising hygiene and safety standards. Asumeng *et al.* 2015; Hamdan and Awang 2015; Liy *et al.* 2016 pointed to a lack of proactive management in enforcing safety measures, with site supervisors not consistently monitoring or prioritizing safety practices. It was observed that many construction companies lacked comprehensive safety policies, making it difficult to systematically enforce scaffolding safety measures.

4. Conclusions

The systematic review reveals that the implementation of safety measures against scaffolding accidents on construction sites in Abuja, Nigeria, is influenced by a range of interrelated factors. Weak regulatory enforcement, inadequate worker training, economic limitations, cultural attitudes toward safety, and substandard management practices were identified as the primary barriers to effective safety implementation. These factors contribute to a higher risk of scaffolding-related accidents, with significant consequences for workers' health and safety as well as legal and financial implications for construction companies. To address these challenges, there is a pressing need for improved enforcement of safety regulations, more comprehensive and frequent safety training for workers, and increased budg*et al*location for safety management. Shifting cultural attitudes toward prioritizing safety over productivity and using quality scaffolding materials and personal protective equipment are also crucial steps. This review underscores the importance of a multi-faceted approach to improving scaffolding safety on construction sites in Abuja, integrating stronger regulatory oversight, financial incentives for compliance, and enhanced safety awareness programs. Future research should focus on evaluating the effectiveness of targeted interventions and policies aimed at reducing scaffolding accidents, potentially incorporating case studies and longitudinal data to provide a deeper understanding of safety dynamics in the construction sector.

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Application of landscape elements for social interaction in public buildings: The Case for FUTMINNA students' centre in Minna, Niger State.

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Abstract

The integration of landscape elements in public buildings significantly enhances social interaction and environmental quality. This study investigates the application of landscape elements in the context of the futminna students' centre in Minna, Niger State, Nigeria. The research aims to identify key landscape elements that promote social interaction among students and to evaluate their effectiveness in enhancing the overall user experience. Through a combination of site analysis, surveys, and observational studies, the study explores how design elements such as green spaces, seating arrangements, and pathways contribute to social cohesion and usability of the students' centre. The findings indicate that thoughtfully designed landscape features not only facilitate social interaction but also create a more inviting and functional environment for users. The study concludes with recommendations for incorporating landscape elements in the planning and development of public buildings to foster community engagement and improve spatial quality.

Keywords: green spaces**,** inclusivity, landscape, social gathering, student community

1. Introduction.

In contemporary educational environments, the role of physical spaces extends beyond mere functionality to fostering social interaction and community engagement (Odumegwu, 2019). The design of educational institutions, particularly student centres, plays a pivotal role in shaping the social dynamics and academic experiences of students. With this understanding, the integration of landscape elements within the architectural design of a Students' Centre becomes paramount. This thesis explores the utilization of landscape elements as a catalyst for enhancing social interaction within the envisioned design of the Students' Centre at the Federal University of Technology, Minna.The Federal University of Technology, Minna, stands as a beacon of academic excellence, with a diverse student body that thrives on collaborative learning and social engagement. As such, the development of a Students' Centre presents an opportunity to not only accommodate the functional needs of students but also to create a vibrant hub that fosters interaction, innovation, and community building. By strategically incorporating landscape elements such as green spaces, communal gathering areas, and interactive installations, the design can transcend its conventional role and become a catalyst for social cohesion and academic enrichment (Emmanuel, 2018) John, 2024 stated that the significance of landscape elements in promoting social interaction cannot be overstated. Green spaces offer more than aesthetic appeal; they provide conducive environments for relaxation, recreation, and informal gatherings. Communal areas designed for group activities, discussions, and cultural events serve as focal points for fostering connections and nurturing a sense of belonging among students.

1.1 Statement of research problem

Public buildings, particularly students' centres, serve as vital hubs for social interaction, collaboration, and community building. However, many of these spaces fail to fully utilize landscape elements that can enhance social interaction and improve the overall user experience ((Hagen, 2022) The lack of thoughtfully integrated landscape design in students' centers often results in underutilized outdoor spaces, limited opportunities for spontaneous social encounters, and an environment that does not adequately support the diverse needs of the student population. This study aims to explore the application of landscape elements such as seating arrangements, greenery, walkways, and recreational areas in students' centers to foster social interaction, create welcoming and inclusive environments, and ultimately enhance the social and academic experiences of students.

1.2 Aim

This study aims to utilize landscape elements for social interaction in the design of students' centre in the study area with a view to enhance students' interractrion

2. Literature Review

Matthew, 2024 states that Landscaping encapsulates a multifaceted approach to the enhancement of outdoor spaces, encompassing a meticulous process of conceptualization, design, and execution. At its core, it entails a delicate balance between artistic expression and practical functionality, aimed at transforming the natural canvas of land into a harmonious symphony of visual delight and usability.Ghorbanzadeh, (2019) also stated that the central to the art of landscaping is the strategic orchestration of various elements, meticulously curated to evoke a sense of tranquility and aesthetic allure. This involves not only the thoughtful arrangement of flora such as plants, trees, and shrubs but also the integration of structural features like pathways, patios, and water elements. Each component is meticulously chosen and positioned to harmonize with the surrounding environment, enhancing both its visual appeal and usability.Furthermore, Ghorbanzadeh,(2019) added that landscaping is an intricate process of sculpting the very fabric of the land itself, wherein the topography is meticulously molded to create captivating contours and focal points. Through the skillful manipulation of terrain, slopes, and elevations, landscapers imbue the landscape with depth and dimension, fostering a sense of intrigue and wonder.Moreover, the art of landscaping extends beyond mere aesthetics, encompassing in also entails a deep understanding of ecological principles and environmental sustainability. By selecting native plants and employing water-efficient irrigation systems, landscapers strive to create outdoor spaces that not only captivate the senses but also coexist harmoniously with the natural ecosystem. (Hagen, 2022) In essence, landscaping is a holistic endeavor that transcends mere decoration, serving as a testament to human ingenuity and our innate connection to the natural world. It is a testament to the transformative power of design, capable of turning mundane landscapes into immersive works of art that enrich the lives of all who behold them (Eldarwish, 2021).

2.1 Contribution to student`s Academic Development

The relationship between students and the natural world stands as a cornerstone for their holistic development and overall well-being. The growing disconnection between youngsters and nature bears profound ramifications for their present and future welfare, manifesting in cognitive deficits and hindered educational progress. Recognizing this, the creation of landscaped areas assumes multifaceted significance, serving not only as aesthetically pleasing spaces but also as havens of hygiene, structure, organization, and instruction. Selecting appropriate landscape features and flora demands careful consideration of environmental factors such as climate and topography, with paramount emphasis placed on ensuring the safety of students (John, 2024).In response to the imperative to reconnect students with nature, initiatives like the Green Schoolyards Project have emerged, aiming to explore the interplay between green environments, heat index, and the health of at-risk youth susceptible to nature-deficit disorder, heat-related ailments, and sedentary lifestyles. Findings underscore the significance of green spaces in mitigating the adverse effects of high temperatures, fostering increased engagement with nature among students (John, 2024).Moreover, studies underscore the pivotal role of green vistas in nurturing students' psychological and cognitive well-being, particularly within classroom settings. The provision of windows overlooking verdant landscapes has been shown to significantly alleviate stress and mental fatigue, underscoring the therapeutic potential of nature-infused educational environments.The impact of landscaping on students transcends mere aesthetics, exerting tangible effects on various facets of their academic and personal development. Among these effects are heightened concentration levels, improved mood regulation, enhanced social interaction, and a deeper appreciation for the natural world. By fostering a symbiotic relationship between students and their surroundings, landscaping cultivates an atmosphere conducive to learning, growth, and holistic well-being. Matthew, 2024 pointed out some of the impacts of landscaping on students in schools which include:

Enhanced well-being

Landscapes that are carefully planned, incorporating lush greenery, expansive open areas, and elements from nature, have demonstrated the ability to decrease stress and enhance the mental health of students.

Types of Landscaping

Two basic types of landscaping

According to (Whyte, 2023) there are two fundamental categories of landscaping, which are;

Hard landscapes

Hard landscapes consist of non-living materials that are static and man-made components of an environment. These encompass various elements such as roads, structures, pathways, walls, sculptures, engineered materials like bricks and metals, as well as synthetic substances like glass and plastics. Additionally, hard landscapes encompass features like paving, stairs, ramps, outdoor lighting, and amenities such as benches. Collectively, these elements define the ground, vertical surfaces, and overhead spaces within a landscape, shaping outdoor areas. (John, 2024)

Soft landscape

Soft landscape encompasses living or natural elements utilized in landscaping, such as vegetation, plant matter, and water features like artificial waterfalls, ponds, lakes, pools, and fountains. When meticulously designed and executed, soft landscapes enrich public areas with allure and dynamism. They serve various purposes including solar shading for buildings, recreational amenities, guidance for pedestrian and vehicular traffic, wildlife habitats, noise reduction, scenic vistas, wind protection, and delineation of spatial boundaries. (John, 2024)

Types of Landscaping Design

The selection of landscaping design primarily relies on factors such as the varieties of plants employed, the local climate and weather conditions, as well as individual preferences (Ghorbanzadeh, 2019).

Naturalistic landscape design

A naturalistic approach, often known as the natural or new perennial garden style, emphasizes the use of indigenous plants, which will differ based on your geographic location. The goal is to opt for resilient, enduring plants that demand minimal upkeep (Ghorbanzadeh, 2019).

Plate i: A natural unhinged Landscape Design
Source; (Eldarwish, 2021)

Cottage garden design

A cottage garden design embodies a romantic and laid-back atmosphere, featuring abundant blooms and lush planting arrangements. It's marked by a rich variety of colors and plant species, often grouped in themed pockets within the garden space. This design style prioritizes dense and informal clusters of edibles, herbs, and flowers, offering a vibrant palette and a diverse range of vegetation compared to more conventional or contemporary styles. Additionally, it's recognized for its characteristic of plants cascading onto pathways and enveloping walls (Odumegwu, 2019).

Modern/ Contemporary landscape design

Modern or contemporary landscape design, on the other hand, prioritizes the functionality and design of the property itself over extensive plantings. This style emphasizes entertaining spaces and functionality rather than a focus on natural elements. It often utilizes sleek materials and asymmetry, presenting bold and visually striking lines throughout the landscape, with hardscape elements assuming a prominent role (Matthew, 2024).

Plate ii; The Edgy hard and soft landscape of a Contemporary Landscape
Source; (Ramirez, 2023)

Elements and Principles of Landscape Design

The design process begins with understanding the client's requirements and the condition of the site, serving as foundational elements for improving outdoor areas. Tangible features like lines, structures, and colors, along with design principles such as balance, contrast, harmony, and proportion, are essential components in crafting both visually appealing and practical landscapes. (Blew, 2020)

3. Research Methodology

This research adopts a mix of qualitative and quantitative research design approach, which is termed "Mixed Method" design (Bamberger, 2012). This method seek to combine the strengths of both quantitative and qualitative evaluations and provide a more comprehensive and multi layered understanding of the topic, there by offering a richer and deeper data set (Bamberger *et al.*, 2010).

4. Data Collection

The data was collected from carrying out survey using 300 copies of a structured questionnaire, which was split into sections which consider; presence, preference and need for landscape in these secondary schools. It is used to find patterns and averages, and test relationships between variables (Bhandari, 2020), through a type of quantitative design approach called "Correlational research design"

4.1 Data Analysis

Perception on presence of landscape elements and features

The results of the mean item score (MIS) employed to rate the presence of landscape elements and features are summarised in the table below.

S/NO	Statements	Always (1)	Very often (2)	Sometimes (3)	Rarely (4)	Never (5)	Mean	Rank	Decision
B6	How often do you observe water features (ponds, fountains) around your school?	36(12.0)	42(14.0)	64(21.3)	34(11.3)	124(41.3)	3.5600	1st	Sometimes
B8	How often do you notice outdoor recreational areas around your school?	40(13.3)	57(19.0)	85(28.3)	64(21.3)	54(18.0)	3.1167	2nd	Sometimes

B7	How often do you observe outdoor seating areas around your school?	82(27.3)	33(11.0)	58(19.3)	40(13.3)	87(29.0)	3.0567	3rd	Very Often,
B9	How often do you spend time outdoors during breaks or after school?	73(24.3)	55(18.3)	106(35.3)	36(12.0)	30(10.0)	2.6500	*4th*	Always
B5	How often do you observe trees or other vegetation around your school?	134(44.7)	48(16.0)	69(23.0)	30(10.0)	19(6.3)	2.1733	*5th*	Always
	Sadness								

Key:) 1 – Always, 2- Very Often, 3- Sometimes, 4- Rarely, 5- Never (John, 2024)

5. conclusion

The finding revealed that the majority of the respondents felt that having outdoor greenery close to their classroom connected them to nature. The findings revealed that the majority perceived that outdoor seating areas have a positive impact on student wellbeing and performance. The respondent perceived that they were sometimes sad about the functional and colourful landscape design. This was followed by those who are sometimes afraid and nervous. The respondent perceived that they sometimes observe water features (ponds, fountains) around the school. Those who occasionally notice the outdoor recreation areas around the school came next. The respondent agreed that lack of awareness is a problem for integrating landscaping. The study concluded that the lack of landscaping in schools, which serves as a method of attention restoration and stress reduction, has a detrimental impact on students' mental and physical health as well as their academic achievements.

6. Recommendations

This study proposes the following recommendations

Landscaping has so many benefits that contribute to man's well-being. Apart from awareness of the need for an attractive environment, there is also awareness of the benefits of the enlightenment programme on beautification.

Architects and landscape designers should make provision for green spaces, trees, and plants in the school's design in order to add to the beauty and aesthetics of the school.

The designers should make provision for the presence of water features such as fountains, ponds, and swimming pools. This can help to provide a soothing atmosphere for learning and assimilation.

School managements should provide students with environment that is climate-friendly. In the summer, it's also crucial to make sure that outdoor educational activities may be carried out in well-ventilated, shaded areas, even when it's raining.

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Ascertaining the Relationship Between Health and Safety Maturity and Performance of Construction Organisations in Abuja, Nigeria

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Abstract

Occupational Safety and Health (OSH) related issues at work place, especially in the construction sector, continue to be a global concern. The prevention of occupational accidents and dissemination of occupational practices in an organisation is to create a good OSH management system in the enterprise; as this does not only affect the productivity of an organisation but also the competition between similar core business. Challenges faced by the Nigerian construction industry with regards to Health & Safety (H&S) such as cost overrun, time overrun, disputes and building collapse among others, has a major role in preventing the benefits of globalization. Health and Safety Maturity (HSM) shows the level at which any organisation can manage its actions and manipulate its internal procedures. Hence, the aim of this study is to ascertain the relationship between Health and Safety Maturity and performance of construction organisations. A survey research design approach was adopted for the study and the study largely derives both qualiitative measures in order to determine the relationship between Health and Safety Maturity and performance of construction organisations. construction organisations that practice OSH and are into building, civil, and heavy engineering works were selected for this study. Correlation analysis was conducted in order to determine the relationship between Health and Safety Maturity and performance of construction organisations and the result was found to be significant ($P < 0.005$). This relationship was modeled using simple linear regression and from the model the result shows that Health and Safety Maturity have a significant effect on the performance of construction organisations. Findings from this research revealed that H&S programmes are rarely implemented on site and recommends that greater efforts are required to improve H&S practices for performance of construction.

Keywords: Construction, Health and Safety, Maturity, Organisations, Performance

1. Introduction

The prevention of occupational accidents and dissemination of occupational practices in an organisation is to create a good OSH management system in the enterprise and establishing an occupational Health and Safety culture; as this does not only affect the productivity of an organisation but also the competition between similar core business (Kartikawati and Djunaidi, 2018).

The term "Health and Safety Maturity (HSM)" is used by organisations to assess performance and their capability to maintain enhanced safety management status (Kartikawati and Djunaidi 2018). HSM shows the level at which any organisation can manage its actions and manipulate its internal procedures, resulting in a better safety performance promoting what is called safety culture. Construction organisations are trying to achieve a safety culture in order to ensure that their activities will neither harm human lives nor the environment (Olutuase, 2014).

According to Okoye (2018), maturity is measured in levels that indicate how capable and matured an organisation is. Maturity levels are depicted in maturity models that describe organisations attitudes regarding safety and behaviours at each increasing level. During the assessment procedure organisations are able to understand their maturity level by the time they define their own attitudes and behaviours towards safety issues, and afterwards will proceed accordingly in order to improve performance.

The fact that a construction job or work environment is considered as highly risky and hazardous does not mean that its susceptibility to accident is not controllable; this largely depends on ''work situation'' which is humanly controllable (Olutuase, 2014). These human controllable elements involve both the leadership and the employees under them. Several factors such as inadequate funding, lack of awareness, lack of management commitment, non-functional legal system, neglect of human rights affecting the implementation of H&S mechanism in Nigeria have been highlighted in the literature, ranging from the parts played by the administrative staffs to the workers and even statutory authorities (Umeokafor *et al*., 2014). Studies have observed that H&S procedures in Nigeria tend to be more reactive in nature; that is waiting for accidents to happen before anything is done. This has resulted in the loss of a large number of human and other resources (Olutuase, 2014). Such reactivity in H&S matters is inimical to the achievement of higher HSM.

Hence, the aim of this study is to ascertain the relationship between Health and Safety Maturity and performance of construction organisations

2. Literature review

2.1 The use of maturity models

Maturity Models are increasingly being applied in many domains, both as a means of assessment and as part of a framework for improvement. David (2013) explained that a maturity model by itself does not guarantee organisational improvement. It is a tool that assist organisations to identify weaknesses but does not fix them. Also, the results of maturity model evaluation help generate improvement plans but not execute the plan. As a result, an understanding of the role of MMs and their use is essential. MMs are mainly used for three purposes, namely:

a. Assessment of strengths and weaknesses ("as-is" assessments) as a descriptive tool;
b. Development of a roadmap for incremental improvement ("to-be" maturity) as a prescriptive tool and
c. for evaluation of a company, compared to standards and best practices of other organisations as a comparative tool (Pöppelbuß and Röglinger, 2011).

MMs provide guidance for action plans and allow organisations to systematically assess their capability to manage its business processes in the best way and continuously monitor their progress (Becker *et al*., 2009; Pöppelbuß and Röglinger, 2011). A structured framework is therefore, provided for describing current capabilities and performance improvement options and strategies. In practice, MMs are usually used to determine the current quality in a particular area through self-assessments. Based on the evaluated level, recommendation for improvements is made and actions also taken. As a consequence, organisations have adopted the maturity model concept as a way to appraise their as-is situation and improve their competences and afterward control the progress of their implementation (Maier *et al*., 2012). With the use of such a technique, management teams of organisations become more critical about their organisation practices, resulting in more periodic reviews and faster production of assessment results. This in turn, enhances managerial competences, strengthens organisational learning, giving priorities to actions and defining roadmaps (Curry and Donnallen, 2012). Despite the lack of a generic standard for maturity model development, more practitioners in many industrial sectors are beginning to embrace the value of maturity models, with its implementation and use growing in popularity across several industrial sectors (Proença and Borbinha, 2016). MMs are quite similar to the management concepts of Business Process Reengineering (BPR) and have attracted the interest of several researchers and organisations. The CMM and its successor the CMMI, which are the most commonly used models have become a reference model for the design of several MMs in various disciplines such as quality or software, showing the different purposes that they might have (Fraser *et al*., 2002).

2.2 Organisational performance in the construction industry

Organisational performance involves analysing a company's performance against its goals and objectives (Yuliansyah *et al*., 2017). In other words, organisational performance comprises actual results or outputs compared with intended works. The analysis focuses on three primary outcomes: shareholder value performance, financial performance, and market performance (Sonson *et al*., 2017). Measuring organisational performance helps business processes know the area requiring special attention from management experts (Panuwatwanich and Nguyen, 2017).

Oladimeji and Aina (2018) opined that organisational performance is a complex construct that cannot be explored using a single method from a single field of study. According to Oyewobi *et al.* (2017), this complex construct is vital in enabling researchers and managers to assess organisations over time and compare them to competitors. Organisational performance is considered an essential criterion in evaluating organisations regarding the environment and the course of action (Saunila, 2016). According to Yaghoobi and Haddadi (2016) and Tripathi and Jha (2017), organisational performance is a measure of how effectively and efficiently a process put in place by an organisation produces results and outcomes along a predetermined dimension target. An organisational performance system should encompass all performance indicators pertinent to an organisation's existence and growth and the means through which organisational goals are achieved (Moulin, 2017).

Considering the view of different authors on the definition of organisational performance, improving the performance of an organisation is necessary to achieve growth in the construction industry and the national economy at large. Table 2.2 highlighted the essential factors for effective organisational performance, identified by Saunila, (2016); Tripathi and Jha (2017); Moulin (2017) and Al Qudah *et al.* (2018). If these factors are properly observed they will lead to the productivity capability of the organisation's products right from inception to completion (Al Qudah *et al.*, 2018). These factors are a priority because the organisation can only stay in business if it achieves higher productivity (Al Qudah *et al.*, 2018). The rest of the factors were quality of the products, human resources, knowledge management, innovations management, environment-friendly practices, industrial sustainability, and professionalism. All these factors were also included in the conventional models used in the measurement of organisational performance (Tripathi and Jha, 2017).

Table 1: Factors for Measuring Organisational Performance

Factors	Description
Productivity	Continuously improve throughout the value chain from project inception to facility management.
Quality of products	Emphasise quality in using workforce, materials, equipment and methods adopted.
Human Resources management	Create a competent workforce through skill upgrading and knowledge enhancement.
Knowledge management	Share best practices to upgrade the level of knowledge of the construction community.
Innovation management	Carry out continuous research and development (R & D) to introduce new and creative methods, materials, tools and equipment.
Environment-friendly Practices	Engage i n sustainable practices to minimise their impacts on the environment.
Industry Sustainability	Generate new opportunities both in the domestic and overseas markets.
Professionalism	Enhance professionalism to improve the image of the industry.

Source: Saunila (2016); Tripathi and Jha (2017) and (Moulin, 2017).

3. Methodology

The study largely derives quantitative measure in order to ascertain the relationship between HSM and performance of construction organisations. Each study has guidelines for who can or cannot participate in the study, these guidelines called eligibility criteria describe characteristics that must be shared by all participants. Study criteria improves the effectiveness of decisions and the reason for undertaking criteria study is to identify major system weaknesses for improvement. H&S in construction is still an area that is not yet matured, the issue of it implementation requires a high level of professionalism and as such certain criteria are outline. The criteria are summarized as follows:

1. The construction organisation must be a large building/civil/heavy/ construction organisation, as they tend to have more records on H&S standard requirements.
2. The construction organisation must have been in building/civil/heavy construction works for a period of not less than twenty (20) years.
3. Such organisation must have an existing construction site.
4. The construction organisation must have a H&S officer, and must have been with the construction organisation for at least a duration of not less than fifteen (15) years.
5. The construction projects that will be selected for this study falls within a period of ten (10) years that is 2013-2022.
6. The cost of construction must be in millions of naira.

Seventy (70) construction organisations out of eighty (80) that are registered with the federation of construction industry (FOCI) and also practise OSH were identified that meet the study criteria and as such seventy (70) of the construction organisations were selected for the study. Data was collected using a structured questionnaire and the inferential method of data analysis was employed for this study.

There was no any sample selection rule adopted this was to make the result reliable and valid because according to Tim Edwin Colbourn of the University College London (2013) that many researchers opined that "the confidence interval surrounding a statistical test results tells you how much you can generalize your results to the whole population as it will tell you the likely range the result will take in the total population, so the larger your sample, the narrower your result which makes your statistical tests more powerful". The analysis of the data was undertaken using the statistical package for social science (SPSS) version 20. Which is a software package used for statistical analysis. It is now named "IBM SPSS Statistics". It is manufacture in Chicago USA, by SPSS Inc. The SPSS Inc is a leading global manufacturer of software used in data analysis, reporting and modeling. In social science study.

4. Results and discussion

Correlation analysis was conducted in order to ascertain the relationship between HSM and performance of construction organisations. Table 2 shows the result of the correlation analysis.

Table 2: performance of construction organisations (PCO)

Component	R	P
HSM	0.030	0.001

listwise N=140

Source: Researcher analysis (2024)

Where;
HSM = Health and safety Maturity.
PCO =Performance of construction organisations.

Table 2 reveals the correlation of HSM and performance of construction organisations, and their correlation is significant at the 0.01 level (2- tailed). N = 140. The Pearson's correlation of the table reveals a positive, strong and highly significant relationship between; HSM and performance of construction organisations.
The Pearson's correlation (r*)* from table 2 is 0.030 while its P< 0.001. This means that HSM has a weak relationship on performance of construction organisations or HSM will only have little or no significant effect on performance of construction organisations. Following the existence of a positive relationship between the variables, there is a need to predict the outcome of the variables. Therefore, simple linear regression was adopted, the simple linear regression seeks to examine the effect of HSM on performance of construction organisations. In the simple linear regression model developed performance of construction organisations is the dependent variable while HSM is the independent variable. The results of simple linear regression analysis are presented in Table 3

Table 3: Model Summary (performance of construction organisations)

Model	R	R square	Adjusted R square	Std error of the estimate
1	.698[a]	.486	.486	1.54887

a. Predictors: (Constant): HSM
b. Dependent Variable: PCO
Source: Researcher analysis (2024)

Table 3 shows 48% (R2 = 48) of the proportion of variation in the performance of construction organisation by HSM. The R2 adjusted is 0.486 implying that the model explains 49% of the variation in the performance of construction organisations within the population leaving 51% unexplained. HSM fail to explain all possible variation in the performance of construction organisations. this implies that the implementation of health and safety maturity drivers remains a perquisite to construction organisations performance. Also, H&S failures might ultimately impact negatively on performance of construction organisations and as such implementing HSM drivers is aimed at reducing or eliminating accidents in constructions, protecting workers and the work place from danger**.**

5. Conclusion and recommendation

Findings from the study reveals a significant and substantial relationship between the two variables which are HSM & performance i.e (productivity, quality of products, human resource management, knowledge management, innovation management, environmentally friendly practices, industry sustainability and professionalism) of construction organisations as the aforementioned performance criteria are influenced either positively or negatively by HSM. The predictor variable is a crucial factor in explaining the target variable behaviour as changes in the predictor variable will likely result in substantial changes in the target variable, this implies that the implementation of health and safety maturity drivers remains a perquisite to construction organisations performance, in line with the findings of this research, the study recommends that greater efforts are required to improve H&S practices for performance of construction.

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Assessment of Building conditions in Government Parastatals; A Case Study of Upper Niger River basin development Authority

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Abstract

The failure of managers of public of public organizations in Nigeria to keep its building facilities in as built/acceptable standard has put many of such buildings in unusable condition and many cases total collapse of the buildings. Poor maintenance of public buildings in Nigeria has led to increased cost of maintenance, early replacement of building components, ill-health to the occupants and short life span of the buildings. The objectives of this study are to evaluate the current physical condition of government parastatals buildings, to identify factors contributing to building deterioration, to assess the impact of building conditions on employee productivity and health, to develop a framework for prioritizing maintenance and renovation efforts and to provide recommendations for improving building conditions. The study adopted building condition survey method to gather the necessary data and analyzed the data using Building Condition Index (BCI). It was found that the average current condition of the buildings surveyed was poor and most of the building components like floors, ceilings, roofs, mechanical and electrical services were in poor conditions. The study concluded that the physical conditions of all the buildings surveyed in Upper Niger River basin were poor. It was recommended that urgent maintenance work should be carry out to restore the buildings concern to as built condition/acceptable standard. This study is important because it would encourage informed decision making for facility management and enhance overall service delivery.

Keywords: As built condition, Acceptable standard, Building condition Index, Public buildings.

1. Introduction

Building is an "enclosure" designed, planned, constructed and managed on standards and specifications established by professional bodies, government and experts who have adequate knowledge of the users and their expectations (Osuagu *et al.,* 2021; Ogunoh, 2014). The primary aim of building is to provide conducive, safe, comfortable, healthy and secured indoor environment to carryout different activities (Osuagu *et al.,* 2021). This can only be achieved through systematic and periodic planned maintenance at regular interval (Ezilyi *et al.*, 2013).

The inadequate maintainance and poor physical condition of governmemt parastatals pose significant risks to employee health, productivity, and overall public service delivery. Despite the critical role of these buildings in supporting public services, there is a lack of systematic assessment and maintenance strategies, resulting in inefficient use of resources, compromised employee well-being, and suboptimal service delivery.

Maintenance are work carried out on buildings to restore or prevent failure so as to keep the building and its fabrics in as built condition. Adequate and correct maintenance of building at regular interval leads to decreasing negative effect on the occupants and environments consequently, improves the quality of life of residents, safety, comfort and durability of buildings and its fabrics (Oviveira *et al.,* 2014 cited in Olagunju, 2021).

Most buildings in Nigeria are inadequately maintained, leading to their gradual deterioration (Ugwu *et al.,* 2018). The situation is worst in public buildings in Nigeria where the maintenance is left in the hands of the managers of public organization. Maintenance of public buildings in Nigeria is near zero in many public organization (Osuagwu *et al.,* 2021; Ojara, 2013). In the educational institution in Nigeria, the maintenance being practiced by majority is unplanned maintenance (Akinsola *et al.,* 2012; Ugwu *et al.,* 2018). This maintenance policy being practiced lows a total failure of the building and its fabrics before repair and in some cases the failure will be beyond repair.

Some of the reasons being giving for poor maintenance of public buildings in Nigeria are inadequate funding, mis priority and outright negligence by the managers of public buildings (Ugwu *et al.,* 2018). Most managers of public buildings in Nigeria, in quest to Amax wealth shift emphasis from maintaining the existing buildings to development of new infrastructures such as roads, power and water when they can get more "Kick back" (Anele, 2010; Florence, 2011; Olarewaju and Anifowose, 2015).

Previous studies on the maintenance of public buildings in Nigeria shows that challenges of maintenance of these buildings were poor quality management in organization, lack of appreciation of the need for maintenance, mis priority and lack of funds (Osuagwu *et al.,* 2021; Ugwu *et al.,* 2018; Ojara, 2013; Siyanbola, 2013). Buildings need to be kept in as built condition for the users to derive maximum satisfaction that will enhance them to perform optimally in their activities (Abigo *et al.,* 2015). The routing maintenance on buildings and its fabrics in many public buildings in Nigeria has become a no-go area, due to mis priority and deliberate negligence by the managers of organization, and bribery and corruption (Oyenuga, 2012). The system of regular and incorrect maintenance being practiced by managers of public building in Nigeria increases pre-matured replacement, increase cost of operating the facilities and waste of related natural and financial resources as well as reducing the life's span of the facilities (Aghili & Mohammed, 2017; Adenuga, 2012; Chan, 2014).

However, a cross examination of previous studies on maintenance of public buildings in
Nigeria, shows that majority of the studies where on educational institutions concentrated in South-West and East. The previous studies focused on maintenance of public buildings, maintenance practices and maintenance management and used questionnaire even when using building condition survey as method of data collection. This study aims to bridge these gaps by providing an in-depth assessment of government parastatals building conditions, exploring the factors contributing to deterioration, and developing a context-specific framework for prioritizing maintenance and renovation efforts.

2. Methodology

This research covers government parastatals in Niger State, Nigeria. Upper Niger River Basin Development Authority, Minna, Niger state was chosen as a case study. The case study was selected because of it's relevance, as a government parastatal involved in water resource management and agricultural development, the authority's building conditions may impact its operational efficiency, also the authority's building stock is diverse, including administrative offices, residential quarters and infrastructural facilities making it suitable for representativeness. It has 5 administrative buildings and to select the sample for this study, a simple random sampling was applied and 3 building was randomly selected for this study. Random sampling ensures that the selected buildings are representative of the entire population and eliminates selection bias, as every building has an equal chance of being selected. A condition survey was carried out on these buildings. The data collected through the survey was analyzed using

Building Condition Index (BCI)
BCI = Asset Current Condition/As-new Condition.

Despite using random sampling, the sample size may not be a representative of the entire population, particularly if the building stock is heterogeneous and this was a limitation faced. Some ethical consideration that was encountered in the condition survey were protecting respondents identities, maintaining data confidentiality and ensuring participants understand the purpose, risks and benefits of the study.

3. Results and discussion

For easy reference and discussion, the selected three buildings were given a code name: UPB1, UPB2, and UPB3. The results obtained from each building were tabulated based on each building and discussion follows immediately.

Table 1 UPB.1

Elements	Description of the physical condition of the building	Current Condition Rating	BCI	Condition Rating
Floor	Generally dirty and minor pot holes here and there.	48	0.51	3
Walls	Stained with dust and minor cracks here and there.	50	0.53	3
Ceiling	Four ceiling boards removed and discoloration of paint on the ceiling boards due to leakages		42	0.44

Doors & Windows	4 window glasses were broken in three offices in UPB1 block.	55	0.58	3	Fair
Roof	Leakages in two offices, roofing sheet decolorized	53	0.56	3	Fair
Electrical Services	Six ceiling fans removed, many of the lighting bulbs are dead	48	0.51	3	Fair
External Surroundings	Generally dirty with overgrown grasses	50	0.53	3	Fair

Condition Rating Scale: BCI 0.00 to 01.9 = 1 (Very poor); 0.20 to 0.49 =2 (poor); 0.50 to 0.74 =3 (fair); 0.75 to 0.94 =4 (good); 0.95 to 1.00 = 5 (excellent)

Table 2: UPB.2

Elements	**Description of The Physical Condition of The Building**	**Current Condition Rating**	**BCI**	**Condition Rating**
Floor	Generally dirty.	60	0.63	3
Walls	Stained with dust and cracks here and there.	40	0.42	3
Ceiling	Four ceiling boards removed and discoloration of paint on the ceiling boards, some ceiling noggins broken	37	0.39	2
Doors& Windows	Some window glasses broken and window lucks damaged.	46	0.48	3
Roof	Leakages in one office and roofing sheet decolorized and two tore	47	0.49	3
Electrical Services	Six ceiling fans removed, many of the lighting bulbs are dead, many switches are bad	48	0.51	3
Mechanical Services	Some WCS and wash hand basin are broken.	46	0.48	2
External Surroundings	Generally dirty with overgrown grasses at the back of the building	47	0.49	3

Condition Rating Scale: BCI 0.00 to 01.9 = 1 (Very poor); 0.20 to 0.49 =2 (poor); 0.50 to 0.74 =3 (fair); 0.75 to 0.94 =4 (good); 0.95 to 1.00 = 5 (excellent)

Table 3 UPB.3

Elements	Description of the physical condition of the building	Current Condition Rating	BCI	Condition rating
Floor	Most of the floor tiles are broken. stained and dirty.	35	37	2
Walls	Stained with dust and minor and major cracks found in some offices.	43	45	2
Doors & Windows	Some window glasses cracked, door hinges in some offices were broken	66	69	3
Roof	Leakages in 4 offices, roofing sheets decolorized	40	42	2
Electrical Services	ceiling fans need cleaning, many of the lighting bulbs are dead	45	47	2
Mechanical Services	One WC broken	54	57	3

Condition Rating Scale: BCI 0.00 to 01.9 = 1 (Very poor); 0.20 to 0.49 =2 (poor); 0.50 to 0.74 =3 (fair); 0.75 to 0.94 =4 (good); 0.95 to 1.00 = 5 (excellent)

Tables 1 to 3 presents the results of condition survey carried out on selected buildings in Upper Niger River Basin Development Authority Minna, Niger state, Nigeria. In table 3.1 block UPB1, the current conditions of the building components indicate that all the components are in fair c0ndition except ceilings and mechanical services. In general, the current condition of UPB1 is fair. This implies that this block of building needs maintenance (Repairs) to be carried out to bring the building to an acceptable standard or in As-new condition.

Table 3.2 presents results of the survey on UPB2. The result shows that only floor and electrical services are in fair conditions. Other components of the building are in poor condition. On the whole the general condition of block UPB2 is poor. This explains that block UPB2 need serious and urgent maintenance to bring the building to a functionable state. That is as-built condition.

Table 3.3 equally present the result of condition survey carried out on UPB3. The result indicate that six out of eight elements/components of the building survey were in poor state, while only two are in fair condition. On average the condition of the building (UPB3) is poor. the poor condition is an indication that the building need urgent maintenance to bring it to as built condition, so as to perform it design function.

The findings of this study are agreement with the previous studies of Ugwu *et al*, (2018); Odeyemi *et al*, (2019) and Eke *et al*, (2017), who investigated maintenance of public buildings in Nigeria and concluded that public buildings in Nigeria are poorly maintained.

4. Conclusions

This research was set out to investigate maintenance of public buildings with a case study of Upper Niger River Basin Development Authority, Minna, Niger state. Based on the finding from the condition survey carried out on the selected buildings, the research concludes that: The conditions of the buildings in Upper Niger River Basin Development Authority, Minna. Niger state are poor. The buildings need urgent maintenance on them to restore the failed components and bring the building to an acceptable standard to perform their deign functions.

Based on this study, it is recommended that government review and update existing policies on infrastructure management, establish national guidelines for building maintenance in government parastatals and provide incentives for parastatals to prioritize maintenance while ensuring adequate funding for infrastural development and maintenance

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Desk Review of Supply Chain Management Practices in Abuja's Construction Sector

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Abstract

Supply Chain Management remains a very important aspect and crux towards product delivery in the construction industry. In the construction industry, supply chain management is the efficient and effective management strategy engaged to improve the performance of the industry with respect to material, expertise, capital and equipment procurement and deployment. Supply chain management practices enable stakeholders to satisfy customers, increase product performance, and reduce cost. The aim of this study is to review the supply chain management practices by the construction industry with a view of proposing an efficient supply chain management service for the construction industry that will increase responsiveness and the performance of the industry. A desk research methodology was employed in this study. This involves the collection of secondary data on supply chain management practices in the construction industry. Documentary analysis is used to analyze the data. Research papers were reviewed with the aim of synthesizing and reporting best practices, drivers, and barriers prevalent in the construction industry. The result of this research is the documented best practices that will give maximum satisfaction to customers, increase product performance and reduce cost. The barriers identified will be used as yardstick to suggest and recommend ways of overcoming the supply chain management challenges. This review will serve as bedrock for maximizing customer satisfaction, improving construction product performance, and controlling cost; through the adoption of top notch supply chain management services in the construction industry.

Keywords: Best Practices, Construction Industry, Performance, Supply Chain Management.

1. Introduction

Supply chain management (SCM) is the efficient and effective management strategy engaged to improve the performance of the industry with respect to material, expertise, capital and equipment procurement and deployment (Oloke, 2023). Cataldo *et al*. (2022) noted that the construction supply chain includes contractors, producers, building materials providers, builders and engineers, the client (customer), as well as individuals, carriers, and other intermediaries who provide warehouse administration. They further wrote that the supply chain is treated as a chain of events and cannot be observed for a single step or stage; the supply chain must be treated as a network. Construction supply chains (CSCs) involve all construction processes: from the initial demands, design and construction, then maintenance, replacement and eventual demolition of buildings and other structures. The construction industry is highly fragmented and consisting of so many temporary organizational configurations. This makes control, a key function of management, very difficult. Despite the nature of the construction industry, it is now that the industry is taking supply chain management seriously. Studer and De Brito Mello (2021) gave us a global perspective by stating that every year, about USD 10 trillion are spent on construction-related goods and services, equivalent to 13 % of the world's GDP, employing 7 % of the world's working population - thus implying that construction is one of the largest sectors of the world economy. Not imbibing best practices in supply chain management can lead to loss in quality, time and cost. Construction supply chain practices implementation in Nigeria still faces significant challenges and barriers. If barriers and challenges are removed or minimized there will be great positive cost implication, customer satisfaction, and fantastic product performance. This research delves into the evaluation of existing best practices, drivers, and challenges / barriers preventing implementation in the supply chain management.

Consistent challenges faced by the researcher in the supply and distribution of building materials to construction companies prompt this study. Existing practices is not seen with contractors, construction companies, and construction sites. Despite the contribution of the construction industry to the economy, its performance and potentials has been affected by a myriad of problems ranging from wastage of construction materials, re-works, scraps and stakeholder's dissatisfaction amongst others (Nawaz and Ikram, 2013). Two-thirds of construction problems are being caused by inadequate communication and exchange of information and data (Tagesse, 2017). Despite above efforts no research have been able to bind various elements (stakeholders, materials, funds, information and relationships) of supply chain management to find their interrelationship and impact on practices and barriers. The lack of continuous improvement,

lack of lean thinking, lack of off-site manufacturing, lack of just in time delivery of services, and lack of sustainability is centered on best practices (Studer and De Brito Mello, 2021). Barriers like lack of planning, lack of proper information dissemination, high operational cost, suppliers patronizing cheaper goods, fluctuation in the cost of materials, lack of compliance to standard norms, lack of adherence to regulatory enforcement, lack of tailored support and training, lack of good IT system management, and lack of stakeholders feedback (Mudigonda *et al*., 2022; and Okafor *et al*., 2022) are all contributory factors to lack of adequate supply of products in the construction industry. The stated issues bordering on supply chain management will continue to jeopardize the performance/efficiency of the construction industry if nothing is done about it. To study further this paper will aim at investigating the supply chain management documented existing practices by the construction industry in Abuja – Nigeria. The following questions will be answered: what are the existing best practices in supply chain management in the construction industry? what are the existing drivers to the implementation of best practices in supply chain management in the construction industry? what are the existing barriers to the implementation of best practices in supply chain management in the construction industry?
From the findings of various authors, it can be seen that only Ahmed *et al*. (2020) contributed on implementation strategies – but for green supply chain management. Most researches were based on identifying drivers or barriers of construction supply chain management practices. A gap exists for the need to outline clear implementation strategies for construction supply chain management practices. Similarly, only Handayani *et al.* (2021) used mixed method. Most researchers on construction supply chain management prefer using only questionnaire; therefore, using a mixed method for the same subject matter gives another perspective to the issue. This is a basis for another research gap. Conducting the study in a cosmopolitan city like Abuja enhances frontiers for the research.

2. Methodology

Qualitative approach was used for this review. Specifically desk research was used. The research methodology employed to address the aim of this review is desk research of publications on A Review of Supply Chain Management Practices by the Construction Industry in Abuja. Secondary data was collected from past research studies and analysed through documentary analysis. Because the result of this review will lean on secondary data, it will reflect the output of other researchers. Relevant publications were gathered to obtain data for this study; a bibliographic survey was conducted via Google Scholar using the string words "best practices" and “drivers” and “barriers” and “supply chain management” – used interchangeably in a moderating mix manner. The choice of Google Scholar is because the database produces recent publications even those published immediately. Documents are presented by Google Scholar ranked by relevance. Publications that their abstract did not reflect meaningful contribution to the researched topic are excluded. Selected and downloaded articles were properly read and scrutinized to ensure relevance. Close attention was paid to the research key words: best practices, construction industry, performance, and supply chain management. Nodes were created for research key words and significant reports from each author were coded and saved into the nodes (A Node is a bucket in which related materials are gathered into one place so that one can easily look for emerging patterns or ideas or themes). All relevant texts were coded into the nodes and aspects that are of interest and essential to this review was then integrated into the study.

3. Results

3.1 Supply chain management in the construction industry

Supply chain management (SCM) is the process of managing the flow of goods and services to and from a business, including every step involved in turning raw materials and components into final products and getting them to the ultimate customer. Effective SCM can help streamline a company's activities to eliminate waste, maximize customer value, and gain a competitive advantage in the marketplace. Supply chain management represents an ongoing effort by companies to make their supply chains as efficient and economical as possible. By managing the supply chain, companies can cut excess costs and needless steps and deliver products to the consumer faster (Fernando, 2024). According to (Ojo *et al*., 2014) there are three components of supply chain management in construction projects which are:

1. The primary supply chain which delivers the material used for the construction.
2. The support supply chain which provides equipment, expertise and materials that facilitates construction.
3. The human resource supply chain that provide the labour force required for the construction.

Ghufran *et al*. (2021) in their research wrote that the supply chain of a corporation comprises merchants, external suppliers, and end users called customers. Ghufran *et al*. (2021) gave the challenges causing hindrance in the adoption of sustainable supply chain management with a particular focus on social dimension in the construction industry (CI). They listed 82 challenges falling under social, environmental, or economic nature. Studer and De Brito Mello (2021) provided different subject areas and associated elements regarding construction supply chain management. It can be seen that elements associated with best practices are inclusive of continuous improvement, lean thinking, just-in-time,

offsite manufacturing, and sustainability. Ghufran *et al*. (2021) research findings show that simulation results predict that due to the lack of top management commitment and lack of corporate social responsibility, project performance decreased gradually to zero after a certain period. Thus, if top management commitment and corporate social responsibility are addressed, then project performance would improve, as these are the two challenges having most of the interrelationships. Okafor *et al*. (2022) research result reveal that little or no visual or information technology system management of material flow, fluctuation in the cost of material required at site, last-minute placement of orders, selecting suppliers or sub-contractors only based on lowest cost, the quality of material delivery not vetted at the site, late material delivery to the construction site, site task planning involving only top cadre or management staff, no physical inspection of the supplier facilities for material vetting, little or no analysis of early or late material delivery to site, and little information sharing between parties in the supply chain are the top 10 lapses of supply chain management in Nigeria's construction industry. This was determined by performing a severity index analysis of the lapses. Okafor *et al* (2022) indicated six principal element groups – for lapses, namely (1) the firm's negligence, (2) the firms' lack of economic framework, (3) the professional's relationship, (4) the firm's inadequate quality assurance policy, (5) the firm's decision-making procedure, and (6) the firm's weak information management strategy. Okafor *et al*. (2022) findings imply that adequate corrective measures can be derived from these elements. Oloke (2023) research results emphasized the importance of building a comprehensive supply chain management plan that addresses each component of the practice in order to ensure smooth and effective contribution of various parties and increase the success rate of the supply chain management in building industry.

3.2 Supply chain management practices

Handayani *et al.* (2021) wrote that 7 (seven) factors influence GSCMs adoption in construction projects in Central Java, Indonesia. Of the seven factors, four are driver factors, and three are barrier factors. The 7 factors are listed as follows: commitment to protect the environment, government regulations on environmental protection, inadequate knowledge and awareness about the impact of construction activities on the environment, shortage of greening experts in construction areas, desire to create a good reputation, pressure from the supply chain stakeholders, and shortage of suppliers who implement green supply chain management (GSCM) practices in the construction area. Akaleme and Mohammed (2022) gave components of SCM practices. Cataldo *et al*. (2022) researched and wrote that several issues of sustainable supply chain management in construction have been found to include environmental, economic and social patterns which are most commonly known as the triple bottom line, typically enhanced by artificial intelligence. After an exhaustive literature review, 59 research questions were formulated for future research. Cataldo *et al*. suggested that in the future, the importance of these questions could be determined using expert questionnaires and multi-criteria evaluation.

3.2.1 Best practices (what are the existing best practices in supply chain management in the construction industry?)

Studer and De Brito Mello (2021) provided different subject areas and associated elements regarding construction supply chain management. It can be seen that elements associated with best practices are inclusive of continuous improvement, lean thinking, just-in-time, offsite manufacturing, and sustainability. Akaleme and Mohammed (2022) list components of SCM practices by ranking to include (this reflects level of adoption of management practices): reduction in wastage, sharing and use of knowledge and skills, reduction in time, decrease in cost and expenses, logistics management, sharing information, management of suppliers in the chain, speed and flexibility in responding to clients demand, early involvement of members, adequate financial management, long term integration and partnering, strong financial flow, incentive of suppliers, strong relationship development and trust, transparency between the suppliers, dedication to same goal, integrated project delivery, development of suppliers in the chain, building information management, and advancement of newest technology or products and techniques.

3.3 Drivers to best practices in supply chain management

Wuni and Shen (2023) findings revealed that design for SCM, effective communication and information sharing, organizational readiness and familiarity with modular integrated construction (MiC), seamless integration and coordination of supply chain, early involvement of critical supply chain stakeholders and extensive supply chain planning are the top five critical success determinants of effective SCM in MiC projects. The 20 success determinants are categorized into five: project strategy, bespoke competencies, process management, stakeholder management and risk management. Kikwasi *et al*. (2023) gave 48 factors for implementing SCM. Their result indicates that 6 factors are the most implemented, 23 are implemented, and 19 are implemented on average.

3.3.1 Drivers (what are the existing drivers to the implementation of best practices in supply chain management in the construction industry?)

Wuni and Shen (2023) called drivers 'success factors' then provided 20 success elements, viz: design for supply chain management; information and communication technology solutions; improved interfaces between offsite and onsite work packages; seamless integration and coordination of supply chain; hedging and transport delay avoidance; long-term relationship and partnership; extensive supply chain planning; effective communication and information sharing; collaborative procurement system and contracting; effective coordination and management of stakeholders; managing disruptions, disturbances and failure points; early involvement of critical supply chain stakeholders; managing complex stakeholder relationships and networks; managing and avoiding dysfunctional supply chain conflicts; engaging competent and experienced key players; top management support and commitment; effective leadership of a specialist contractor; organizational readiness and familiarity with mic; adequate resources and funding; and competent specialist management team. Kikwasi *et al*. (2023) gave 48 SCM factors with their corresponding implementation level, by ranking: provide logistics at lower cost (most implemented), provide on-time delivery to customers (most implemented), have a centrally coordinated logistics function (most implemented), top management's commitment and support (most implemented), supply chain performance contributes to cash flow (most implemented), planning and involving customers and stakeholders in demand management (most implemented), JIT delivery (implemented), inter-organisation information systems to coordinate integrate the entire supply chain (implemented), teamwork and inter-organisational coordination (implemented), deliveries in full and on time to customers (implemented), effective use of enterprise resource planning (ERP) and material requirements planning (MRP) systems (implemented), JIT manufacturing (implemented), responsiveness to meet engineering changes (implemented), monitoring and measuring customer service level (implemented), intra-organisational information coordination and sharing (implemented), company-wide coordination and management of inventory (implemented), superior quality services compared to competitors (implemented), a 360° view of customer needs and performance (implemented), vendor managed inventory at production sites (implemented), partnership with suppliers (implemented), information sharing with supply chain partners (implemented), sell-through information (point-of-sales data) from distributors, partners and retailers (implemented), a process to manage customer dissatisfaction returns (implemented), low inventory driven costs (implemented), optimising supply chain via efficient customer response (ECR) system (implemented), supply chain performance is continuously improving (implemented), outscoring of non-core manufacturing activities (implemented), customers are very satisfied with our supply chain capabilities (implemented), there is high employee morale and productivity (implemented), effective management of customer complaints (implemented on average/low), effective use of internet to manage business to business commerce (implemented on average/low), cycle times from supplier to customer delivery are excellent (implemented on average/low), effective use of internet to manage business to consumer commerce (implemented on average/low), collaboration and bidding for parts and commodities via the internet (implemented on average/low), high utilisation of employees' skills and abilities (implemented on average/low), quick resolution of industrial disputes (implemented on average/low), eliminating non-value layers like wholesalers in the supply chain (implemented on average/low), supply chain cost is low compared to competitors (implemented on average/low), company-wide purchasing contracts for best pricing (implemented on average/low), employees are involved in SCM (implemented on average/ low), regional distribution centres for product distribution (implemented on average/low), product design for environmental and recycling needs (implemented on average/low), product customisation or postponement to meet customer needs (implemented on average/low), employees are trained in supply chain concepts and management (implemented on average/low), employees are empowered to make decisions and changes (implemented on average/low), focus on reducing the number of suppliers (implemented on average/low), automated warehouse management systems (automatic storage and retrieval system) (implemented on average/low), and effective use of multiple media to manage customer relationships (implemented on average/low).

3.4 Barriers to implementing best practices

Ahmed *et al*. (2020) findings show five barriers at the top of the pack, being: insufficient policies, incentives, regulations or commitment by leaders or top management; lack of legal enforcement by the government for GSCM or government support; lack of public awareness/interest; insufficient training and guidance; and lack of information distribution or understanding among construction organisations and suppliers or stakeholders, i.e. stakeholders' engagement and collaboration. Okafor *et al*. (2022) revealed that the top two most severe challenges are slow IT adoption in material flow management and below-par worker training and motivation. Mudigonda *et al*. (2022) wrote and gave the following as the most major obstacles we face now in incorporating SCM into existing practices: uncertainty about the effectiveness or implementation; the absence of a proven model of cost, quality, or other improvement through SCM implementation in our industry; inadequate top-level management buy-in, resulting in insufficient resource allocation; opposition to web-enabled technology; resistance to incorporating the far more transparent, value-driven SCM method

into present intuitive, person-driven practices; and our inability to move our attention from managing day-to-day challenges to investing time and resources to give decision makers and users with a long-term strategy shift.

3.4.1 Barriers (what are the existing barriers to the implementation of best practices in supply chain management in the construction industry?)

82 challenges causing hindrance in the adoption of sustainable supply chain management as itemized by Ghufran *et al*. (2021) were given alongside their nature. Some of them are listed here, viz: lack of top management commitment (social), lack of training and education (social), complexity to design, reuse, recycle product (environmental), financial constraints (economic), supply chain configuration (social), organization culture (social), health and safety (social), lack of awareness (social), company policies (social), environmental performance (environmental), lack of trust (social), less involvement in environmental related programmes and meetings (environmental), high cost for waste disposal (economic), return on investment (economic), suppliers' top management commitment (social), lack of resource (human) (social), lack of corporate social responsibility (social), child labour and forced labour (social), discrimination (social), human rights (social), stakeholder engagement (social), lack of awareness about reverse logistics (social), suppliers firm culture (social), inadequate performance measurement (social), vendor selection (social), lack of strategic planning (social), employment creation (social), gender inequality (social), green induced changes (environmental), product quality (environmental), and lack of effective environmental measures (environmental). Ahmed *et al*. (2020) findings show five barriers at the top of the pack, being: insufficient policies, incentives, regulations or commitment by leaders or top management; lack of legal enforcement by the government for GSCM or government support; lack of public awareness/interest; insufficient training and guidance; and lack of information distribution or understanding among construction organisations and suppliers or stakeholders, i.e. stakeholders' engagement and collaboration. Akaleme and Mohammed (2022) in their findings ranked 15 challenges of SCM in order of priority: inability of suitable integration of organizational internal procedures, organizational resistance to change, temporary nature of relationship between parties, lack of trust inside and outside organization, diverse objectives, lack of knowledge and understanding of SCM, ignorance and unawareness, lack of skilled or competent persons involved to ensure implementation and handle inconsistencies, unfair risk allocation, lack of guidance, ineffective communication, lack of knowledge of downstream agents about upstream agents' decisions, several layers of subcontracting, myopic mindset, and inadequate investment in IT. Wong *et al*. (2023) results also revealed that the critical barriers for the GSCM were lack of company's leadership and support, lack of awareness, and lack of sustainable GSCM practices. Both Mudigonda *et al*. (2022) and Okafor *et al*. (2022) gave what should be ten top challenges or barriers in the implementation of supply chain management best practices – shown in Table 1.

Table 1: Mapping and new creation for barriers of supply chain management.

S/NO	Mudigonda *et al*. (2022) - top ten barriers in implementation of sustainable strategies.	Okafor *et al*. (2022) - top 10 lapses of supply chain management in Nigeria's construction industry.	Mapping and new creation.
1	High impact of environmentally friendly and sustainable practices on the final cost of product in the market.	Site task planning involving only top cadre or management staff.	Practices and planning impact cost of the final product.
2	Lack of proper information sharing between different competitors in the industry.	Little information sharing between parties in the supply chain.	Lack of proper information flow among stakeholders.
3	Initially high operational costs to comply with sustainability standards.	Last-minute placement of orders.	High operational cost and last-minute transactions.
4	High demand for cheaper products rather than sustainable products.	Selecting suppliers/sub-contractors only based on lowest cost.	Suppliers/sub-contractors and cheaper products.
5	High costs for purchasing environmentally friendly materials.	Fluctuation in the cost of material required at site.	Fluctuating high cost of materials.
6	High costs in adapting sustainable and environmentally friendly norms.	Late material delivery to the construction site.	Complying with standard norms.
7	Lack of strict regulatory enforcement.	The quality of material delivery not vetted at the site.	Adherence to regulatory enforcement.

8	Lack of tailored support and training regarding implementation strategies with respect to construction industry technology.	Little or no analysis of early or late material delivery to site.	Tailored support and training.
9	No proper long-term strategies in place towards a sustainable development technology.	Little or no visual/IT system management of material flow.	Long term strategies and visual/IT system management.
10	Lack of proper customer feedback regarding the need for sustainability in the supply chains.	No physical inspection of the supplier facilities for material vetting.	Stakeholders' feedback.

Source: creation of the author. Drafted from Mudigonda *et al*. (2022) and Okafor *et al*. (2022).

4. Discussion

Tagesse (2017) findings show that supply chain management practices are moderately applied. Okafor *et al*. (2022) proffered two most severe challenges: slow IT adoption in material flow management and below par worker training and motivation. Tagesse (2017) finding state that two-third of construction problems are being caused by inadequate communication and exchange of information and data. Kikwesi *et al*. (2023) gave most implemented six factors. Ahmed *et al*. (2020) and Okafor *et al*. (2022) gave principal barriers. Being that this review is limited by the findings of authors of sourced works and availability of resources on Google Scholar, there will be the need to use this review as input for more extensive research.

5. Conclusion

In this study, recent developments in the areas of best practices, drivers, challenges, and barriers of supply chain management in the construction industry were discussed. This review creates a better understanding on supply chain management practices by examining documented practices in the construction industry. From the reviewed literature, best practices include: continuous improvement, lean thinking, just-in-time, offsite manufacturing, and sustainability. Components of supply chain management practices include: reduction in wastage, sharing and use of knowledge and skills, reduction in time, decrease in cost and expenses, logistics management, sharing information, management of suppliers in the chain, speed and flexibility in responding to clients demand, early involvement of members, adequate financial management, long term integration and partnering, strong financial flow, incentive of suppliers, strong relationship development and trust, transparency between the suppliers, dedication to same goal, integrated project delivery, development of suppliers in the chain, building information management, and advancement of newest technology or products and techniques. 20 success elements seen as drivers were listed to include: design for supply chain management; information and communication technology solutions; improved interfaces between offsite and onsite work packages; seamless integration and coordination of supply chain; hedging and transport delay avoidance; long-term relationship and partnership; extensive supply chain planning; effective communication and information sharing; collaborative procurement system and contracting; effective coordination and management of stakeholders; managing disruptions, disturbances and failure points; early involvement of critical supply chain stakeholders; managing complex stakeholder relationships and networks; managing and avoiding dysfunctional supply chain conflicts; engaging competent and experienced key players; top management support and commitment; effective leadership of a specialist contractor; organizational readiness and familiarity with mic; adequate resources and funding; and competent specialist management team. Barriers of supply chain management were listed to include: practices and planning that impact cost of the final product, lack of proper information flow among stakeholders, high operational cost and last-minute transactions, suppliers/sub-contractors and cheaper products, fluctuating high cost of materials, complying with standard norms, adherence to regulatory enforcement, tailored support and training, long term strategies and visual or information technology system management, stakeholders' feedback. This study can be used as guidance for future studies.

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Space Optimization of Office Workspace in Telecommunication Offices in Abuja, Nigeria

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Abstract

In recent years, experts in the construction industry have been faced with the challenge of optimizing available spaces in telecommunication buildings. As a result, interest in sustainable development as means of solving this problem has grown exponentially. Office space is one of the critical factors in managing an organization. Without efficient optimization, the organization has to bear many problems such as high cost and inefficiency of space utilization and optimization. Hence, this paper aims to review the optimization of spaces in telecommunication office buildings. The distribution of buildings and office space across departments and staff is a difficult undertaking in large corporations. An organization's workforce synergies may be maximized through optimal office space utilization. This study identifies important elements impacting space usage and makes useful recommendations using empirical data analysis, workplace observation, and stakeholder interviews. The results indicate that the use of digital technology, ergonomic furniture, and flexible workspace designs may considerably improve employee happiness and productivity. The use of Space-efficient layouts, Technology integration, Vertical utilization are the basic methods used to optimize telecommunication offices. To achieve the desired objectives, a descriptive research design was employed using qualitative research method. Intensive literature review of journals, books, and observation of existing telecommunication offices. 100 questionnaires were administered o the staffs of telecommunication offices. The study provide practical insight and recommendations for architects seeking to optimize telecommunication office spaces to be better planned, functional and used.

Keywords: Facilities management, performance management, physical space, space, space management

1. Introduction

In recent years, experts in the construction industry have been faced with the challenge of optimizing available spaces in telecommunication buildings. As a result, interest in sustainable development as means of solving this problem has grown exponentially. Office space is one of the critical factors in managing an organization Allen, T. (2016). Without efficient optimization, the organization has to bear many problems such as high cost and inefficiency of space utilization and optimization. Hence, this paper aims to review the optimization of spaces in telecommunication office buildings Johnson, M. (2021).

The distribution of buildings and office space across departments and staff is a difficult undertaking in large corporations. An organization's workforce synergies may be maximized through optimal office space utilization (Kumar & Singh, 2020). This study identifies important elements impacting space usage and makes useful recommendations using empirical data analysis, workplace observation, and stakeholder interviews. The results indicate that the use of digital technology, ergonomic furniture, and flexible workspace designs may considerably improve employee happiness and productivity (Smith *et al*., 2019).

Workspace optimization and office building design in the telecommunications industry are critical factors that influence company culture, promote teamwork, and increase efficiency (Jones & Patel, 2021). The telecommunications sector is marked by swift technological progress, shifting consumer tastes, and fierce competition (Anderson, T. 2021). As a result, workplace optimization has become a critical strategic need for organizations looking to improve productivity, morale, and corporate outcomes (Harrison, A., & Wheeler, P. 2020). This chapter offers a full overview of the study topic "Space Optimization of Workspace in Telecom Offices," delving further into its background, importance, goals, and organization.

The strategic planning, designing, and managing of office spaces to optimize effectiveness, productivity, and worker well-being while reducing expenses and resource usage is known as office workspace optimization (Davis, L, 2021). In order to establish an environment that supports the many demands and activities of employees, it entails examining and enhancing a number of physical workplace elements, such as layout, furniture arrangement, technology integration, and environmental conditions (Li *et al*., 2018). Important elements of optimizing an office workplace consist of:

Space Utilization: Making effective use of the space at hand to support a variety of uses and activities, including private workspaces, group work spaces, conference rooms, and communal areas. Optimizing storage solutions, integrating flexible workstations, and rearranging layouts may all be necessary to maximize the amount of square footage that is accessible (Johnson & Lee, 2021).
Layout Design: The thoughtful placement of furnishings, tools, and facilities to promote cooperation, communication, and efficiency. Open-plan designs that foster collaboration and communication, private or semi-private areas for concentrated work, and ergonomic layouts that enhance comfort and wellbeing are a few examples of this (Kumar and Singh, 2020).

1.1 Statement of the Research problem

Despite the recognized importance of optimizing workspace in telecom offices, a multitude of challenges persist, hindering the effective implementation of workspace optimization strategies. These challenges encompass various dimensions, including:
Inflexible design, technological integration, employee well-being, operational resilience.

2. Aim

The aim of the research is to investigate, analyze, and propose effective strategies for optimizing office workspace in order to enhance organizational performance, employee satisfaction, and overall workplace effectiveness within the context of a specific industry or organizational setting, with the following specific objectives:

1. To conduct a comprehensive review of existing literature on workspace optimization and its applicability to the telecommunications industry.
2. To examine current practices, trends, and challenges associated with workspace optimization in telecom offices, drawing insights from empirical studies, industry reports, and expert perspectives.
3. To identify best practices, innovative approaches, and emerging trends in workspace design, layout, and utilization within the telecom sector.

2.1 Concept of Space optimization

Space optimization in a telecom office involves the strategic design and use of office space to enhance operational efficiency, reduce costs, and improve overall productivity. This concept is particularly relevant in the telecom industry, where rapid technological advancements and evolving business needs often require flexible and efficient use of space. Below is a detailed exploration of space optimization concepts specific to telecom offices, including references to practical examples and studies.

Space Planning and Layout

- **Open vs. Closed Layouts:** Decide between open-plan offices, which can foster collaboration but may also lead to distractions, and closed or semi-closed layouts that provide privacy but may limit interaction.
- **Flexible Workspaces:** Incorporate modular and adaptable workstations that can be reconfigured as needed to accommodate changing team sizes or project requirements.
- **Dedicated vs. Shared Spaces:** Evaluate the need for dedicated offices versus shared workspaces. For example, shared desks or hot-desking can be effective if employees have varying schedules.

2. Technology Integration

- **Telecom Equipment Placement:** Strategically place telecom equipment, such as servers and networking hardware, to ensure efficient use of space and easy access for maintenance.
- **Ergonomic Considerations:** Incorporate ergonomic furniture and workstation designs to enhance employee comfort and productivity.

3. Collaboration and Communication Areas

- **Meeting Rooms:** Designate specific areas for meetings, brainstorming sessions, and collaborative work to keep noise levels down and provide necessary privacy.
- **Breakout Zones:** Create informal spaces where employees can gather, relax, and collaborate in a less structured environment.

3. Research Methodology

The research method refers to the techniques and procedures that researches use to collect and analyze data in order to answer research questions and test hypotheses. This method includes qualitative which includes interviews, focus groups, observation and quantitative

The quantitative method uses a structured survey aligned with the study's aim via questionnaires which consists of 5-point like scale questions. This is used to measure the opinions of respondents on how well their office spaces have been optimized. The questionnaires were hand-delivered to respondents within the study area. Purposive Sampling was employed in the sample selection because it enables respondents that are likely to provide rich and detailed information to make their best contribution in answering the research questions. The quantitative data for this study is obtained from questionnaire distribution and is presented descriptively and statistically in tables. One hundred 100 questionnaires were distributed, 92 were completed and received. This constituted a response rate of 92%. There were 92 questionnaires returned for valid analysis.

Table 1: Participants' response rate

S/No	Location	Distributed	Returned	Not Returned	Rate (%)
1	GLO OFFICE MINNA	25	23	2	92
2	MTN HEAD OFFICE IN ILORIN	25	24	1	96
3	NOKIA OFFICE LAGOS	25	22	3	88
4	NATIONAL PRODUCTION CENTRE	25	23	2	92
5.	Total	100	92	8	92

3.1 Discussion of Results

Table 2 presents the analysis of the general information provided by users. As regards the gender of the users, 73.9%, which accounted for the majority, were male, while 26.1% were female. The findings with respect to the age bracket reveal that 28.3% are between the ages of 30 and 49, 25.0% are between the ages of 50 and 59, 20.6% are between 40 and 49 years, 5.2% are 60 years of age and older, and the remaining 10.9% are between the ages of 18 and 29 years. Regarding the highest level of education that the users have attained, 4.3% are minimum SSCE certificate holders, 7.7% hold OND degrees, 13.0% hold HND degrees, 50.0% hold bachelor's degrees, and the remaining 25.0% hold master's degrees. The findings on employment status reveal that 5.4% of the users were students, 42.4% were employed, and 52.2% were self-employed.

Table 2: General Information for Users and Professionals

Variable	Frequency	Percentage
Gender		
Male	58	73.9
Female	34	26.1
Total	**92**	**100.0%**
Age bracket		
18-29	45	30.9
30-39	36	25.3
40- 49	19	18.8
50-59	23	15.0
60 and above	14	10.0
Total	**92**	**100.0%**
Highest level of education		
SSCE	4	4.3
OND	7	7.7
HND	12	13.0
Bachelor's Degree	46	50.0
Master's Degree	23	25.0
Total	**92**	**100.0%**

Determine the Effect of spaces optimization on the Users of Telecom offices

The results of MIS, which was employed to rate the effect of biophilic design principles on the users of hotels, are summarised in Table 3.

Table 4: Effect of space optimization on the users of telecom offices

SN	Variables	S.D(1) Freq (%)	D.A(2) Freq (%)	N (3) Freq (%)	A(4) Freq (%)	S.A (5) Freq (%)	Mean score	Rank
1	Do you feel more comfortable at working in an office with open plan layout?	2(2.3%)	3(3.6%)	4(14.9%)	64(69.3%)	9(9.9%)	4.20	1
2	Do you feel that integration of technology into office enhance working experience?	3(3.3%)	5(4.6%)	16(17.8%)	60(65.4%)	8(8.9%)	4.15	2
3	Do you agree that good furniture layout improve your comfort in your offices?	5(5.2%)	4(4.9%)	23(25.2%)	49(52.8%)	11(11.9%)	4.00	3
4	Do you agree that most offices spaces aren't well planned?	9(9.6%)	4(4.6%)	20(21.7%)	29(31.1%)	30(33.0%)	3.90	4
5	Do you agree that offices with well planned spaces and layout have adverse effect on there staff ?	7(7.6%)	9(9.9%)	14(14.9%)	46(49.8%)	16(17.8%)	3.85	5
6	Do you prefer to go to offices or work from home ?	8(9.2%)	7(7.2%)	14(14.9%)	37(40.6%)	26(28.1%)	3.83	6
7	Do you think more offices should work on optimizing there office spaces?	11(11.8%)	5(5.3%)	14(14.9%)	29(31.7%)	33(36.3%)	3.80	**7**
	Average MIS			***11(11.8%)***	***5(5.3%)***		***3.96***	

Mean score range: Strongly disagree (0.01 to 1.00); disagree (1.01 to 2.00); Neutral (2.01 to 3.00); Agree (3.01 to 4:00) and Strongly agree (4.01 to 5.00)
Source: Author (2023)

Identify the Relevant space optimization technique in telecom office Design

The results of MIS, which was employed to rate the Identify the relevant space optimization techniques in telecom office design are summarised in Table 5.

Table 5: Identify the relevant space optimization technique in telecom office design

SN	Variables	S.D(1) Freq (%)	D.A(2) Freq (%)	N (3) Freq (%)	A(4) Freq (%)	S.A (5) Freq (%)	Mean score	Rank
1	Do you agree that 0ffice spaces can be fully optimized?	4(4.1%)	11(11.6%)	8(8.5%)	60(65.5%)	9(10.3%)	4.00	1
2	Do you agree that offices spaces can be fully user friendly?	7(8.2%)	14(15.1%)	2(2.3%)	59(63.8%)	10(10.6%)	3.95	2
3	Do you agree that furniture arrangement and layout can help space optimization?	6(6.9%)	12(12.6%)	8(8.6%)	55(60.4%)	11(11.5%)	3.80	3
4	Do you agree that our office places most times do not conform with the usage of staffs?	13(14.1%)	5(5.6%)	5(5.9%)	53(58.6%)	15(15.8%)	3.70	4

5	Do you agree that having office work flow enhance your productivity?	3(3.1%)	9(10.5%)	19(20.6%)	51(55.3%)	10(10.5%)	3.65	5
6	Do you agree that offices should try different office layouts for different office units?	5(5.2%)	8(8.4%)	14(15.1%)	50(55.2%)	15(16.1%)	3.60	6
	Average MIS						***3.78***	

Mean score range: Strongly disagree (0.01 to 1.00); disagree (1.01 to 2.00); Neutral (2.01 to 3.00); Agree (3.01 to 4:00) and strongly agree (4.01 to 5.00)

Source: Author (2023)

4. Conclusions

Space optimization in telecom offices is essential for maximizing operational efficiency, reducing costs, improving employee productivity, and promoting sustainability. Through a comprehensive review of existing literature, it is evident that effective space utilization directly influences the technical, financial, and human aspects of telecom office environments. Prior research has focused on several key areas, including the optimization of technical infrastructure (such as server rooms), cost savings through efficient office layouts, and the integration of technology and sustainable design practices (wang, p. 2018).

The integration of full optimization methods such as

Space-efficient layouts: Use modular furniture and flexible designs, like hot-desking and shared workstations, to maximize utility.

Technology integration: Implement digital solutions like cloud-based systems to reduce hardware needs and storage space.

Vertical utilization: Optimize vertical spaces with shelving, racks, and smart cable management to declutter and improve organization.

Has really helped to full optimized the use if telecom offices in various areas of life.

5. Recommendations

The following practice should be incorporated into the design of telecom offices space

Adopt Modular Furniture: Use adaptable furniture to easily reconfigure workspaces.

Integrate Smart Technology: Implement energy-efficient systems and smart controls.

Design Collaborative Zones: Create areas for team meetings and informal interactions.

Optimize Storage: Shift to digital management and utilize vertical storage.

Promote Sustainability: Use eco-friendly materials and practices.

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Geospatial Mapping Of Malaria Susceptibility in Suleja Local Government of Niger State, Nigeria

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Abstract

The accurate measurement of malaria incidence is essential to track progress and target high-risk populations. While health management information system (HMIS) data provide counts (occurrences) of malaria cases, quantifying the denominator for incidence using these data is challenging because catchment areas and care-seeking behaviors are not well defined. This study seeks to investigate malaria incidence rate (persons infected with malaria) in Suleja local government area (LGA) of Niger state. Malaria time series datasets data (2014-2022) was retrieve from the Ministry of health, Niger state. The dataset was sorted, filtered and refined for missing data using linear interpolation method. Statistical tools such as Bar chat and simple least square regression analyses tool was used to represent the malaria vector data at each ward and to estimate the malaria occurrence rate in the next ten years. At 95% confidence level, the malaria susceptibility rate was estimate to be fifty-six thousand four hundred and thirty-eight (56,438) persons infected with malaria vector in the LGA in the next ten years. The number of persons to be infected is quite disturbing when compared to the total population density of the LGA. However, the veracity of the research needs to be investigated by the LGA, this will aid in making policies and law relative to the causes of the high breed of female Anopheles mosquitoes in the LGA.

Keywords: Malaria Susceptibility, Plasmodium Falciparum, Female Anopheles Mosquitoes, Indiscriminate Solid Waste Dumpsite, Demographic, Mortality Rate.

1. Introduction

Malaria is a protozoan infection in humans which is mainly caused by the parasite called Plasmodium. It's classified into four main species P. falciparum, P. oviale, P. malaria and P. vivax (Jame *et al*., 1996). Plasmodium falciparum is the agent of the most malignant form of malaria, usually presenting with severity mostly in children in sub-Saharan Africa (WHO 2019). It is the most dangerous form of malaria with the highest rates of complications. It is also the commonest species in virtually all parts of Africa accounting for up to 98% of the confirmed cases in Nigeria and is associated with significant morbidity and mortality (WHO) (2010). Malaria is known as a serious health challenge in tropical and subtropical regions of African and the world at large. It has far-reaching medical, social and economic consequences for the countries in which it is endemic, due to its high and alarming morbidity and mortality rates. Each year, approximately 2.5 million people die of malaria, many of whom are children. According to (USAID, 2010) estimates, 40% of the population of the world live in areas where malaria is endemic with the direct and indirect costs of management being very high.

Malaria affects five times as many people as AIDS, leprosy, measles and tuberculosis combined (WHO/UNICEF, 2003). WHO (2015) put malaria cases in the Africa region at 86% of the world malaria menace with 80% of the cases occurring in 13 countries in Africa. Malaria poses a serious threat to the health of pregnant women and young children in sub–Saharan Africa and other tropical regions of the world. More than 45 million women (30 million of them in Africa) become pregnant in malaria endemic areas each year (Shulman *et al*., 1999; Steketee *et al*., 2001). The population at high risk of malaria incidence in Nigeria is estimated at 135,552,389 (WHO, 2015). The country's confirmed and suspected cases of Malaria incidence as at 2015, stood at 19,555,575 people (WHO) (2015). Among vector-borne diseases, the malaria is influenced by seasonal or spatial changes in the environment (Messina *et al*., 2011). Environmental factors such as the presence of bushes and stagnant water around homes, rainfall, low altitude and high temperatures favor the breeding of malaria vectors, as well as parasite reproduction within them (Messina *et al*., 2011). Malaria has, therefore, been defined as an environmental disease (Hay *et al*., 2000).

Tropical areas including Nigeria have the best combination of adequate rainfall, temperature and humidity allowing for breeding and survival of anopheles mosquitoes (Efe *et al*., 2013). An increase in rainfall and temperature enhances mosquito development and improved breeding sites leading to incidence of malaria (Vincent and Sunday, 2015). Rainfall provides the breeding sites for mosquitoes and increases relative humidity necessary for mosquito survival,

leading to increase in the number of mosquitoes biting an individual per unit time (Lindsay and Martens, 1998). An adult mosquito`s chance of survivorship is determined by the ambient temperature, humidity and rainfall. Warmer ambient temperatures shorten the duration of the extrinsic cycle, thus increasing the chances of transmission (Jackson *et al*., 2010).

Malaria pandemic alone has caught the attention of both the local authorities and international agencies. Several measures have been adopted to reduce the rate of morbidity due to malaria. It is believed that climatic parameters had changed significantly over the past two/three decades (Akinbola *et al*., 2010). Hence, a deeper knowledge of environmental variables, conducive to mosquito vector life cycle, is important to target control interventions. The objective of this research is to map out the areas susceptible to malaria in Suleja Local area from data retrieved from ministry of health of the state across all the wards . using geospatial techniques in depicting the wards which is most affected by person with malaria with the sole purpose of reducing, mitigating the effect of malaria infection in the LGA

2. Study Area

Suleja local government Area (LGA) is one of the oldest LGA in Niger State. It was created in the year 1976, its one among the Twenty-five 25 Local Government in Niger State. It is located between latitude 090 08' 00.16''N to 90 16' 00.17'' and longitude 070 08' 00.13'' E to 070 12' 00.13'' E situated about 20km north of Abuja the Federal Capital of Nigeria. It is about 100km south east of Minna the Administrative Headquarters of Niger State. Suleja LGA enjoys sub-humid climatic condition with mean annual rainfall and temperature of 1640mm and raining season of over five (5) months in the year. There is a single maximum in the rainfall regime usually in the month of August. Temperature are generally high during summer, but cool during the harmattan which last from November to March Suleja master plan (1987-2006). This provides favorable breeding condition for the malaria vector and enhances occurrence, intensity and length of malaria transmission. Figure 1.1, depicts the map of the study area,

Figure 1: Map of Nigeria to the right up, map of Nigeria to the right down and map of the study Suleja Local government area to the left.

3. Method

3.1 Data Acquisition

The primary data was retrieved from Ministry of health, Niger state with the collaboration of the Primary Health Care (PHC) provider in the Suleja LGA. Table 1 summarized the data used for the research. The dataset cut across all the ten wards that constitute the LGA for the period of nine (9) years (2014-2022). The (Persons with Confirmed Cases of Malaria) dataset was sorted and refined for the missing data. The interpolation technique was used to predict the missing data. equation 1 depict the linear interpolation model (Pedro *et al*., 2003)

$$y = y_1 + (y_2 - y_1) * \frac{x - x_1}{x_2 - x_1} \quad 1$$

Where:
x: *Independent variable*
x_1: *Dependent Variable of the first known data point before* x
x_2: *Independent Variable of the second known data point before* x
y_1: *Dependent Variable coresponding to* x_1
y_2: *Dependent Variable coresponding to* x_2
y: *Interpolated value*

Table 1. Dataset Used for the Research

Type	Resolution	source	Relevance
Shape File	30*30 Pixel	USGS	Delineate each words
Administration Map	1.300,000	OSGOF	Validate the wards
Malaria Vectors		NSMH	Affection rate

Geographic informatics system (GIS) tool aid with remotely sense data were used to plot the spatial distribution map showing the level of malaria infected person across the state. Statistical tools such as bar chat and simple least square regression analyses was used to represent data and also make prediction of malaria vectors for the next ten years internal.
The projection was executed using a simple least square regression method to find the line (or curve) that best fits a set of data points. It works by minimizing the sum of the squared differences between the observed (y) values and the values predicted by the regression line for each corresponding (x) value. In simpler terms, the principle involves finding the line closest to all the data points. According to Douglas *et al.,* (2013), the relationship between (y) *and* (X)

$$y = mx + b \quad (2)$$

Where
(m); slope of the line (coefficient of x), (b): y-intercept (the point where the line crosses the y-axis). To compute the values of (m) and (b) that best fits the data; you can use the following.

$$m = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad (3)$$

$$b = \frac{\sum y - m(\sum x)}{n} \quad (4)$$

Where
n:The number of data points, $\sum x$: the sum of all (x) values, $\sum y$:The sum of all (y) values, $\sum xy$: The sum of the products of each (x) and (y) pair, $\sum(x)^2$ Is the sum of the squares of each (x)

4. Result and Discussion

Table 4.1, depicts the names of ten (10) wards that constitute Suleja local government area (LGA) of Niger state, Nigeria.

Table 4.1. Wards of Suleja LGA

i	Bagama A	ii	Bagama B	iii	Hashimi A	iv	Hashimi B
v	Iku I	vi	Iku II	vii	Kurmi sarki	viii	Magijiya
ix	Maji	x	Wambai				

Suleja LGA is the second largest in population density and the also the second highest in terms internal generated revenue for the state (NGS, 2012). This could tell how relevant it is to the state Government. The geographical location of the LGA is an advantage, been it close to the Federal Capital Territory (FCT) Abuja gave it an edge over other LGAs in the state.

4.1 Malaria Susceptibility Rate across the wards of Suleja LGA

The malaria occurrences over the past nine (9) years in Suleja LGA is disturbing. There is need to understanding the magnitude at various wards and also the causes. Figure 2, depicts the spatial distribution of malaria infection rate across the LGA.

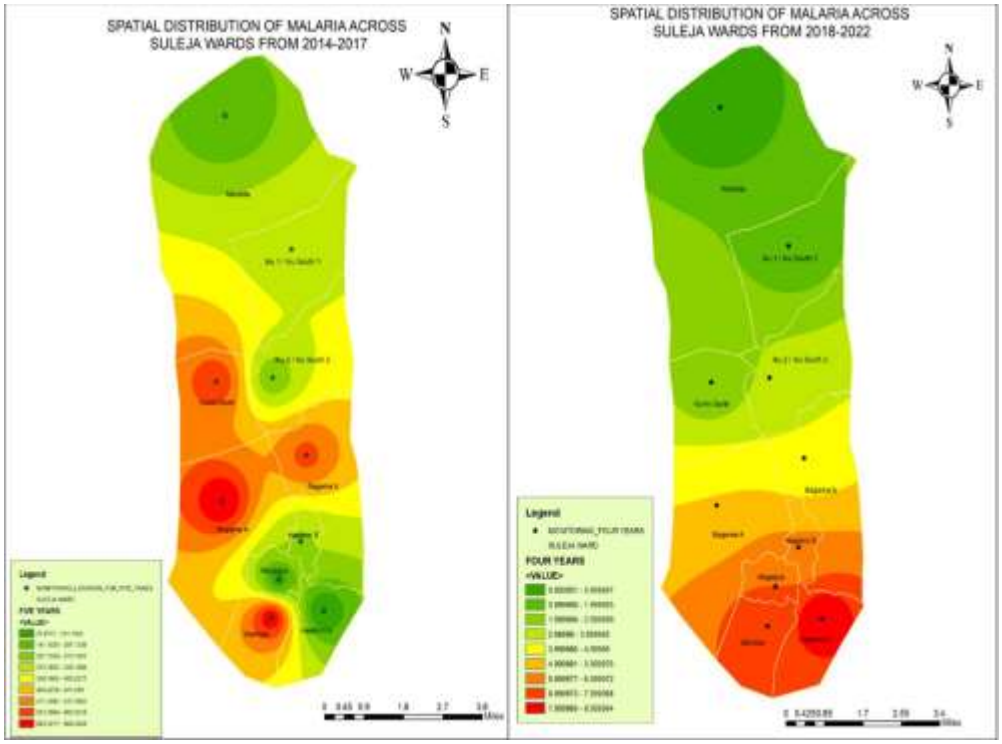

Figure 2. Spatial Distribution of Malaria Vector in Suleja LGA from the Year 2014-2017 at the left while from the year 2018-2022 at the right side

The year 2014, a total number of seventeen thousand, three hundred and eighty six (17,386) people were infected with malaria bacteria which translate to be 5.23% when compared with nine (9) years data. It was confirmed that Hashimi (A) ward recorded the highest number of persons infected with malaria with about 25.81% while Magajiya wards recorded the lowest with about 2.39%. The highest occurrence was recorded between the months of June and July. This corroborate with DWB (2020), breeding of mosquitoes anopheles is highly predominant during raining season.

In the year 2015, the number of persons with malaria infection experienced an upward trend pattern of about 1.45% increase when compared with the previous epoch. Hashimi ward A recorded the highest number of infected persons having about 20.28% while Wambai ward recorded the lowest with about 1.65%. The highest number of malaria patients occurs during the months of August and September which happen to be raining season. The year 2016 also indicated an upward trend pattern, it recorded an increase of 3.45% compared to the previous epoch. The continuous increase indicated the fear of malaria outbreak in the LGA. The highest number of occurrences was recorded in Hashimi A with about 20.15% while the lowest was recorded at Wambai ward with about 0.5%. Wambai ward is experiencing a downward movement in it trend pattern which shows a level of check from the indigene. The highest value of malaria vector was recorded between the month of august and September. The year 2017 indicated an upward trend pattern of number of persons infected by malaria, it recorded about 1.51% increase compared with the previous year. This also shows an increasing trend for the years in view and it calls for concerns. Hashimi (A) ward recorded the highest number of infected patients, having about 21.07% while wambai ward maintained it position of been the lowest with about 0.37%. The year 2018 also indicated a positive trend, it recorded an increase of about 0.14%, while the increase cannot be compared with the previous years. However, Iku (I) recorded the highest number of persons infected with malaria vector having about 20.81% and Wambai ward remains the lowest having recorded about 2.30%. The trend of wambai ward is disturbing as it recorded a negative trend compared to the last three epochs. The months of highest occurrences fall within the raining season.

The year 2019 indicated a downward trend pattern, it recorded a decrease of 0.38% compared with the previous years. The rate is still disturbing as at the year 2019, the reduction is infinite compared to the ratio of the number of infected persons. Hashimi A ward regain the position of the highest infected persons with malaria while Wambai maintained its position as the least with a decreasing trend pattern of 1.96% and the highest was attained in raining season. The year 2020 indicated a positive trend, it recorded an upward movement of about 1.07% compared with the previous epoch. This also indicated an acute jump from the previous year. Hashimi A ward was the highest in terms of persons with infected cases of malaria having recorded about 18.035% of forty-one thousand four hundred and thirty (41,430) malaria cases recorded in the ward for the year 2020. Wambai ward recorded the lower of about 1.80%, the trend

pattern is decreasing for the past three epochs which suggest that authority in charge are putting hands on desk to checkmate the trend.

The year 2021 indicated an acute jump compared from the previous year, it recorded an increase of about 3.28% compared to the previous. Maje ward recorded the highest malaria vector infection with about 20.85% while 1.93% was recorded at Wambai ward as the lowest. The highest infection rate was experienced within the month of August and September. The year 2022 indicated a negative trend pattern, it recorded a downward movement of about 0.81%. However, Iku (II) ward was the highest in terms of malaria vector infection rate with about 21.26% while Wambai ward maintain the lowest position with about 2.24% of the total infection for the year. The total of about three hundred and thirty-two thousand, two hundred and eighty-five (332, 285) confirmed cases of malaria for the span of nine years at Suleja LGA. This is quite disturbing and its calls for urgent attention, as for the causes of continuous rises in the trend. The study also confined the claimed of World Malaria Report (2019), Nigeria had the highest number of global malaria cases (26.6 % of global malaria cases) and the highest number of deaths (31 % of global malaria deaths) in 2021. There is possibility that due to the outrageous growth in persons infected by malaria vectors, there could be death casualty amidst the high number recorded. However, there was no proof as to data was recorded the number of deaths incurred. Figure 3 summarized the trend pattern of malaria vectors (mosquitoes) persons infected for the period of nine years in Suleja LGA of Niger state.

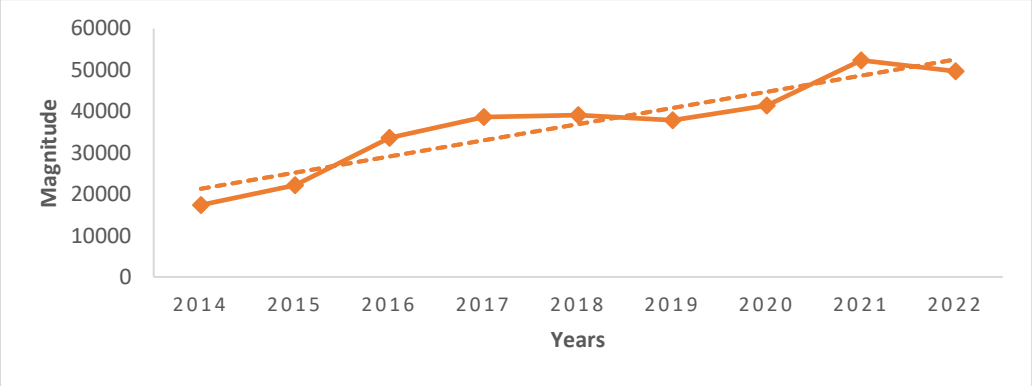

Figure 3. Trend Pattern of Malaria Vectors Infected Persons in Suleja LGA

4.3 Projection of Malaria Vector

Using simple linear least square equation to estimate the projection of the malaria vectors as it infects persons in the LGA. The projection sample equation was developed using the two variables, time as the independent data and malaria occurrences data as the dependent data. The projection model was $y = 17398 + 3904x$. Hence the projection of malaria vector infection in the next ten years will be fifty-six thousand, four hundred and thirty-eight (56, 438) persons is projected to be infected by malaria vectors by the year 2032. Figure 4. depicts the malaria anopheles infected persons rate projection to the year 2032 in Suleja LGA, Niger state, Nigeria

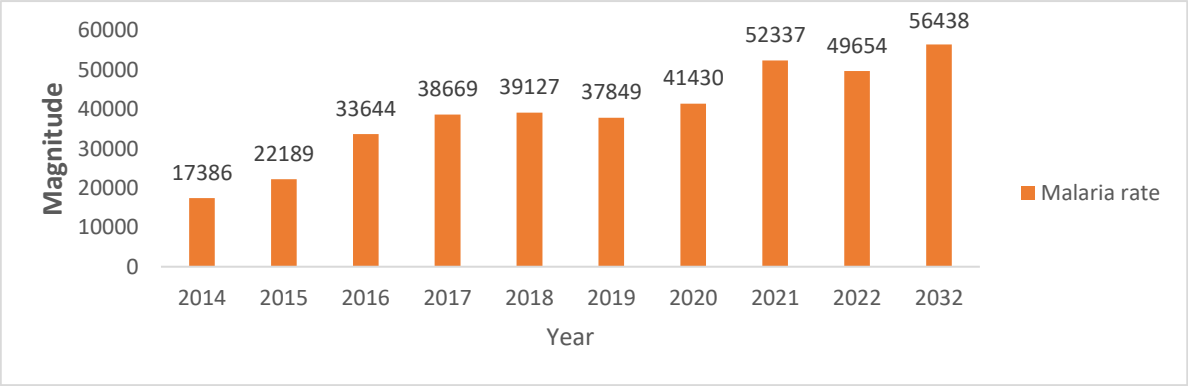

Figure 4. Malaria Projection for the year 2032 in Suleja LGA, Niger State

5. Conclusion

Malaria susceptibility rate in Suleja LGA is on the increase, this was confirmed from the trend pattern judging from the nine years datasets that was analyses. The wards of the local government areas are on a timebomb. Disease outbreak

could break out from the wards which could result to the loss of lives. There is need for the local authority responsible to do investigation on the remote causes of the high infections rate. It was also observed that while other wards malaria susceptible rate was increasing such as Hashimi A, Iku I and II, Maje etc some wards were also experiencing a downward slope of malaria occurrences such as Wambe, Bagama A and B. This can infer that, these wards that are experiencing downward trend are monitoring their attitudes towards clean environment and the possible causes of the causes. From the analyses, by the year 2032, the malaria bacteria vector will rise to about fifty-eight thousand, four hundred and thirty-eight (58,438) persons with malaria anopheles. Juxtaposing such number of infected persons with the population density of the LGA, this further confirmed the claimed of Nigeria been having the highest malaria cases of about 26% of the global cases (WHO) (2019).

The steps and condition slated by environmental protection agency, if abided to, it will go a long way in reducing the rate of malaria bacteria vectors in the various wards. Hashimi A wards continuously being the highest for almost 8years, it was also confirmed that the position of the wards in relative to the number of indiscriminate waste site and the earth gravity drainage which seems to be the major causes of the bacteria vectors growth. The breeding of plasmodium Anopheles mosquitoes from the number of indiscriminate waste site and the drainage have resulted to the increasing rate of malaria susceptibility.

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Impacts of Urbanization on Land Use and Land Cover Dynamics in Chanchaga Local Government Area of Niger State, Nigeria

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Abstract

Given that urbanization is considered as one of the most significant anthropogenic alterations of the environmental framework. The increasing urbanization generally is brought about by many eco- environmental problems, such as the drastic change of land use and development of the area. This study analyses the impacts of Urbanization on Land use and land cover dynamics in Chanchaga, Niger State, Nigeria. From 1993 to 2023, these were done with the view to determining the effects of changes in urban growth on land use/cover of the area. The primary data were coordinates of geographic features within the study area, collected through the use of global positioning system. The secondary data were Landsat imagery, Landsat TM/ETM & OLI imageries for three epochs (1930, 2003, and 2023). Individual components (built-up, grassland, farmlands and surface water bodies). The results revealed that the study area has been growing to a relatively compact urban cluster area. The concentration of built-up area at the western and the central part of Chanchaga which is study area has been getting larger and more aggregated. Built-up area increased by 23.46% from 16.75 km2 (24.20%) in 1993 to 33 km2 (47.66%) in 2023 while grassland decreased by 30.48% from 55.78% in 1993 to 25.30% in 2023. The land cover trend of the study area from the period of 1993-2023 shows dramatic changes for the dominant land cover types. Findings show that uncontrolled developmental activities contribute significantly to environmental deterioration in the study area. Hence, there is need to implement and enforce sustainable development methods, effective monitoring of urban growth activities through strict adherence to master plan of the city.

Keywords: Urbanization, Land Use and Land Cover, Remote Sensing, Geographic Information System, Landsat image, OLI

1. Introduction

The Land use and land cover changes are directly related to urbanization, which include the replacement of natural surfaces, such as vegetative cover, and porous surfaces, such as water bodies, with impervious surfaces like urban buildings constructed with warm concrete (Luo *et al.,* 2022). Factors driving LU/LC change include an increase in human population and population response to economic response. Despite the social and economic benefit of LU/LC change, this conversion of LU/LC usually has an unintended consequence on the natural environment. For example, LU/LC change has been shown to negatively impact on stream water quality/quantity and stream ecosystem health (Akinbobola, 2019). Changing LULC has also been shown to influence weather patterns and the generation of streamflow (Jande *et al.,* 2020). Developing countries are experiencing a significant population growth, particularly in sub-Saharan Africa where the annual rate population growth exceeds 2 % (Dimnwobi *et al.,* 2021).

The knowledge of land use/land cover change is important to understand some occurrences in the earth's biophysical composition. It entails a conversion of natural types of land to uses associated with the growth of population and economy, transforming the landscape from its natural form to impervious urban lands termed cities and towns (Sunday, Abdulkadir and Anene, 2020). It was observed that, "cities are expressed as the nodes of man's greatest impact on nature, the places where he has most altered the essentially reserved resources such as land, air, water and even organisms. A city is the quintessence of man's capacity to induce and control changes in his habitat. Through urbanization, man has created new ecosystems within which the interactions of man, his works and nature are examples". Urbanization is therefore a necessary process that leads to the formation of what we now have as urban areas, which is not without its consequences, one of which is the modification of land surface and atmospheric boundary conditions that lead to a modified thermal climate which leaves the cities warmer than surrounding non urbanized areas (Omogunloye *et al.,* 2022)

Rapid world population growth accompanied by economic activities causing urban growth and acceleration of urbanization processes has led to rapid LULC changes (Yirsaw *et al.,* 2017). Land use and land cover change has been identified as an important driver of environmental change on all spatial and temporal scales (Mishra *et al.,* 2014), as

well as emerging as a key environmental issue and on a regional scale is one of the major research endeavors in global change studies. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. LULC change studies have resulted in diverse impacts including the extensive modification of Earth's ecosystems. The impact of human activities is becoming more and more visible in the natural environment. One of the most important and obvious areas of concern of these activities is LULC change.

This work presents changes in land use and land cover pattern between 1993 and 2023 for the study area. This study is aimed at analysis of impacts of urbanization on land use and land cover dynamics in Chanchaga local government area, Niger state, Nigeria through a geospatial approach so as to achieve these specific objectives:

i. Map the types and extent of LULC classes in the study area.
ii. ii. Analyse the trend and rate of LULC changes between 1993 and 2023.

2. Research Methodology

2.1 Study Area

2.1.1 Location of the Study Area

Minna is located in Chanchaga which is the capital of Niger State. It is one of the twenty-five local government areas in Niger State, with its headquarters in Minna with a land mass of 1,592 km^2 (Dalil *et al.*, 2015). Minna lies between Latitudes 9°33' and 9°40' North of the Equator and Longitudes 6°29' and 6°35' East of the Greenwich Meridian (Figure 1). The town spanned along the main spine road that separates the city into West and East. This road is from Chanchaga in the South to Maikunkele in the North, covering a distance of about 20 km. The West-East pattern, spanned from Gidan-Kwano along Bida axis in the West, to Maitumbi to Gwada axis, in the East, over a distance of 15 km (Figure 1).

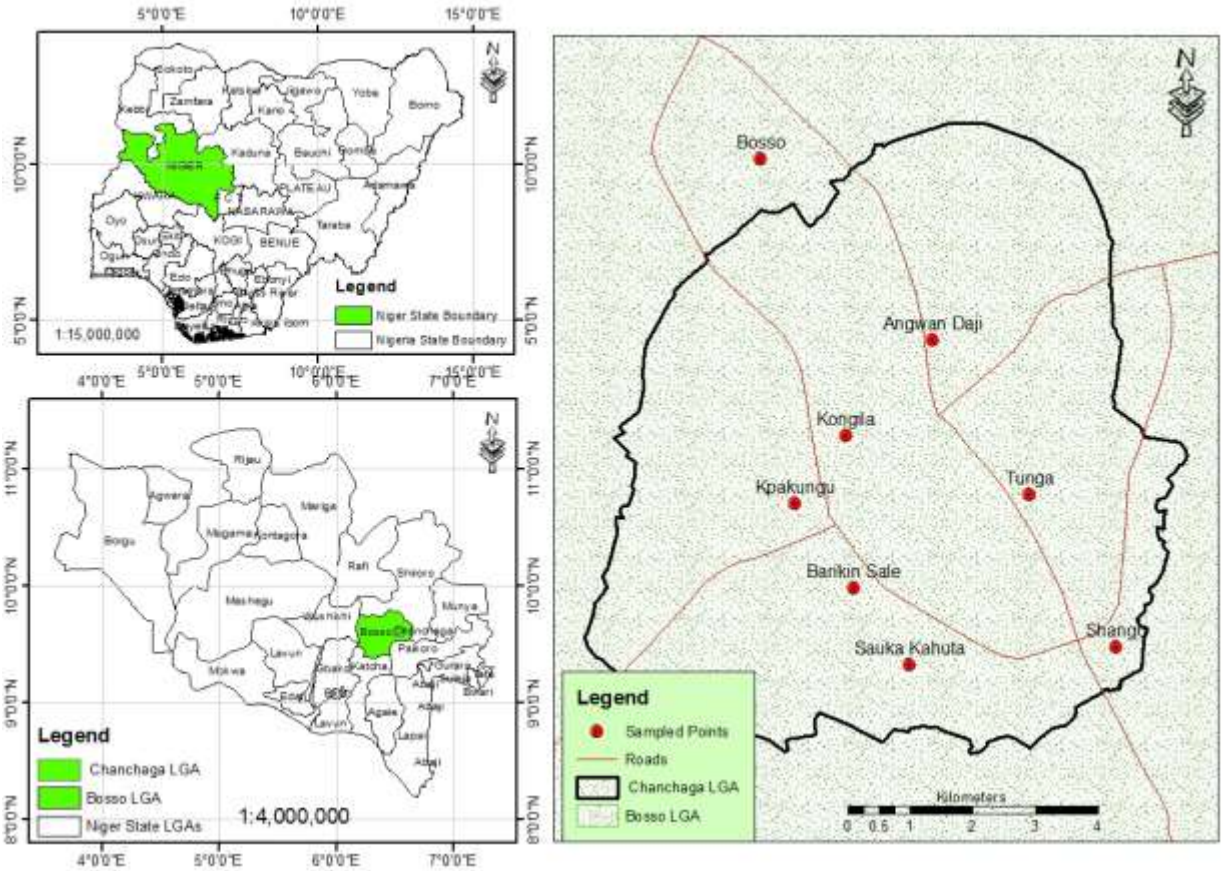


Figure 1: Map of Nigeria, Niger and Chanchaga LGA
Source: Pedas Geospatial Concept.

Minna is a commercial urban area or more of a central place in Chanchaga. The study area has two distinct seasons the dry and wet season. Precipitation per year varies between 1000- 1400 mm on the average. The duration of rainy season ranges from 150 to 210 days or more from the north to the south. Mean maximum temperature remains high throughout the year, hovering about 37°C and 20°C respectively (Adeoye *et al.,* 2018). However, the lowest minimum temperature occurs usually between December and January when most parts of the state come under the influence of the tropical continental air mass which blows from the north (Dalil *et al.*, 2015).

Geological mapping shows the study area is underlain by granite and schist with granite occupying a greater portion of the area. Specifically, three major soils types can be found in Bosso LGA. These include the Ferruginous tropical soils, hydromorphic soils, and ferrosols. Hydromorphic or waterlogged soils are largely found in the extensive flood plain of the Bida basin (Adeoye *et al*., 2011).

The vegetation is mainly guinea savanna which is characterized by grasses shrubs and trees. The study area lies within the middle belt of Nigeria which is a transitional zone between the rainforest of southern Nigeria and the guinea savanna of northern Nigeria. This is characterized by tall grasses with light forest, evenly distributed trees along the major river channel.

Drainage systems are pathways created naturally or artificially to address the increasing problems of diffuse sewage and run-off over an area. The run-off whether deliberate or accidental can be a major cause of flooding and polluted stagnant water in urban environment (Dalil *et al.*, 2015). Two kinds of drainage System are available in the entire Bosso which are the artificial drainage system (constructed drainage system) and the natural drainage system (originated through occurrence of erosion or flooding).

2.2 Data Requirement and Collection

The data for this research was derived from primary and secondary sources. The primary data consist of first-hand information and comprises personal observation, taking pictures; and taking of location of points using handheld Global Positioning System (GPS). The GPS was also used for ground trothing during image classification. The secondary data consists of Satellite Remote Sensing imageries. The Satellite imageries used included Landsat TM (1993 and 2003) and Operational Land Imager (OLI) (2023). The Landsat imagery dataset were downloaded from the United States Geological Surveys (USGS) using the Earth explorer online platform.

Dry season images of the three data sets were acquired from January to March in order to reduce the effects of clouds that are prevalent during the rainy season. Because the images are from the same season and comparable climatic conditions, it enhanced the classification as the spectral reflection of most features are easily comparable across the different images. In addition, high resolution Google earth images were used to aid in classification. Table 1 shows the summary of the characteristics of the satellite images.

Table 1 Details of Satellite Data Used

S/N	Sensor	Path / Row	Source	Year of Acquisition	Scale/ Resolution
1	TM	189/053	Earth explorer	1993	30
2	ETM+	189/053	Earth explorer	2003	30
3	OLI	189/053		2023	30

Source: Author's Analysis, 2024

The tools used for carrying out the research were:

i. ArcGIS 10.2 used for pre-processing of images and vector data.
ii. Idrisi Selva, used for change detection analysis
iii. Google Earth Image, used to compliment image analysis
iv. Global Positioning System-This was used for classification and data validation

3. Mapping the types and extent of LULC cover classes in Chanchaga

This objective was achieved by examining Landsat TM of 1990, Landsat ETM+ of 2010 and Landsat OLI of 2020 images acquired and their subsequent classification. In order to map the types and extent of LULC classes, the data were subjected to these processing and analytical procedures.

i) **Data Pre-processing:** the Landsat images were pre-processed, so that inherent errors and formatting that are required for further direct processing of the data will be done. The downloaded Landsat images were in separate bands and need to be layer stacked. This is a process whereby different bands of an image are joined together to form a single multispectral image. Specifically, the three (3) satellite imageries of 1993, 2003) and Landsat OLI (2023) were corrected radiometrically through haze removal operations

ii) **Image enhancement:** Image enhancement is concerned with the alteration of images to make them more suited to the capabilities of human vision. Irrespective of the extent of digital intervention, visual interpretation plays a very strong role in all aspects of remote sensing (Eastman, 2012). In order to improve visual quality and outlook of an image for easy interpretation, image enhancement is necessary. It increases the contrast among different features thereby enhancing easy identification of features and subsequent classification. After the enhancement process, band combination operations were performed to select the different bands which will enable the classification of a given earth surface feature. The major reason for colour composite is to highlight certain

brightness values that are associated with certain surface features. A band combination of 4, 3, 2 (for RGB) was used for the Landsat TM and ETM images and 5, 4, 3 for OLI images as this produced superior results. It is suitable for urban application and delineating land, water and vegetation boundaries.

iii) **Image classification:** A per-pixel image classification method for ground cover analysis was used through a supervised classification algorithm which is a procedure for categorizing spectrally similar areas on an image by identifying "training" sites of known targets and then generalizing those spectral signatures to other areas of targets that are unknown (Hashem and Balakrishnan, 2015). It is a process of using samples whose identity is known to categorize samples whose identity is unknown. A Maximum Likelihood algorithm of supervised classification was adopted because of the author's familiarity with the terrain. This method was chosen because it is easier to accomplish and more so, the large volume of images to be interpreted could not warrant the use of visual on-screen interpretations. The Maximum Likelihood is one of the most commonly used supervised classifiers, which uses the Gaussian threshold stored in each class signature to assign every pixel a class (Huang *et al.,* 2009). Maximum Likelihood classification assumes that the probability distributions for the classes follow the normal distribution model (Richards and Jia, 2006).

3.1 Analysis of the extent and rate of urbanization in the study Area

The extent of land use change was analysed by subtracting the reference year (2020) from the base year. It is represented mathematically as:

E_T=B-A

A= the base year (1993)

B=the reference year (2023)

E_T =total extent of forest land

3.2 Change analysis by area calculation

There are three steps in calculating change detection by area calculation

a) The first step is the calculation of the magnitude of change, which is derived by subtracting observed change of each period of years from the previous period of years.

b) The second step was the calculation of the trends, that is, the percentage change of each of the land-use, by subtracting the percentage of the previous land-use from the recent land-use divided by the previous land-use and multiplied by 100 (B-A/Ax100).

c) The last is the calculation of the annual rate of change by dividing the percentage change by 100 and multiplied by the number of the study years, that is, 30 years (1993-2023).

4. Results and Discussion

4.1 Analysis of the various Land use/Land cover (1993, 2003 and 2023)

The classification results for the LULC changes of the study area (Chanchaga) was presented using charts and figures for illustration and interpretation of all land use/land cover classes of the study area.

4.1.1 Land use and land cover Analysis of 1990 imagery

Figure 4.1 shows the landuse land cover (LULC) change map of the study area in 1990, it reveals that grassland which covers an area of 38.63 km^2 (55.78%) was the dominant land cover features on the study area. This can be found on every section of the map but more at the centres of the study area. This is followed by built up areas land cover features covering about 16.75km^2 (24.20%) of the area.

Most of the cultivated lands were located majorly at the south eastern and northern fringes. Similarly, on the other farmlands covers an area of 13.59km^2 (19.63%) at the base year located centrally and in other sections of the map areas while water bodies covers 0.27km^2 (0.39%). The total land area of the study area is 69.22km^2

4.1.2 Landuse and landcover Analysis of 2003 imagery

Figure 4.2 shows the result of the analysed landuse and land cover (LULC) map of the study area for 2003, findings reveals that there were drastic changes among the various land use and cover categories. It was revealed that farmlands increase drastically from 13.59km^2 (19.63%) in 1993 to 23.08 km^2 (33.32%) in 2003 indicating the second most dominant land cover features. The increase in built up areas can be attributed to the fact that the area is the state capital and centre of economic and administrative activities.

The most dominant land cover, grassland which covers an area of 38.63km^2 (55.78%) in 1993 but has reduced to 26.09 km^2 (37.68%) in 2003, a 18.1% reduction between the time period. This can be found on northern section of the map; this is attributed to the influx of more people into the area. This is followed by built up area land cover features covering about 16.75km^2 (24.20%) in 1993 but also increased to 20.00 km^2 (28.88%) in 2003 of the area. Most of the

cultivated lands were located majorly at the southern eastern and northern fringes. Additionally, water bodies 0.08 (0.12%) in 2010 indicating a reduction of 0.27%.

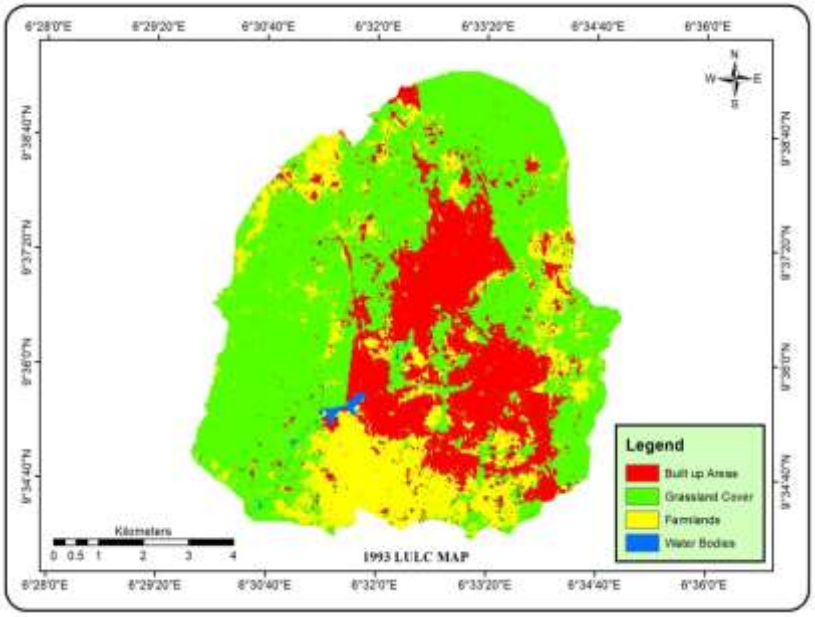
4.1.3 Landuse and landcover Analysis of 2023 imagery

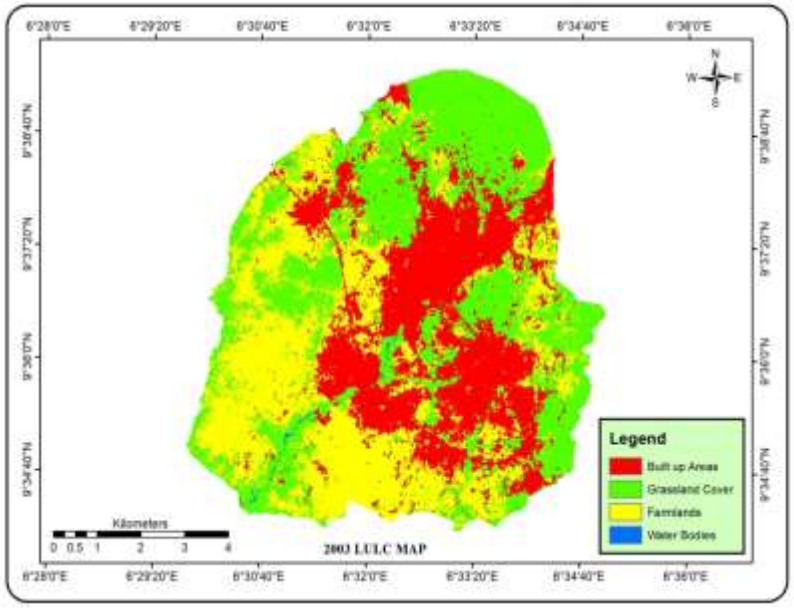
Figure 4.3 shows the result of the analysed landuse and land cover (LULC) map of the study area for 2023, findings indicates that there were more drastic changes among the various land use and cover categories most especially on built-up areas. It reveals that built up areas continues to increase drastically from 20.00 km² (28.88%) in 2003 to 33.00 km² (47.66%) in 2023 indicating the most dominate land cover features. The increase in built up areas can be attributed to the fact that the area is the state capital, centre of economic and administrative activities as well as host to several tertiary educational institutions.

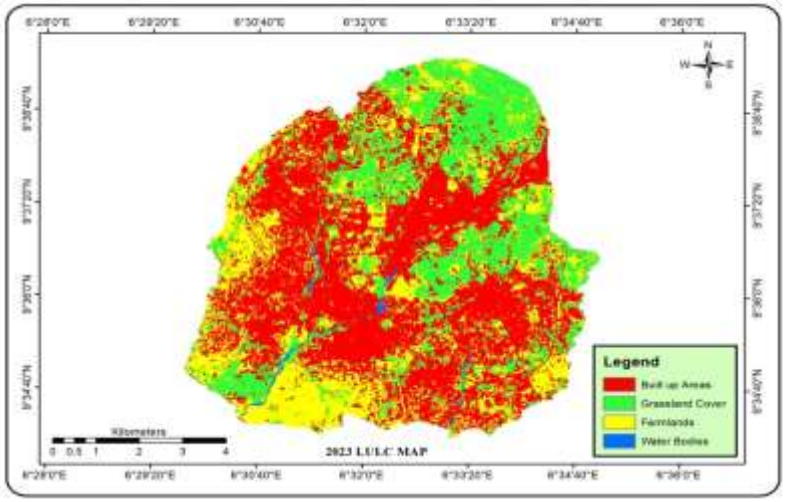
This is followed by grassland cover covering an area of 26.09 km² (37.68%) in 2003 but reduce slightly to 17.52 km² (25.30%) in 2023. Farmlands on the other hand covers an area of 23.08 km² (33.32%) in 2023 but reduction to 18.38 km² (26.54%) in a 2023. Most of the farmlands were located parches at fringes areas. Finally, water bodies covers 0.35km² (0.50%) in 2020 indicating a reduction of 0.38%. The areal statistics for each of the land use and land cover categories are summarised on table 4.1. Furthermore, figure 4.4 shows the land use and land cover trend chart for the study area.

Table 2: LULC Distribution between 1993 and 2023

LULC	**1993**		**2003**		**2023**	
Land Cover Category	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)
Built up Areas	16.75	24.20	20.00	28.88	33.00	47.66
Grassland	38.63	55.78	26.09	37.68	17.52	25.30
Farmlands	13.59	19.63	23.08	33.32	18.38	26.54
Water Bodies	0.27	0.39	0.08	0.12	0.35	0.50
Total	**69.25**	**100.00**	**69.25**	**100.00**	**69.25**	**100.00**


Legend
Built up Areas
Grassland Cover
Farmlands
Water Bodies
Kilometers
0 0.5 1 2 3 4
1993 LULC MAP


Legend
Built up Areas
Grassland Cover
Farmlands
Water Bodies
Kilometers
0 0.5 1 2 3 4
2003 LULC MAP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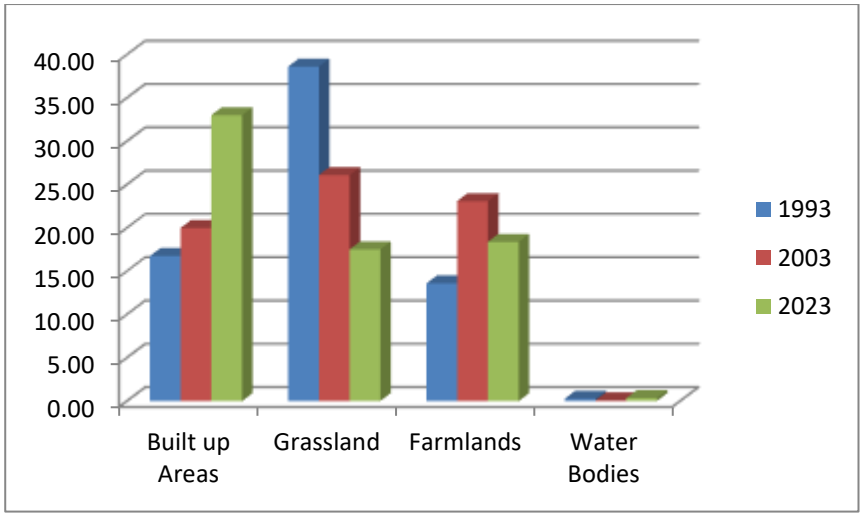
Built up Areas
Grassland Cover
Farmlands
Water Bodies
Kilometers
0 0.5 1 2 3 4
2023 LULC MAP


40.00
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Built up Areas
Grassland
Farmlands
Water Bodies
1993
2003
2023

Magnitude and Percentage of Change in Land Use/Landover between 1993 and 2003

The magnitude of change of built up area for 10 years between 1993 to 2003 shows that built up areas increased by 3.24km^2 representing a change (19.36%) of the total change for the period as shown on Table 3. farmlands has the highest annual rates of change of 6.98% while water bodies has the least annual rate of change of -6.85%. The period also witnessed a decrease in grassland. The grassland decreased by -3.24km^2 representing -32.44% of the total change.

Table 3: Magnitude and Percentage of Change in LULC between 1993 and 2003

LULC Class	1993 Extent	2003 Extent	Magnitude of Change	Percentage of Change	Annual Rate
	(km^2)	(km^2)	(km^2)		of Change %
Built up Areas	16.75	20.00	3.24	19.36	1.94
Grassland	38.63	26.09	-12.53	-32.44	-3.24
Farmlands	13.59	23.08	9.48	69.77	6.98
Water Bodies	0.27	0.08	-0.18	-68.46	-6.85

Magnitude and Percentage of Change in Land Use/Landover between 2003 and 2023

The magnitude of change of built up areas for 10 years between 2003 to 2023 shows that built up areas increased by 13.01km^2 representing a change (9.77%) of the total change with annual rate of change of 3.25% for the period as shown on Table 4. Water bodies have one of the highest annual rates of change of 15.43% while farmlands has annual rate of change of –1.02%. The period also witnessed a decrease in cultivated lands. The grassland decreased by -32.86km^2 representing -1.64% of the total change with annual rate of -1.64%.

Table 4: Magnitude and Percentage of Change in LULC between 2003 and 2023

LULC Class	2003 Extent (km^2)	2023Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of change (%)
Built up Areas	20.00	33.00	13.01	65.03	3.25
Grassland	26.09	17.52	-8.58	-32.86	-1.64
Farmlands	23.08	18.38	-4.70	-20.37	-1.02
Water Bodies	0.08	0.35	0.26	308.51	15.43

Magnitude and Percentage of Change in Land Use/Landover between 1993 and 2023

The magnitude of change of the various land use and cover categories for 30 years between 1993 to 2023. Findings shows that built up has the highest annual rates of change of 3.23%. This is followed by farmlands which has the highest annual gain of areas to build up and other categories at 1.17%. Water bodies has annual rate of change of 0.96%. Grassland decreased by -21.11km^2 representing a change (-54.65%) of the total change with annual rate of change of -1.82% for the period as shown on Table 5. The period also witnessed a decrease in cultivated lands.

Table 5: Magnitude and Percentage of Change in LULC between 1993 and 2023

LULC Class	1993 Extent (km^2)	2023 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Built up Areas	16.75	33.00	16.25	96.99	3.23
Grassland	38.63	17.52	-21.11	-54.65	-1.82
Farmlands	13.59	18.38	4.78	35.19	1.17
Water Bodies	0.27	0.35	0.08	28.86	0.96

5. Conclusion and Recommendation

In this study, remote sensing and GIS were integrated for the evaluation of urban expansion and its impact on land surface temperature in Minna city, Chanchaga. Results showed a significant increase in urban LULC changes between 1993, 2003 and 2023 where most land covers such as vegetation and cultivated lands were converted to urban or built-up areas

The study recommends Government to adopt a policy of —Greening in the study area through planting of trees, shrubs and ornamental plants. This will reduce runoff, hence prevent flooding, preserve soil moisture and reduce

the rate of atmospheric warming thereby controlling the microclimate of the area. Also, government must enforce compliance with physical planning and development regulations within the study area.

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Affordances of Outdoor Landscape on Children Learning Environments: A Study of Selected Public Primary Schools in Niger state

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Abstract

A well-landscaped environment creates a conducive atmosphere that plays a role in assisting in the learning process of children directly or indirectly through calming of the mind and increased concentration, Rapid urbanization and increase in building density has squeezed the urban public space. Communities can no longer sufficiently support a multifunctional schoolyard for children to carry out safe and independent activities, lack of spatial function of outdoor landscape elements results in a decline in children's subjective initiative and learning abilities, integrating previous researches on the function of landscape elements children's growth and interaction with environment results on Gibson's affordance theory, which states that the environment provide affordances or possibilities for actions that are perceived by individuals. The study aims to explore the significant characteristics of landscape elements and environmental affordances of children outdoor spaces, data for the study was collected through qualitative method ranging from observation through children behavioural mapping and interview with educational planners (teachers) from selected three (3) public primary schools in Niger state. Interviews was conducted with educational planners to saturation level while observations was targeted on children interaction with outdoor features through behavioural mapping focusing on the perspective of cognitive learning and environmental affordance. Results from findings showcased the behavioural possibilities provided by the environment, the needs of the children functional and educational space, perspectives of preference, safety and security. It also highlights the significant characteristics of primary schools outdoor landscape that effectively support children's outdoor learning activities. The study conclude by analysing the outdoor spaces in terms of Positive and negative affordances, actualised and potential affordance, in order to attain full optimization of landscape elements at all levels and further recommends various features of children outdoor space, such as accessibility to public facilities, method of circulation and available play facilities, Noise reduction facilities, buffer zones, highly readable warning signs for children, and attention restorative elements will influence children's transaction in their outdoor space.

Keywords: Outdoor Landscape, Children Learning Environment, Public Primary Schools

1. Introduction

Child Friendly environments Initiative as proposed by The United Nations International Children's Emergency Fund (UNICEF) at the second United Nations Conference on Human Settlements. The main goal of this initiative is to realize the basic rights of children in their outdoor environments, including shaping a child friendly social and material environment and promoting children's interests (Unicef, 2016). The United Nations series of advocacy documents adopted the statement, "children can interact safely in their outdoor spaces independently," as the core goal of a child-friendly environment and emphasized the importance of schools and other learning spaces as the basic spatial unit of children's daily activities (McGranahan & Satterthwaite, 2014).

However, with the rapid urbanization in Nigeria and increasing building density has squeezed the primary school outdoor spaces. Resulting into dysfunctional environments that can no longer sufficiently support children to carry out safe and independent activities (Loebach & Gilliland, 2022; Ryan & Vansteenkiste, 2023). As an important space for children's daily natural contact and social activities, the deficient functional outdoor infrastructures as well as functional spaces results in a decline in children's subjective initiative and social abilities (Balık & Balık Lökçe, 2019).

This study reflects on the objective attributes of environment based on children interaction, behaviour, and experience in line with Gibson theory of affordance. To aid at establishing the mutual relationship between the environmental functions of primary school outdoor spaces and the groups of children using them, so as to provide an eco-psychological perspective on the optimisation of such spaces to achieve a sustainable child friendly environment.

1.1 Study aim and objectives

The study aims to understand the relationship between children and the outdoor environments of primary schools, to provide valuable evidence for the study of children outdoor space and the affordances of their environment. With objectives to

- To explore the environmental affordances of outdoor landscape of primary school
- To assess childen interaction with outdoor landscape element towards learning

2. Affordance Theory in Design of Child Friendly Environment

Child-friendly environment is one where children feel comfortable and experience a sense of belonging, children are able to participate without worrying of being judged about what is shared and who is watching them, (Can & İnalhan, 2017) there are spaces where children can have fun and experience positivity and are free from any challenges they are experiencing. Children perceive environment differently from adults. Nowadays the cities are growing without considering the social needs especially that of the children as a result, the children are suffering from lack of physical activities and as a result lack of social relationship. (Browning & Rigolon, 2019) Therefore, for children growth and social interactions there is need of improvement of these spaces

Affordance theory as coined by James J. Gibson (1979), suggests that there is a reciprocal relationship between people and environments. When the object of the environments and the user respectively reach the corresponding relationship required for the occurrence of a certain behaviour, affordance will exist and will serve as the direct driving force of behavioural activities. The essence of this theory is to explore the ecological coordination between the subject of behaviour, activities, and the environments on whom its behaviour depends (Rekers, 2022).

Researchers within the field of environmental planning and design emphasises on the significance of environmental affordance, not to debate its existence, but to discuss whether it can be perceived by users (Hedegaard, 2016). In realizing, the objective attribute of the environment the important influencing factor in the process of people-environment interactions remains a key factor to be considered by the designer (Adeli & Nadimi, 2022) The support for various behavioural activities from different users in the environment creates the relationship between the environment, human behaviour, and the quality of life. (Can & İnalhan, 2017).

3. Environmental affordance and children's outdoor preferences

Outdoor landscape with provision of necessary infrastructures are important factor that influence the healthy development of children (Arlinkasari & Cushing, 2018). Other factors, such as openness, density, and accessibility are closely related to children's growth (Larrea *et al.,* 2019). This implies that diverse environments create different situations that support children in the implementation of different social activities in their outdoor spaces. Specifically, children may perceive certain environmental features with a specific meaning and establish social values around them, Provision of necessary outdoor facilities encourage children to use, such environment more frequently, thereby promoting social interactions among them (Chandwania & Natu, 2022).

The theory of affordance describes the environment from the perspective of function, so that designers can appreciate the process of children's environmental perceptions from the perspective of “experience” Significantly, environmental affordance also has a negative effect on children's development (Lerstrup & Konijnendijk van den Bosch, 2017). As such, there is need to study the interaction between children and the social and physical environmental factors that affects their required functionality, which is a direct approach to understand and avoid erroneous planning and design.

3.1 Theoretical Framework

The theoretical framework underpinning this study lies in the work of previous researches on the foundation of Gibson affordance theory,(1979), Vigosky social development theory (1978), Bron fenbroners ecological system theory(1979) and Deweys experiential learning theory(1938) fig. 2 shows the relationship between the affordance theory and the research deliverable within the context of environmental affordance, child interaction and.learning outcome

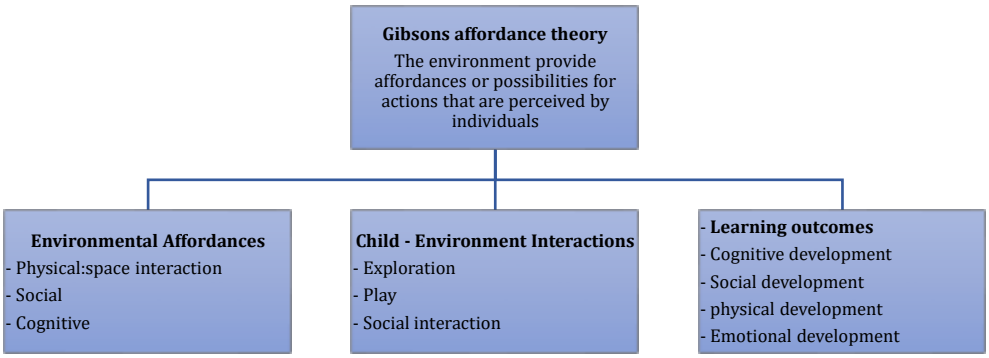

Figure 1.0: framework for interconnection of research objects
Source: Researcher 2024

4. Study Area and Methods

The study was conducted in three selected public primary schools in Niger state of Nigeria fig. 2a which cut across the three senatorial zones notably Bida, Minna and Kontagora fig. 2b. It adopted qualitative method of data collection, through site observation on children behavioural mapping and interview with educational planners to to elicit information on the environmental affordances and children interaction with outdoor landscape of primary schools

Figure 2a: Map of Nigeria Showing North Central states
Source: Adapted from Emmanuel and Olufemi (2017).

Figure 2b: Map of Niger state Showing the Study areas
Source: Adapted from Emmanuel and Olufemi (2017).

5. Case selection criteria

Based on the analysis of the affordance theory and the relationship between children and their outdoor spaces, the selected research cases were required to meet the following criteria. The first is their age of establishment, size and location, which are in line with the laid down criteria for the establishment of primary school in north central Nigeria. as contain in (Minimum Standards For Basic Education In Nigeria 2010), The second criteria is public schools with relatively acceptable standards and necessary facilities, which could objectively reflect the affordances of their educational spaces and sustainable child-friendly environments, and finally is public primary schools with different characteristics of outdoor landscape elements with non-homogeneous outdoor play equipment in order to achieve the research comprehensiveness. These schools were established and has from time to time received modification and upgrading of infrastructure in line with changes in the curriculum, and also with requisite educational and outdoor spaces as noted by (Abel & Amenger, 2014; Duchesne & McMaugh, 2018). Hence, The schools selected include Abubakar Anike primary school in Bida Local Government (Zone A)fig. 3a. Limawa primary school in Minna West Local Government (Zone B)fig. 3b and Remaye primary school in Kontagora local government (Zone C)fig. 3c of Niger state respectively.

6. Documentation from the selected cases

Case 1

(Abubakar Anike primary school Bida) Established in 1963, it comprises of an open yard with block of classrooms, perimeter fence, with land size of (90 X 120) m. on site include undefined footpaths, with introverted communal spaces, the access street is located at the entrance façade of the school It's characterised with clump of giant and intermediate trees, shrubs and other geological features ranging from lose sand, pebbles and deposit of hard surfaces.

Case 2

(Limawa Primary School Minna) The School comprises of 8 block of classrooms, administrative offices, conveniences with open yard, bounded by perimeter fence in a land size of (84 x 96) m The school is characterised with various vegetative elements such as intermediate trees, scattered shrubs and spotted plant with ground covers. Others include different types of play equipment with differ ranges of ancillary structures

Case 3

(Remaye Primary School Kontagora) The school has an approximate land (123 x 90) m, and it has a perimeter fence with defined entrance and exit gate, block of classrooms, administrative offices and conveniences. The outdoor is characterised with trees shrubs and ground covers with large number of engrossed spaces for children physical activities

Fig 3a. Abubakar Anike primary school Bida

Fig 3b. Limawa Primary School Minna

Fig 3c. Remaye primary school kontagora

Source: https://earth. google.com.web

7. Data collection

There is no standard method to measure the affordance of open space from the perspective of children interaction with outdoor spaces considering the socio cultural characteristics of each community, the abilities and characteristics of children background. The study collects descriptive data of children's interaction with their outdoor spaces through a behavioural mapping (Cox *et al.,* 2018), interviews with educational planners based on the behaviour notes as assessed.

7.1 Observations

The behavioural mapping as children engaged in outdoor activities most frequently in climate-appropriate seasons The periods chosen are during physical education (9:00 - 9:30) am, Breakfast period (10 - 10:45) am, short break period (11:30 -12:00) pm and at closing period (1:45pm). Moreover, considering that children's activities are affected by their own school guidelines, on-site observations was planned to cover all possible situations hence, the behavioural assessment was conducted three (3) times in a week notably Monday, Wednesday and Fridays respectively. The situation of environmental elements within the school outdoor spaces and the behaviour of children are recorded through still and motion photographs, behavioural notes, and mapping guide. In terms of environmental elements, the observations mainly cantered around the conditions of the outdoor infrastructures, spatial configuration of the school, road interface, and other facilities within the school. In terms of the behaviour of children, the observations cantered around the use of their outdoor spaces in relation to the existing landscape elements chosen from vegetative and geological features, wild life and ancillary features.

7.2 Interview

A semi-structured interviews, was randomly conducted among the head teachers who are regarded as the educational planners in the school, with emphasis on their expertise opinion on children interaction with outdoor

environment, (Ventouris *et al.,* 2021) the interviewees were mainly children's educational tutors. In order to ensure the effectiveness and credibility of the interview results, a simple pre-interview was conducted with the respondents. Three respondents from each of the three public primary schools participated in the interviews (Singh & Masuku, 2014), which covered areas such as children's daily paths and space preferences for outdoor activities that support learning, as well as problems related to the affordances of different environmental elements within the school. In doing these, interviewees' doubts were clarified prior to the exercise as noted by (Jamshed, 2014)

8. Data analysis

First, the schools visited were illustrated in drawings (figure 3) based on the notes obtained from on-site observations and behavioural mapping. Second, from the interviews, the study determined the importance of various environmental elements for children, based on interaction as observed and their affordances. Hence, the degree of children interaction emerging from the behavioural mapping and interviews were recorded and analysed through thematic and content analysis. These was further related to child-friendly outdoor landscape elements, and their performance characteristics, the affordance of various elements was summarized in the behavioural notes. The study elicits the positive affordances to which the outdoor space of the school provide for children. Uncovering the potential value of school outdoor in stimulating interaction with children, it provides a basis for bridging the gap between the provision of sustainable built environment and demand for maximum functionality.

9. Results

Affordance of environmental elements

Relating the data collected through the interviews and the observations from behavioural mapping as shown in tale 1., the study provides a preliminary assessment of the affordance of the school outdoor space. From the perspective of the environmental affordances of the school outdoor space, the frequency of various landscape elements, such as natural contact, identification, environmental consciousness, and functional richness provides positive affordances, indicating that these environmental elements had an important impact on children's activities. For example, the outdoor spaces with variety of landscape elements such as trees and shrubs with variety of geological features such as lose sans and pebbles significantly provides more sense of interaction for children than ordinary empty spaces (fig. 4a). The former could provide clear innovative information for children to acknowledge the use of space, while the latter could induce dullness and reduction in the sense of space. Restriction in the use of infrastructure, and provision of unsafe features had negative affordances for children in outdoor spaces. Absence of environmental elements such as facilities in activity areas, signage and decorations, define playgrounds, communal spaces, failed to provide effective affordance of the outdoor space; these by implication indicate that these environmental elements had little impact on children's activities. For example, some outdoor spaces could be kept clean, safe, and pollution-free, but lack necessary infrastructures occasioned with children's educational preference. The value of children's transactions in school outdoor spaces would rarely change due to the affordance of outdoor landscape element.

Table 1. Affordance of environmental elements

S/N	Elements	variables	Positive affordances	Negative affordances
1.	Vegetative Elements	Trees	Affords climbing, sitting under shade, and	Stoning of the fruit bearing trees
		Shrubs	Affords playing, rounding, knitting and playing with roses	Risk in the case of poisonous shrubs
		Climbers	No species of climbers are found within the school yards	
		Ground covers	Soft surface for playing, walking on, running, watching, and resting	Falling on hard surface can result to injury
2.	Geological Features	Lose soil	Affords surface for playing, walking on, dramatic skilling and rolling on	Afford splashing resulting to face and eye injury
		Rocks	hard surface for sitting, climbing, writing on, engraving skill	Falling on hard surface can result to injury
		Stone pebbles	sieving, counting, playing games, walking on:	Afford stoning, walking on and smashing Stone pebbles:
		Dips and hills	climbing, hiding, rounding, skipping, and jumping on	Affords falling and hitting on the surface of deep

3.	Live Creatures	Animals	Animals around the school affords watching, touching, panicking, chasing and riding	Animals around the school affords watching, touching, panicking, chasing and riding
		Insects:	chasing, hunting, catching, and watching	Exposure to some insects are harmful and dangerous
4.	Water Bodies	Water pools	swimming, diving, smashing, jumping on, watching and, drinking	Dirty water pools may be harmful to children
		Water ponds	playing, watching, rearing, fetching	Careless interaction can result into naegative affordance
		Water fountains	playing and watching in the case of running streams	
5.	Ancillary structures	Outdoor benches	sitting on, playing on, dragging, jumping on and	Instrument in destruction of other facilities
		Garden poles:	climbing, rounding, touching, leaning on,	Falling off in the event of illegal climbing
		Play equipment:	Playing, jumping skipping, rolling, imitations,	Causes accident in the event of mishandling fighting in the case of inadequate provision
		Art and craft:	Talking to, playing with, watching, imitation, and improves curiosity	

Source: Researcher 2024

Children Interaction with Outdoor Landscape Elements

The inquiry on these was based on the identified elements of outdoor landscape in educational spaces as noted by (Adeyemi, 2020) ranging from vegetative elements, geological features, water bodies and ancillary features. Questions were set in the observation guide to elicit information on the children interaction with outdoor elements through behavioural mapping. Several options were set under these questions with a corresponding relationship as indicators of environmental elements as shown in Table 2.

Table 2. Children Interaction with Outdoor Landscape Elements

S/N	Landscape Elements	Field observation notes
1.	**Abubakar Anike primary school Bida**	
	Vegetative Elements	Children interact with Shrubs and ground cover during p1 and all the elements except climbers for p2 p3 and p4, in the second visit, No interaction during p1 but with all elements except climbers for p2 p3 and p4 while Shrubs and ground cover during p1 &p2 and all the elements except climbers for p4
	Geological Features	Lose soil and pebbles during their outdoor activities for both first and second visit except for Fridays which are characterised with few outdoor activities due to short period to closing time although children interact with hard surfaces such as pavements and compacted earth surface of the class corridor
	Live creatures	Live creatures and animals are not part of the school landscape but children are found transacting to close neighbouring compounds to associate with horse and ships from their cages this usually occur during period p4
	Water bodies	Water bodies within the school include that of the water supply pipe network, children during break time p2 and p3 are found associating and appreciate its dramatic discharge and outflow to the discharge pond, although they do transact also around the water streams on their way off the school after closing time (p4)
	Ancillary structures	Play equipment, garden poles, outdoor benches are some features children transact with during p2 and p3 although art and craft features include those constructed by the children during outdoor play period p4 this happens throughout the period of the three observations

2.	**Limawa primary school Minna**	
	Vegetative Elements	Children interact with Shrubs and ground cover during p1 and all the elements except climbers for p2 p3 and p4. In the second visit, there is less interaction with trees during p1 but with all elements except climbers for p2 p3 and p4 while in the third visit, they interact with Shrubs and ground cover during p1 & p2 and all the elements except climbers in p4
	Geological Features	There is evidence of activities with Lose soil during their outdoor activities for both first and second visit except for Fridays which are characterised with few outdoor activities due to short period to closing time although children interact with surface rocks for stone smatching but no trace of pebbles present in the school
	Live creatures	There is no trace of animals within the school landscape but children are found chasing crawling and flying insects within the school compounds during breakfast and closing time p2 & p4 only for all the visits these are activities characterised with long period
	Water bodies	There is no trace of Water bodies within the school, although they do transact arround the adjoining water streams during breaktime p2 and on their way off the school after closing time (p4)
	Ancillary structures	Play equipment, and outdoor benches are some features children transact with during p2 and p3 although art and craft features include sculpturing of rock surface are found during outdoor play period p4 this happens throughout the period of the three observations
3.	**Remaye primary school**	
	Vegetative Elements	Children interact with scanty ground cover during p1 and all the elements except climbers for p2 p3 and p4, but in the second visit, there is less interaction during p1, but with all elements except climbers for p2 p3 and p4 while Shrubs and ground cover during p1 & p2 and all the elements except climbers for p4 were observed during the Last visit
	Geological Features	There is interaction with Lose soil during outdoor activities in p1, p2, p3, & p4 for both first and second visit but the third visit was characterised with few outdoor activities except with walking interface with ground covers, this is due to short period to closing time
	Live creatures	There is no trace of interaction with animals within the schoolyard but and flying insects were found within the school at all times with less interaction during p2 & p4 only, for all the visits these are activities characterised with long period
	Water bodies	There is no trace of any form of water body as landscape feature, hence there is less children transaction with such within and outside the school boundary. Children are therefore not expose to these features during school time
	Ancillary structures	There is no trace of signage, benches and garden poles. Children are found crafting with lose soil as well as wetted soil during raining season during break time and off school period P4 personal play equipment, are some elements children transact with during p2 and p3. Although there is trace of children appreciating art and craft features including furniture craft making and other associated craft works off the school time p4

Source: Researcher 2024

At the same time, the specific expression of the options in the observation note clarified the children behavioural assessment of the affordance performance of a particular element was positive. By tracking the frequency of selection of each option with respect to time, it helps in determining the importance to which the respondents ascribed to each element, each option in the observation schedule was scored through unified rules in the mapping guide, and determine the children assessment of the affordance of each element. The position of various landscape elements in the assessment of children interaction and their influence towards learning process through head teachers we also obtained

Fig 4a. Affordances of Soft Landscape Elements

Fig 4b. Children Interaction with Shrubs and Lose Soil

Fig. 4c. Children Interaction with Shrubs and Play equipment

Source: Researcher 2024

In terms of affordance characteristics, the five environmental elements of outdoor landscape provided in Table 1 such as vegetative elements, ranging from Trees, Shrubs and Ground cover was found to have higher interaction, in the observation schedule, indicating that children interact more with these elements (fig. 5a). In terms of geological features, lose soil and stone pebbles are found to be common in most of the schools (fig 5a) these in turns reveals that children interact with them more often, this is because other elements such as rocks, deeps and hills are features not dominantly found in most of the schools

Figure 5a: children interaction with vegetative outdoor elements

Figure 5b: school outdoor landscape with outdoor landscape corridor

Figure 5c: children interaction with hard surface pavements

Source: Researcher 2024

Wild life such as animals and insects are landscape elements which are not common in primary schools as most of the schools are characterised with no provision for such, although in schools where the perimeter fence are not fully provided, children are found appreciating the passing by animals resulting from nomadic exercise.

Similarly, water bodies are considered less important in terms of children interaction this is because such features are not present in the school yards even though research has it that water bodies are one of the children prefer landscape elements (Allahyar & Kazemi, 2021) but the underlying fact is because of its associated risk and its management

The ancillary features within the context of this study ranges from Outdoor benches, Garden poles, Art & Crafts and Play Equipment's. In this, outdoor benches and play equipment are found to have higher rate of interaction, fig. 6c. this indicates that children interact with these elements at all time the provision of play equipment affords children a variety of outdoor play such as swing, balancing, skipping, and so on, depending on the type of equipment provided

Finally, the affordances of permeability, hard surface, facility obstacles, and facility location received negative assessment as most of this elements are not provided except for the classroom corridors as in fig. 5b. Combined with the children attention to environmental factors in the observation schedule, it can be concluded that one of the reasons for the negative assessment of some elements (e.g., permeability) in some schools is that children considered that the negative affordance of these environmental factors would not significantly impact their activities. In addition, in the interview session, some respondents observed that restriction towards some outdoor elements as well as their locations were factors of great importance.

Figure 6a: children interaction with lose soil

Figure 6b: children use of surface rocks

Figure 6c: children interaction with school ancillary features

Source: Researcher 2024

10. Result Discussion

The result of the qualitative data collected from the field is as discussed based on their positive and negative affordance, Actualized and potential affordances as presented below

10.1 Positive and negative affordances

This study found that children outdoor activities in school are triggered by play equipment and other dangerous items, which are liable to the risk or misuse. Similarly, some structures climbed on during play may not only support children's entertainment, but also provide adverse environmental conditions for accidents, such as falling or bumping. The above negative affordance problems stem from the differences in understanding between the designers and the end users (children) of the outdoor spaces, as well as the complexity and diversity in user behaviour which tend to increases the risk of triggering negative behaviours. Various studies have reported on environmental affordance in a positive context, exploring the environmental and human factors of communication, learning, fitness, rest, and other activities, but have rarely tackled the environmental affordance behind negative phenomena such as destruction of property, safety consideration and accidents. The practical context of the theory of environmental affordance is limited to a positive and ideal background, which ignores the environmental conditions of negative behavioural activities. However, the environment can support the development of positive behaviour and discourage negative behaviour (Cox *et al*., 2018).

10.2 Actualized and potential affordances

The study reveals that children's interaction with outdoor space of primary school have a significant positive effect on individual, and peer group activities. Its potential affordance lies in providing functional spaces to enhance learning opportunities with outdoor elements. Children are the main beneficiaries of these elements as it affords them the opportunity to learn and grow in healthy ways (Cheng & Monroe, 2012) which provide them opportunities to engage in social activities. The indication of environmental affordance is highly dependent on the existence of its users. In the process of human-environment interactions, some affordances may be detected and used as "realized affordances," while others may be ignored as "potential affordances." Which forms the source and basis of other environmental affordances. While a majority of potential affordances remain undetected, this does not mean that their affordance is meaningless. The exploration of "potential affordances" is discuss the specific contents of all environmental affordances generally, but to refine a certain number of affordances of significance based on the premise of hypothetical users and their behavioural patterns.

11. Conclusion and Recommendations

Research into the area of child-friendly outdoor space of primary school is a topic of great concern in the design of primary school. The open space within the school is an indicator that exposes children to variety of landscape elements, which in turn affords them the opportunity to interact and foster their learning experience. Using the theory of affordance, this study investigated 3 public primary schools in Niger state through interviews and observations. It comprehensively considered the behavioural possibilities provided by the surrounding elements and children environmental preference. Moreover, it analyses the spatial situation of the outdoor spaces in terms of Positive and negative affordances, actualised and potential affordance, in order to attain full optimization of landscape elements at all levels,

This study regarded the environmental affordance of primary school yard as a resource, in controlling various risks to which children are exposed to, and maximizing the utilization of available resources. More also, in the provision of children preferred landscape elements, Safety consideration is one of the main factors affecting children's

independent activities within the schoolyard. Compared with their regular daily activities such as general study, unstructured and random play that can stimulate their enthusiasm for independent activities. To this end, outdoor space can be balanced with security to foster smooth connectivity around the facilities, which compensate the need to minimize potential accident and other safety hazards. The study therefore recommends that various characteristics of children outdoor space, such as accessibility of public facilities, method of circulation and available play facilities for maximum functionality, will positively influence children's transaction in their outdoor space. Noise reduction facilities, assessment and delimitation of buffer zones, highly readable warning signs for children, and attention restorative elements through environmental design can all provide children with opportunities to risk management and accident reduction there by create safe and sustainable outdoor space with high degree of e.

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Pattern of Crime in Relation to Neighbourhood Development in Traditional Lokoja, Kogi State, Nigeria

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Abstract

The study examines the pattern of crime in relation to neighbourhood development in the traditional area of Lokoja, Kogi State, Nigeria. Through Environmental Design (CPTED) strategy was used as a tool to reduce the intricacies of crimes and criminality in the study area. A total of 200 questionnaires were distributed using simple random sampling technique and 166 representing 82.5% of the sample size were validly returned. Data collected were analysed using percentage distribution tables. The study found that 20.0% at the frequency of 33 as respondents claimed that sexual offence/rape is the type of crime present in the study area, another 20.0% at the frequency of 33 as respondents declared theft and assault as the type of crime available in their neighbourhood, while 60.0% at the frequency of 99 as respondents said the type of crime activities found in their area is people openly selling drugs/usage of drugs. 23.0% at the frequency of 38 as respondents affirmed that the preventive measure taken to avoid becoming crime victim is by no longer taken certain routes in the study area. Findings revealed that poor urban planning, inadequate infrastructure and weak community engagement contributed to increased crime rates. Also, traditional institutions and community based initiative play a crucial role in crime prevention control in Lokoja metropolis. The study recommends Crime Prevention Through Environmental Design (CPTED) principles to prevent crime in traditional areas.

Keywords: Crime Prevention Through Environmental Design (CPTED), Urban crime patterns, Traditional urban areas, Neighbourhood development.

1. Introduction

Crime is fundamentally defined as an antisocial act that violates laws of the constituted authority, and for which punishment can be imposed (Isiaka *et al*., 2018). Crime and violence are serious problems in cities around the world threatening the quality of life, human rights, social and economic stability and sustainable development. Global studies by UN Habitat (2015), shows that 60% of all urban residents in developing countries have been victims of crime, at least once over the past five years, 70% of them in Latin America and Africa. Globally, crime incidence has steadily increased overtime from the 20th century period, rising about 30% from 2300 to over 3000 crimes per 100,000 inhabitants.

The situation in Nigeria is very disheartening especially in areas of rapid growth of unplanned cities and population pressure forces the poor populace to live in congested environment thereby increasing the tendencies of crime and violence to occur (Ugwuoke *et al*., 2020) stressed that the rapid pace of urbanization coupled with the growth in city size and density is associated with increased crime and violence threat. In line with the global trends, the rate of crime in Nigerian urban centres has been on the increase.

Capital cities in Nigeria such as Lagos, Ibadan, Kaduna, Abuja, Lokoja, Jos, Kano, and Maiduguri, among others have witnessed and are still experiencing sophisticated crimes of wide dimension. The major types of crime incidence in urban centres are categories into three; crime against person, property crime and crime against public order and welfare (Silver, 2017).

Poor urban planning, design, and management play a role in the shaping of urban environments that put residents and property at risk. It is argued that 10 to 15% of crimes have been estimated to have environmental design and management components (Wilkerson *et al*., 2018). The Land-use arrangement, street layouts, building, and site design, transportation system planning, infrastructure improvements had shown to have variable impacts on crime opportunity and on the subsequent incidence and fear of crime (Ugwuoke *et al*., 2020). There is no doubt that crime and violence is a major challenge in Nigerian cities including Lokoja metropolitan area. The emerging dimension and complexity of crime in Lokoja metropolitan area requires effective crime prevention and management measures

that will require adequate information and knowledge on the spatial pattern of crime incidence (Ojo and Ojewale, 2018).

The United Nation has noted that, challenges for growing cities are; growing slums, increase in air pollution and heightened risk of disasters, environmental degradations, and so on, for the population (Singh, 2015). Lokoja, the capital city of Kogi State, Nigeria is culturally rich and historically significant area with a blend of traditional and modern influences. The traditional area of Lokoja in particular faces unique challenges in balancing cultural heritage with modern development. One of the critical issues affecting his area is the intricate relationship between neighbourhood development encompasses various physical, social, and economic factors that shape the quality of life for residents. However, in traditional Lokoja is rapid urbanization, poor planning and inadequate infrastructure have contributed to increased crime rates, threatening the safety and security of residents. This study will analyse the pattern of crimes and neighbourhood development in traditional communities of Lokoja Metropolis.

2. Methodology

2.1 The Study Area

Lokoja Metropolis, which includes the traditional areas, lies on Latitude 7° 45' 27.56''- 7° 51' 04.34''N and Longitude 6° 41' 55.64''- 6° 45' 36.58''E, (figure 1) with the total land coverage of 63.82 Sq.km (Adeoye, 2012). It is situated on the Western bank of the confluence of River Niger and River Benue at an altitude between 45-125 metres above sea level towards the North-South at the foot of 1349mm of Mount Patti Ridge, with an altitude of 411 metres above sea level.

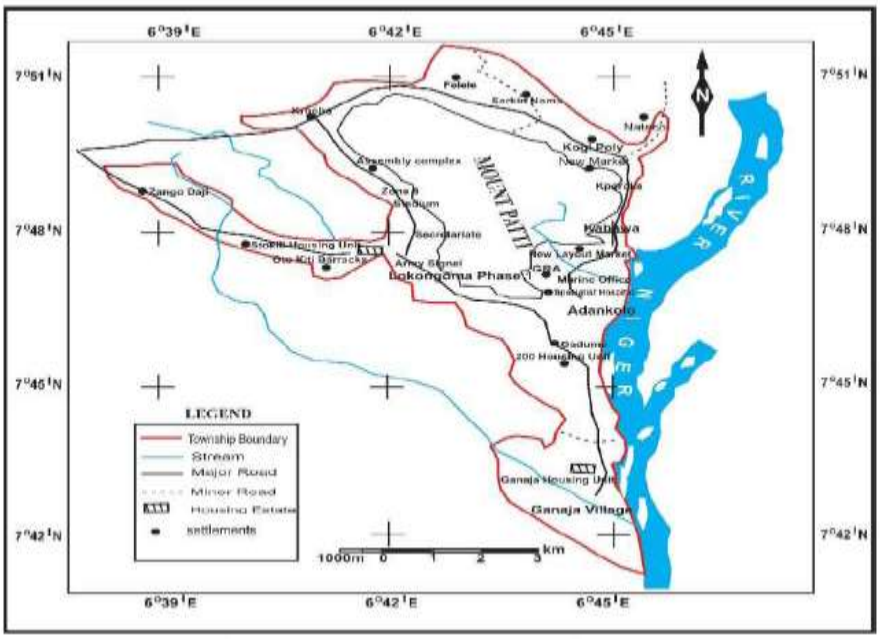

Figure 1: Lokoja Metropolitan Area
Source: ArcGIS, 2024

2.2 Sources of Data and Research Design

Primary data includes questionnaires administration through oral or personal interview with the stakeholders, to acquire relevant information for inferences. While secondary data was an extractive information from textbook, journals, magazines, encyclopaedia, Library resources, internet facilities.

2.3 Data Sampling and Analysis

Using random sampling technique, a total population of the study area from Kabawa, Cantonment and Maigari palace is 110,501 people, from which sample size of 400 people were sampled, using Taro Yamane (1967) formula to determine the total numbers of questionnaires needed for administered.

The formula is expressed as:

n= N/ (1+N (e) 2)

Where:

n = sample size

N = signifies the population under study

E = signifies the margin error (it could be 0.10, 0.05 or 0.01)
A total of 200 questionnaires were distributed and 165 representing 82.5% of the sample size were validly returned. The analysis of data collected based on the sample size taken from the population of study was based on the survey carried out on the influence of urban design in reducing urban crime in the traditional city centre of Lokoja, Kogi state (Magairi palace, cantonment and kabawa axes respectively).

3. Results

3.1 Types of Crime in the Neighbourhood

It was revealed that, 20.0% at the frequency of 33 as respondents claimed that sexual offence/rape is the type of crime present in the study area, another 20.0% at the frequency of 33 as respondents declared theft and assault as the type of crime available in their neighbourhood, while 60.0% at the frequency of 99 as respondents said the type of crime activities found in their area is people openly selling drugs/usage of drugs(Table 1)..

Table 1: Types of Crime in the Neighbourhood

Types of Crime	Frequency	Per (%)
Sexual offence/Rape	33	19.9
Theft & Assault	34	20.5
People openly selling/usage of drugs	99	59.6
Total	166	100.0

Source: Author's Fieldwork, 2024

3.2 Motivating Factors for Crime in the Area

It was observed that, 15.8% at the frequency of 26 as respondents said isolated routs within the vacant plots/building is the factors that motivate crime in the study area, 45.5% at the frequency of 75 as respondents claimed that the factors is as a result of poor lighting and dark spots, 15.8% at the frequency of 26 as respondents agreed that the factors which motivate crime is dead end street in the area, while 23.0% at the frequency of 38 declared overgrown shrubs/trees (Table 2).

Table 2: Motivating Factors for Crime in the Area

Factors that Motivate Crime	Frequency	Per %
Isolated routes within the vacant plots/building	26	15.6
Poor lighting/dark spots	76	45.7
Dead end street in the area	26	15.6
Overgrown shrubs/trees	38	22.9
Total	166	100.0

Table 3: Period of Crime Occurrence in Your Area

Period of Crime	Frequency	Percentage (%)
Morning	13	7.8
Afternoon	26	15.6
Evening	26	15.6
Night	101	60.8
Total	166	100.0

The results revealed that, 7.3% at the frequency of 12 as respondents claimed that the period of crime occurrence in the study area has always been in the morning, 15.8% at the frequency of 26 as respondents said crime do occurs in the afternoon, another 15.8% at the frequency of 26 affirmed that crime do take place at the evening hour of the day, 15.8% at the frequency of 26 as respondents also agreed that crime occurs at the early night, while 54.5% at the frequency of 75 declared late night as shown in Table 3..

Table 4: Crime Preventive Measure

Preventive Measures to Avoid Crime	**Frequency**	**Per (%)**
No longer taken certain routes	38	23.0
Avoid going out at night	89	53.9
Avoid going out alone	38	23.0
Total	165	100.0

The results revealed that, 23.0% at the frequency of 38 as respondents affirmed that the preventive measure taken to avoid becoming crime victim is by no longer taken certain routes in the study area, 53.9% at the frequency of 89 as respondents claimed that the preventive measure taken to avoid becoming crime victim over time is to avoid going out at night, while 23.0% at the frequency of 38 as respondents declared that the only preventive measure taken to avoid becoming victim of crime in their area is simply to avoid going out alone as shown in table 4.

4. Discussion

The findings in this study deduced that, there is high population of people as low income earners, and inference can be made to say that there is low standard of living and high poverty level, and this usually triggers high crime rate in most traditional corridors. Similarly, Coccia, (2017) socioeconomic inequality is positively associated with violent crime. Similarly, Coccia, (2018). The reports of Violent behavior and crime can be due to manifold determinants, such as poverty Agada *et al* (2022) reported kernel density and hotspot analysis shows that there exist three crime hotspots within Lokoja metropolis namely; Paparanda roundabout, Local Government Secretariat junction and Ganaja junction.

The findings in this study have deduced that, the majority of the respondents agreed to the fact that people openly sell hard drugs/usage of hard drug which by implication has polluted the entire neighbourhood over time. The reports of Oche, (2019) reported that the use of illicit drugs appeared

to increase with males in some hotspot's areas of Lokoja. Odejide (2006) reported that psycho active substance abuse among secondary school neighbourhoods in Enugu, Nigeria Similarly, Dambazau (2022) reported that unlawful possession of drugs is offence against lawful authorities in Nigeria.

The findings in this study have reported that the majority of the respondents simply subscribes to the fact that poor lighting and dark spots are the prime factor that motivate all kinds of crime activities. Dambazau (2022) has underlined problems such as security and crime in urban areas in developing countries as a phenomenon to be taking seriously when planning a city. Liu *et al*., (2020) in their work aimed at understanding the motives behind crime happenings, the major indicators of crime

The majority of the respondents in this study have agreed to the fact that crime incidence oftentimes do take place at late night when virtually everybody is asleep. This agrees with the reports of Agada *et al* (2022), who stated that crime incidences such as theft are concentrated in the city centre with few crime cases when people are asleep.

The findings in this study have revealed that the majority of the respondents agreed to the fact that, there should a minimized level of avoidance of going out at night as a preventive measure taken over time to avoid becoming victim of crime. This agrees with the reports of Jin (2023) who stated that, the government should create employment chances for vulnerable youths as such cannot make them engage in night crime. Similarly, Sherman and Doussard (2019) also reported that the art of crime prevention to that of art of medicine whose effectiveness lies in the coffers of the State and local crime prevention assistance program. Agada *et al*., (2022) reported that the possibility of utilizing crime maps and analysis generated using Geographic Information System as a tool in policing for crime fighting, control and crime prevention programs.

5. Conclusion

The study found that traditional areas and their environs can adequately be planned to adopt Crime Prevention Through Environmental Design (CPTED) principles in order to reduce the crime rate. The study of pattern of crime in Lokoja

Traditional areas also reveals that personal and property crimes are predominant in neighbourhoods classified as hotspots and high crime areas, and finding revealed that neighbourhood characteristic influence crime occurrence. The study recommends a policy based on Crime Prevention Through Environmental Design (CPTED) to prevent crimes in urban area.

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Factors Influencing Energy Efficiency of Buildings in Nigeria's Tropical Humid Dry Zone

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Abstract

This study addresses the limitations of Nigeria's National Building Energy Efficiency Code (BEEC) by identifying context-specific factors influencing building energy efficiency in the country's tropical humid dry zone. Using a Delphi approach, the research engaged experts from academia and practice to evaluate and reach a consensus on key factors. The study revealed five critical elements: mechanical factors, lighting, openings, size of features, and height of features. Building material did not emerge as a significant factor. These findings highlight the importance of considering regional climatic variations and sociocultural contexts in developing energy efficiency frameworks. The study revealed the inadequacy of the current one-size-fits-all approach and recommends a more context-specific strategy for improving building energy efficiency in Nigeria. This study contributes to the growing body of knowledge on sustainable building practices in developing countries and provides a foundation for future research on energy-efficient building design in tropical climates

Keywords: Building Energy Efficiency Code, DELPHI, Efficiency, Energy.

1. Background to the Study

The world faces significant environmental challenges due to excessive energy consumption, primarily from fossil fuels and coal (Alhashmi *et al*., 2021; Nunez *et al*., 2019). Buildings are major contributors, consuming up to 40% of global energy resources and accounting for nearly one-third of greenhouse gas emissions (Kasozi and Tutesigensi, 2007; Pearce and Ahn, 2017). This has led to the development of energy efficiency mechanisms and policies worldwide (Mclennan, 2014). In response, Nigeria developed the National Building Energy Efficiency Code (BEEC) in 2017. BEEC aims to provide a pathway to energy efficiency using four indicators: window openings to wall ratio, lighting, roof insulation, and air conditioning. However, it has faced criticism on various grounds, including cost concerns, compliance and enforcement challenges, and issues with variability and regional differences.

A key criticism is that BEEC doesn't adequately account for Nigeria's climatic variability. The country is divided into five climate zones according to the Köppen-Geiger classification, but BEEC doesn't sufficiently consider these differences in its development. Research has shown that it's challenging to design energy-efficient buildings for specific microclimatic areas without studying the context (social, economic, and cultural) and analyzing area-specific data (Ochedi and Taki, 2021). Building materials, influenced by economic capability and sociocultural factors, are also crucial determinants of energy efficiency (Alabi and Fapohunda, 2021; Danso and Obeng-Ahenkora; Musarat *et al*., 2021; Oladipo and Oni, 2012). Understanding these dynamics is essential for developing an effective energy efficiency framework.

The tropical humid dry zone of Nigeria, characterized by high temperatures averaging 32°C and distinct wet and dry seasons, presents unique challenges for building energy efficiency. In this region, buildings typically require significant energy for cooling and ventilation, with air conditioning accounting for up to 60% of total building energy consumption (Oladipo and Oni, 2012). Despite these specific climatic challenges, local building practices often prioritize cost reduction over energy efficiency, resulting in structures that rely heavily on mechanical cooling systems rather than incorporating passive design strategies suited to the regional climate (Ochedi and Taki, 2021). The BEEC has been criticized for downplaying the importance of building orientation, which is a low-cost option to improve occupant comfort and reduce energy consumption (Albatayneh *et al*., 2018; Ochedi and Taki, 2021). Additionally, while BEEC considers roofing, it overlooks building and ceiling height, which can significantly affect thermal comfort and energy use (Yuksek and Karadayi, 2017; Ghafari *et al*., 2018; Ochedi and Taki, 2021). Other key factors missing from BEEC include fenestration, landscaping, building density, and socioeconomic dynamics. Furthermore, BEEC uses an equal weighting approach for its indicators, which has been criticized for not reflecting the unique contribution of each factor to energy efficiency (Winkler, 2015). The study therefore seeks to answer

the research question "how can building energy efficiency frameworks in Nigeria be adapted to better reflect local climatic conditions, socioeconomic factors, and technical requirements specific to the tropical humid dry zone? This study aims to identify and prioritize context-specific factors influencing building energy efficiency in Nigeria's tropical humid dry zone using the DELPHI approach, thereby addressing the current BEEC framework's limitations and providing recommendations for a more locally adapted energy efficiency code

2. Literature Review

The literature on building energy efficiency reveals an interplay of factors that influence energy consumption in buildings across various contexts. Ochedi and Taki (2021) developed a framework for energy-efficient residential buildings in Nigeria, though their approach did not fully account for climatic variability and sociocultural factors. In a broader context, Gillingham *et al*. (2021) demonstrated the potential impact of ambitious energy efficiency upgrades in the United States, projecting significant reductions in emissions and potential prevention of premature deaths. The impact of climate change on building energy consumption, particularly for heating and cooling demands, was highlighted by Bazazzadeh *et al*. (2021). This perspective was complemented by Mostafavi *et al*. (2021), who focused on high-rise buildings and identified envelope design, plan layout, and natural ventilation as key factors for reducing energy consumption.

Chen *et al*. (2020) provided a comprehensive categorization of factors influencing building energy efficiency in China, encompassing building characteristics, equipment/technologies, and occupant behaviours. This multifaceted approach was echoed in the work of Qarnain *et al*. (2021), who modelled the driving factors of energy efficiency in buildings, identifying motivation, education/awareness, coercive factors, occupant behaviour, and energy-saving equipment as key elements. In more specific contexts, Azmi *et al*. (2021) assessed factors influencing energy efficiency in Malaysian mosques, while Akande *et al*. (2014) explored sustainable approaches to energy efficiency in Nigeria's Northern Guinea Savanna region. Both studies underscored the importance of considering local climatic and cultural factors in energy efficiency strategies.

The potential for energy efficiency improvements in heritage buildings was examined by Akande *et al*. (2014), who noted that significant energy reductions could be achieved without compromising the unique characteristics of these structures. This idea of context-specific approaches was further reinforced by Awawdeh and Tweed (2011), who emphasized the importance of tailoring building energy codes to reflect the climatic, cultural, and political context of each community. Collectively, these studies highlight the multifaceted nature of building energy efficiency and the need for comprehensive, context-specific approaches that consider climate, building design, occupant behaviour, and local sociocultural factors when developing energy efficiency frameworks and policies.

3. Research Methodology

The primary instrument used for data collection for this study is the DELPHI questionnaire. The Delphi survey method is a group facilitation technique that seeks to obtain consensus on the opinions of `experts through a series of structured questionnaires (commonly referred to as rounds). The questionnaires are completed anonymously by experts (panellists, participants, or respondents) from diverse field of study. As a part of the process, the responses from each questionnaire are fed back in summarized form to the participants (Hasson *et al*., 2000). The Delphi is therefore an iterative multistage process designed to combine opinion into group consensus (McKenna 1994, Lynn *et al*., 1998). The initial questionnaire also collected qualitative comments, which are fed back to the participants in a quantitative form through a second questionnaire.

Therefore, a well-structured closed and open-ended Delphi survey questionnaire were developed to elicit requisite information on indicators and weight of indicators from experts from academia and practice in the southwest region of the country. A total of 15 experts from the built environment and 15 experts from academia with a minimum of ten years' experience in energy efficiency projects were purposively selected. The DELPHI survey focused on identifying and validating various dimensions and indicators of energy efficiency while taking cognizance of the climatic variability in the region. A three-round Delphi survey was proposed for the study, but consensus was achieved at the end of the second round. The descriptive and inferential analytical tool was adopted. The descriptive analytical tool to be used include mean and standard deviation, which will be used to describe the subjective response of the professionals. The data will also be subjected to exploratory factor analysis to extract the core factors or drivers of energy efficiency in residential buildings in the southwest region. Interquartile Range/deviation was used to measure consensus among experts. Values below 1.00 represent consensus, while values above 1.00 means there is no consensus.

Table 1: Levels of Consensus

Quartile deviation (QD)	Level of consensus	Median	Level of importance
Less or equal to 0.5 (QD ≤ 0.5)	High	4 and above (M ≥ 4)	High
More than 0.5 and less than or equal to 1.0 (0.5 ≤ QD ≤ 1.0)	Moderate	3.5 and less (M ≤ 3.5)	Low
More than 1.0 (QD ≥ 1.0)	Low and no consensus	–	–

Source: Adopted from Norizan (2003)

4. Results and Discussion

4.1 Factors Influencing Energy Efficiency of Residential Buildings by Professionals

The result from the first round of assessment by 12 out of 30 invited professionals, seven academia and five practitioners that participated is presented in Table 2. The panel assessment of the six (6) factors was rated to determine the importance of the factors extracted from residents' responses on the energy efficiency of residential buildings. The result of the panel assessment was statistically analysed to determine their consensus based on three (3) defined criteria of Mean score of ≥7 on a Scale of 1 -10, inter-quartile range (IQR) of ≤ 1.5, and Coefficient of Variation (CV) of ≤ 0.3. Items are considered for consensus if they achieve the panellist assessment based on the set criteria.

The Delphi result shows that consensus was reached on four (4) factors -Mechanical factor, Lighting, and Size of feature – that mutually met the three (3) criteria. However, the academic professionals did not achieve panellist consensus on the influence of two factors – Building material (IQR = 2) and height of features (IQR = 2.0), which failed to meet two of the three criteria. Similarly, the result reveals that the panel of professional practitioners achieved consensus on the importance of four (4) factors, Mechanical factor (M = 7.50; CV = 0.08, IQR =1.0), Size of features (M = 8.10; IQR = 1.0), Building Height (M = 7.60; IQR = 1.0) and Lighting d to consensus (M = 8.10; IQR = 1.5). However, Consensus was not achieved for Openings (M = 6.10; IQR = 2.0) and Building Material (M = 6.90; IQR = 2.0). The variability in the opinion of both professionals (Academia and Practitioners) is also reflected in the weight assigned to the factors. The variability in experience and teaching may be a major factor influencing the high degree of variability in the opinion of the experts from academia. Overall, only the 'Mechanical factor', 'Lighting', and 'Size of features' gained consensus in round 1.

Table 2: First Round of Energy Efficiency Factor

	Academic			Practitioners		
Components	**Mean**	**CV**	**IQR**	**Mean**	**CV**	**IQR**
Mechanical Factor	8	0.08	1.5	7.50	0.08	1.0
Lighting	8.18	0.08	1.5	8.10	0.08	1.5
Opening	6.42	0.12	1.5	6.10	0.13	2.0
Size of features	7.92	0.08	1.5	8.10	0.08	1.0
Building Material	7.46	0.08	2	6.90	0.10	2.0
Height of features	7.57	0.08	2	7.60	0.08	1.0

Table 3 shows the Delphi result of the second round of assessment of factors for the energy efficiency of residential buildings. The result indicates that consensus was reached on five (5) out of six (6) factors – 'Mechanical factor', 'Lighting factors', 'Opening factors', 'Size of features', and 'Height of features, – that mutually attained the three (3) criteria for both panellists. However, panellist consensus was not achieved by both the academic professionals and practitioners on 'Building material' (M = 6.20) and (M = 6.50), respectively, as an essential factor due to the mean score < 7.0 on a Likert scale of 1-10 rated. This invariably shows that the panellists agreed that five factors play a significant role in determining the energy efficiency level of residential buildings as against six that were extracted from the response of the households.

Table 3: Second Round of Energy Efficiency Factor

	Academic			Practitioners		
Components	**Mean**	**CV**	**IQR**	**Mean**	**CV**	**IQR**
Mechanical Factor	9.10	0.08	0.8	8.30	0.08	1.0
Lighting	8.50	0.08	1.0	8.40	0.08	1.0
Opening	7.42	0.09	1.0	7.30	0.09	0.3
Size of features	8.30	0.08	1.0	8.30	0.08	1.0
Building material	6.20	0.13	0.8	6.50	0.11	1.0
Height of features	9.30	0.08	1.0	9.00	0.08	1.0

The most intriguing finding is the persistent lack of consensus regarding building materials. Despite two rounds of consultation, neither academic nor practitioner groups rated building materials above the threshold mean score of 7.0 (final scores - Academia: 6.20; Practitioners: 6.50). This divergence is particularly significant given Nigeria's context, where the choice of building materials is often constrained by economic factors, market availability, and the tension between traditional and modern construction practices. Traditional building materials, which often possess natural cooling properties, compete with modern materials that may be perceived as more durable or prestigious, creating a complex decision-making environment for builders and developers.

5. Conclusion and Recommendations

This study sought to identify context-specific factors influencing building energy efficiency in Nigeria's tropical humid dry zone, addressing limitations in the current National Building Energy Efficiency Code (BEEC). Using a Delphi approach, the research achieved consensus on five key factors: mechanical factors, lighting, openings, size of features, and height of features. Surprisingly, building material did not emerge as a significant factor, contrary to initial expectations. These findings demonstrate the importance of regional climatic variations and sociocultural contexts in developing energy efficiency frameworks, highlighting the inadequacy of a one-size-fits-all approach like the current BEEC.

The findings have several practical implications for policymakers and building professionals. First, the BEEC should be restructured to incorporate the weighted importance of different factors rather than its current equal weighting approach. Mechanical factors and lighting, which received consistently high ratings, should be given greater emphasis in the assessment criteria. Second, the code should include specific guidelines for building height and feature sizing, which are currently overlooked despite their significant impact on energy efficiency in tropical climates. Third, while building materials did not achieve consensus, this suggests a need for more detailed investigation into cost-effective, locally available materials that meet both energy efficiency and economic requirements. Future research should extend this investigation to Nigeria's other climatic zones to develop region-specific recommendations for the BEEC. Additionally, economic analyses of different energy efficiency measures would help identify cost-effective solutions for implementation. Studies examining the intersection of traditional building practices with modern energy efficiency requirements could also provide valuable insights for policy development.

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Small Hydropower: Nigeria's Untapped Solution to Rural Electrification. A Case Study of River Osun

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Abstract

This study investigates the potential of small hydropower (SHP) as a sustainable solution for rural electrification in Osun State, Nigeria, focusing particularly on river Osun and three rural catchment communities: Aponmu, Awo, and Ileogbo. Using remote sensing and geographic information systems (GIS), the research identified and analyzed potential SHP sites across ten Local Government Areas (LGAs). The study employed a quantitative approach, incorporating descriptive research design and multi-tier analysis techniques to assess current energy access levels. Results revealed 86 viable SHP sites with a cumulative potential of 109.52 MW, with Ayedire LGA showing the highest potential of 37.02 MW. Despite high grid connection rates (Connection Index = 1), the analysis of electricity access revealed concerning patterns of low to moderate access due to poor duration, reliability, and quality indices. The findings indicate that the identified SHP potential could serve between 41,484 to 82,969 households, depending on plant performance capacity. The study utilized Wagner and Mathur's hydropower equation for energy potential calculations and the ESMAP multi-tier framework for energy access assessment. Analysis of current electricity access levels showed an overall moderate access index of 0.58 when considering all four dimensions, but a low access index of 0.44 when excluding connectivity. The research concludes that SHP presents a viable alternative for rural electrification in Osun State, recommending integrated policy frameworks, technical implementation strategies, and community engagement approaches for successful development.

Keywords: Energy Access; Geographic Information System (GIS); Multi-tier Framework; Renewable Energy; Remote Sensing; Rural Electrification; Small Hydropower (SHP); Sustainable Development;

1. Introduction

Nigeria, Africa's most populous nation, continues to grapple with significant electricity access challenges, particularly in rural communities where approximately 60% of the population resides (World Bank, 2023). Recent data indicates that only 55.4% of rural areas have electricity access, compared to 83.9% in urban regions (African Development Bank [AfDB], 2023). Despite the country's abundant water resources and over 278 identified small hydropower sites, with a cumulative potential of about 3,500 MW, only 8.5% of this capacity has been developed as of 2023 (Abdullahi *et al*., 2022; UNIDO, 2022). The persistent energy deficit has impeded socio-economic development, with rural businesses reporting average losses of 34% in potential revenue due to unreliable power supply (Ohunakin *et al*., 2023).

Traditional grid extension to remote communities often proves economically unfeasible, with estimated costs of $25,000-$30,000 per kilometer of transmission line (Mohammed *et al*., 2024). Small hydropower technology presents a viable alternative, offering a decentralized, renewable energy solution that can harness Nigeria's extensive network of rivers and streams, with implementation costs averaging $2,500-$3,000 per kilowatt for systems under 100 kW (Adewuyi *et al*., 2023). Studies indicate that small hydropower installations have shown a 65% lower environmental impact compared to large hydroelectric projects, with an average project completion time of 18-24 months versus 5-7 years for large-scale dams (Kumar & Sharma, 2023; Oyedepo *et al*., 2024). With only 8.5% of Nigeria's 3,500 MW small hydropower potential currently harnessed, despite rural businesses losing 34% of potential revenue due to unreliable electricity, there is an urgent need to accelerate SHP deployment. While previous studies have documented the technical feasibility of SHP installations, there remains a significant knowledge gap regarding the comprehensive framework needed to effectively implement and scale these systems within Nigeria's unique socio-economic and geographical context

2. Literature Review

Small hydropower (SHP) presents a viable solution for rural electrification in Nigeria, a country facing significant energy access challenges. The potential of SHP systems is particularly relevant in rural areas where traditional grid extension is often economically unfeasible and technically challenging. The literature indicates that SHP can significantly contribute to alleviating the energy deficit in these regions, thereby enhancing socio-economic development. Edomah *et al*. highlight the role of foreign interventions in Nigeria's renewable energy sector, emphasizing the World Bank and African Development Bank's efforts to improve energy access in rural communities through renewable technologies, including SHP (Edomah *et al*., 2021). This aligns with Chinweoke *et al*.'s findings, which advocate for off-grid power generation via small hydropower plants as a means to provide sustainable energy services to underserved populations in Nigeria (Chinweoke *et al*., 2020). The authors argue that SHP can effectively mitigate the challenges of rural electrification, particularly in isolated areas where grid connections are absent.

Moreover, Odetoye's research supports the economic advantages of small and medium-scale renewable technologies, including SHP, in rural electrification efforts (Odetoye, 2023). The Rural Electrification Agency of Nigeria has identified these technologies as critical for addressing the electricity access gap, particularly in remote communities. Olanrewaju and Olanrewaju further emphasize the socio-economic benefits of electrification, noting that access to reliable electricity can enhance productivity and profitability among rural microenterprises, thereby fostering economic growth (Olanrewaju & Olanrewaju, 2020). The feasibility of SHP systems is also underscored by studies assessing specific sites for potential development. For instance, Fagbohun and Omotoso conducted a viability assessment of the Elemi River in Ekiti State, demonstrating the potential for SHP to provide off-grid electricity and address the persistent power outages affecting local institutions (Fagbohun & Omotoso, 2018). Similarly, Olanrele *et al*. discuss the broader implications of electricity access on education and health in rural communities, highlighting the urgent need for reliable energy sources to support essential services (Olanrele *et al*., 2020).

In addition to SHP, hydrokinetic energy presents another promising avenue for rural electrification. Olatunji *et al*. argue that hydrokinetic systems, due to their simpler design and lower costs, could be more economically viable than traditional small hydropower systems in Nigeria (Olatunji *et al*., 2018). This suggests a diversified approach to harnessing water resources for energy generation, which could complement SHP initiatives. Despite the promising prospects of SHP and hydrokinetic energy, challenges remain in the implementation of these technologies. The literature indicates that the lack of a coherent electrification strategy and investment in infrastructure continues to hinder progress. For instance, Akpojedje and Mormah discuss the systemic issues within Nigeria's electricity transmission framework that complicate rural electrification efforts (Akpojedje & Mormah, 2019). Addressing these challenges requires a multi-faceted approach, incorporating policy reforms, investment in technology, and community engagement to ensure sustainable energy access. In conclusion, small hydropower represents a critical component of Nigeria's strategy for rural electrification. The existing literature underscores its potential to provide sustainable energy solutions, enhance economic development, and improve quality of life in rural communities. However, for SHP to realize its full potential, concerted efforts are necessary to overcome infrastructural and policy-related challenges..

3. Methodology

The study adopts the descriptive research design approach with the use of remote sensing and geographic information system as requisite tool for data collection and analysis. The study focused on river Osun and three rural catchment communities of river Osun, namely; Aponmu, Awo, and Ileogbo. The study had a population of 42,320 households, However, due to the homogeneous nature of the communities, a total of 98 households were sampled across the communities. Remote sensing and GIS data was collected and analysed using ArcGIS and Global Mapper platform to identify suitable and viable Small hydropower potential Sites (Table 1). The flowchart for the The current level of energy access in the communities were estimated using the multi-tier technique developed by ESMAP (2014). Wagner and Mathur, (2011) hydropower equation was adopted to determine energy potentials of the site.

$$Pp = r * g * n_t * n_g * c *. Q * (H_{p.up} - H_p) \quad (1)$$

The estimated number of households that can be served by the potential energy identified across river Osun was estimated at a minimum of 500kWh/per annum as proposed by International Energy Agency (IEA, 2015) for urban households with a household size of 5. The result was presented in Tables and Charts.

Table 1: Remote Sensing Data Collected

S/N	Dataset	Type	Source	Data
1	Digital Elevation Map (DEM-SRTM)	Raster	CGIAR-CSI SRTM 90m Database	Elevation, Gradient, and watershed
2	Global River Network (Hydroshed)	Vector (polyline)	Hydroshed	Natural river network
3	Global Streamflow Characteristics Dataset (GSCD)	Raster	Hydroshed	Natural river flow direction
4	Topographical Map	Raster-Vector	Openstreet Map	River profile/Slope

4. Results and Discussion

4.1 Distribution of small hydropower potentials in Osun State

Table 2 shows that Eight-six (86) small hydropower potentials sites were identified in the river basin within Osun State Boundary. The potential sites were distributed across ten (10) LGAs of Osun State. The minimum small hydropower potential sites in Osun State are in Ejigbo LGA with 0.111mw, while the maximum is in Isokan LGA with 6.459mw. Similarly, Ayedire LGA had the highest total of 37.02mw of small hydropower potential Osun State, followed by Isokan (20.312), and Egbedore (15.096). However, Atakumosa, Ejigbo, and Ola-Oluwa LGAs had the least total small hydropower potential in the State with 1.191mw, 1.358mw, and 1.648mw respectively. The average small hydropower potential available within Osun State region of the river basin is about 1.1598mw. Overall, the findings from Table 2 suggest that there is significant small hydropower potential in Osun State, particularly in LGAs like Ayedire and Isokan. These findings align with the broader literature on hydropower development and its potential benefits for rural electrification and sustainable energy generation.

Table 2: Spatial Distribution Pattern of Small Hydropower Potential in Osun State

No	LGA	Count	Min (mw)	Max (mw)	Sum (mw)	Mean (mw)
1	Ayedaade	4	0.602	1.476	3.499	0.87
2	Ayedire	27	0.272	3.278	37.02	1.371
3	Egbedore	10	0.462	2.949	15.096	1.51
4	Ejigbo	4	0.111	0.877	1.358	0.4
5	Irewole	5	0.57	3.455	9.989	1.998
6	Isokan	6	1.359	6.459	20.312	3.38
7	Atakumosa East	2	0.509	0.682	1.191	0.087
8	Ife South	13	0.167	3.509	13.843	1.064
9	Iwo	11	0.135	1.607	5.563	0.506
10	Ola-Oluwa	4	0.184	0.736	1.648	0.412
	Aggregate	**86**	**0.111**	**6.459**	**109.52**	**1.1598**

4.2 Current Level of electricity access in Osun State LGAs

Table 3 presents a comprehensive evaluation of the level of electricity access in various Local Government Areas (LGAs) within Osun State. The Connection Index (C.I) serves as an indicator of the extent to which households are connected to the electricity grid. In all three LGAs, Apomu, Awo, and Ileogbo. The C.I is uniformly rated at 1, suggesting a complete connection to the grid in these areas. Across the assessed LGAs, the D.I is consistently recorded at 0.4, indicating a moderate duration of electricity availability. Notably, Awo and Ileogbo both exhibit an R.I of 0.4, denoting a moderate level of reliability, while Awo records a slightly lower R.I of 0.3. The Quality Index (Q.I) range from 0.45 to 0.68, with Awo registering the highest Q.I, indicating a comparatively better quality of electricity supply in this LGA. Considering the four indicators of access, the communities in Osun state had a moderate level of access with an index of 0.58. However, excluding connectivity provides a nuanced view of the level of electricity access, which shows that energy access level in the communities is low with an index of 0.44. All the LGAs were low in access to electricity with Ileogbo recording the least electricity access index of 0.42, Apomu 0.43, and Awo 0.49.

Table 3: Level of Electricity Access in Osun State LGAs

Level	C.I	D.I	R.I	Q.I	4D Access	3D Access	Remark
Apomu	1	0.4	0.3	0.58	0.57	0.43	**L.A**
Awo	1	0.4	0.4	0.68	0.62	0.49	**L.A**
Ileogbo	1	0.4	0.4	0.45	0.56	0.42	**L.A**
Mean	**1**	**0.40**	**0.37**	**0.57**	**0.58**	**0.44**	**L.A**
Remark	**A**	**L.A**	**L.A**	**M.A**	**M.A**		

Note: C.I= Connection Index; D.I= Duration Index; R.I=Reliability Index & Q.I.=Quality Index
0.00-0.29= No Access; 0.30-0.49= Low Access; 0.50-0.70= Moderate Access & 0.71-1.00= Access

4.3 Estimated Potential Energy Available to Households

Table 4, presents the estimated household population to be served by small hydropower potential in various Local Government Areas (LGAs) within Osun State. For example, in Ayedaade, with an energy potential of 3.499 MW, the SHP projects are estimated to serve 2,651 households at 100%, 1,988 households at 75%, and 1,325 households at 50%. Similarly, Ayedire, with a substantial energy potential of 37.02 MW, is projected to serve 28,045 households at 100%, 21,034 households at 75%, and 14,023 households at 50%. These figures underscore the significant potential for electricity generation and the consequential reach of the SHP in addressing the household energy needs in these LGAs. The cumulative SHP for Osun State indicates an overall energy potential of 109.52 MW, projected to serve 82,969 households at 100%, 62,227 households at 75%, and 41,484 households at 50% operational capacity. These aggregated figures provide a holistic view of the collective impact of SHP in Osun State region of the basin, showcasing the potential for widespread electrification and contributing to socio-economic development and improved living conditions for the residents if harnessed.

Table 4: Estimated Household Population to be Served by the SHP in Osun State

		Plant Performance Capacity		
Osun State	**Energy Potential (MW)**	**No of Household (100%)**	**No of Household (75%)**	**No of Household (50%)**
Ayedaade	3.499	2651	1988	1325
Ayedire	37.02	28045	21034	14023
Egbedore	15.096	11436	8577	5718
Ejigbo	1.358	1029	772	514
Irewole	9.989	7567	5676	3784
Isokan	20.312	15388	11541	7694
Atakumosa East	1.191	902	677	451
Ife South	13.843	10487	7865	5244
Iwo	5.563	4214	3161	2107
Ola-Oluwa	1.648	1248	936	624
Total	**109.52**	**82969**	**62227**	**41484**

5. Conclusion and Recommendation

5.1 Conclusion

The identification of 86 small hydropower potential sites across Osun State, with a cumulative capacity of 109.52 MW capable of serving up to 82,969 households at full capacity, demonstrates a significant opportunity to address rural electrification challenges. These findings are particularly relevant given the current low electricity access indices (0.42-0.49) across surveyed LGAs, despite their high connection rates, highlighting the critical gap between grid connection and reliable power supply. The study's revelation that even well-connected areas like Apomu, Awo, and Ileogbo experience substantial reliability and duration constraints (R.I: 0.37, D.I: 0.40) aligns with previous findings of 34% revenue losses in rural businesses due to unreliable power supply (Ohunakin *et al*., 2023). With implementation costs of $2,500-$3,000 per kilowatt for small hydropower systems being significantly lower than the $25,000-$30,000 per kilometer for traditional grid extension (Mohammed *et al*., 2024; Adewuyi *et al*., 2023), the identified sites, particularly in high-potential LGAs like Ayedire (37.02 MW) and Isokan (20.312 MW), present cost-effective opportunities for decentralized power generation.

5.2 Recommendations

Based on the findings of this study, several key recommendations are proposed to facilitate the successful implementation of small hydropower (SHP) projects in Osun State. Primarily, there is an urgent need for the government to establish a comprehensive policy framework specifically tailored for SHP development. This framework should include clear guidelines, streamlined approval processes, and attractive incentives such as tax breaks to encourage private sector participation in rural electrification projects. From a technical perspective, implementation efforts should initially focus on high-potential areas identified in this study, particularly Ayedire and Isokan LGAs, which demonstrate the highest SHP potential.

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Reviewing Emerging Technologies Adoption Among Construction Project Managers in Nigeria

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Abstract

Though emerging technologies are available to improve project performance, project managers in the Nigerian construction sector avoid their adoption. This have resulted in the rate of failed projects within the Nigerian construction sector due to poor coordination of construction tasks relying on obsolete process. Hence, the review of literature to ascertain the influencing factors of project managers avoidance in implementing emerging technologies in their professional practice. Using thematic analysis, four (4) influencing themes were identified in the literature namely; technology, organizational, environmental and sociocultural related factors. These themes evidenced the influencing factors in emerging technologies adoption among project managers in the Nigerian construction industry. The potentials of emerging technologies adoption on project managers performance in the construction industry is impacted in terms of cost, quality and time of successful projects delivery. However, technology avoidance behaviour of project managers will lead to project abandonment, continued inadequate automated evaluation, monitoring of construction project performance Therefore, the study recommends that stakeholders in the Nigerian construction industry must continue to navigate through the barrier factors limiting construction project managers adoption of technology to lower the rate of failed and abandoned projects in the Nigerian construction industry.

Keywords: Construction Industry; Project Manager; Emerging Technologies; Developing Countries; Technology Adoption

1. Introduction

The construction industry is vital for the development of any nation, as the pace of physical infrastructure produced from the industry can determine the pace of economic growth (Olatunji *et al*., 2016). In Nigeria, the Construction Industry (CI) accounts for 3–8% of gross domestic product (Waziri *et al*., 2017), and it is estimated that the industry will account for 13.2% of Gross Domestic Product (GDP) globally by 2025 (McKinsey, 2021). Hence, the contribution of the industry to the economies and wealth of a nation is enormous (Pan *et al*., 2018), such that it requires Emerging Technologies (ET) to continuously drive its contribution sustainably (Ogunde *et al*., 2017).

Ghada (2021) described ET as scientific breakthroughs with the potential to establish new industries or transform existing ones. They include dramatic inventions that result in discontinuous innovations, as well as more evolutionary technologies that result from the convergence of previously distinct research lines. For the Construction Industry (CI), Kissi *et al*. (2022) avow that these ET offer a simplified construction process. Therefore, it is imperative that the need for efficiency in managing the construction process through ET offers perhaps, the best opportunities to enhance its function and efficiency (Kissi *et al*., 2022). With the rapid advancement of technology, Construction Firms (CF) are embracing emerging solutions to improve their practices. ET are digital innovations like Internet of Things (IoT), Building Information Modelling (BIM), and blockchain hold great potential for revolutionizing the construction process in CF (Kissi *et al*., 2022).

However, Holt (2015) adjudge that CF are a slow adopter of technology, of late, the technology available to increase productivity and hence profit margins have seen appreciable adoption and advancement. Consequently, Takim *et al.* (2013) found that the reason for lagging implementation of technology is that CF still adhere on to old business models and processes for decades. Furthermore, Chen and Zhang (2018); Ben-Daya *et al*. (2020) emphasize issues like initial investment costs, technology adoption, interoperability concerns, the need for skilled personnel and organizational preparedness. Olawumi and Chan (2019) also affirmed that while many construction projects in developed countries are progressively enforcing technology innovations, the cultivation of the technology in developing countries is lagging. Similarly, there is an agreement in the literature that problems are more serious

proportionately in developing countries and more apparent throughout the execution of projects by project managers (Kissi *et al*., 2022).

According to Project Management Institute (PMI)'s definition, and as adopted for this study, a Project Manager (PM) is a person assigned by the performing organization to lead the team that is responsible for achieving the project objectives (PMI, 2017). Research shows that adoption and utilization of cutting-edge technology have advanced among PM in developed countries, but, construction project managers in the Nigerian CI are five years behind in the adoption spectrum of new technology (Adebisi *et al*., 2018; Hamma-Adama *et al*., 2018). Though new technologies are available to improve project performance, PM in the Nigerian construction sector avoid their adoption (Akande *et al*., 2018; Ozumba and Shakantu, 2018). This technology-adoption avoidance behaviour may be resulting in continued substandard evaluation and monitoring of construction project performance in the Nigerian CI (Afolabi *et al*., 2018; Amusan *et al*., 2018). Scholars have repeatedly documented the high rate of failed projects (e.g., 66% in a recent survey) within the Nigerian construction sector, and question why construction PM in Nigeria remain slow to adopt new technologies for improving decision-making processes and project success rates (Afolabi *et al*., 2018; Hamma-Adama *et al*., 2018).

Adoption itself results from a series of individual decisions to begin using the new technology. These decisions are often the result of comparing the uncertain benefits of the invention and the uncertain costs of adopting it (Ghada, 2021). However, the developing CI remains clueless about these ET (Darko and Chan, 2018). Also, clear-cut clarification on the several emerging technologies that best fit the improvement of collaboration was not delved into so much. Studies on the associated challenges were equally given less attention (Osabutey and Croucher, 2018). Kissi *et al*. (2022); Ngowi *et al*. (2005) were among the few researchers who hinted that the lack of literature regarding the impact of adopting emerging technologies within the CI in developing countries such as Nigeria has hindered CF growth. Therefore, the need for this study to unprevail influencing factors hindering the adoption of ET by PM in the Nigerian CI.

2. Literature Review

2.1 Construction Emerging Technologies and their Applications

Mura (2020) argued that new enabling technologies and construction methods are emerging that will assist enterprises and the construction sector in various ways. Construction ET is described by Irizarry and Costa (2016) as a revolutionary paradigm in which three transitions occur: industrial production and construction, cyber-physical system, and digital technologies. BIM (building information system), CDE (common data environment), cloud-based systems engineering, AR/VR (augmented reality/virtual reality), big data and analytics, blockchain, and laser scanners are all instances of emerging innovations. Robotics and automation, sensors, the internet of things, industrial manufacturing, off-site and on-site construction, employees using wearable sensors, and devices fitted with sensors all fall into the category of cyber-physical systems (Irizarry & Costa, 2016). Below and as shown in Figure 1. is a brief outline of each of these ET and their contributes to improved efficiency in CI.

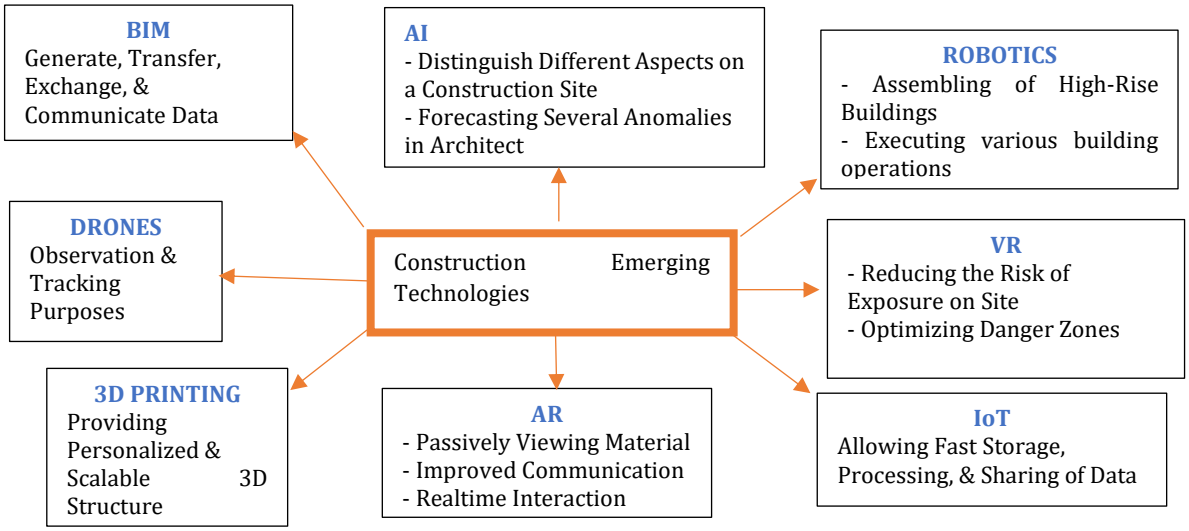

Figure 1: Emerging Technologies in Construction
Source; Autor's Construct, 2024

2.2 Challenges in the implementation of Emerging Technologies

Holt (2015) state that stakeholders in the CI have been reluctant to follow the digital world in adopting innovations. The attitude not only obscures their understanding of the technology but also it obscures the potential limiting factor of these technologies. Galanakis (2013) mentioned that opportunities and challenges in the field are discussed to inspire researchers to investigate the critical parameters that prevent, for the moment, the broad commercial implementation of ET in the particular application. As a result, continuous demand for hardware and software upgrades has been a significant challenge for implementing several ET, according to the Qi and Costin (2019) survey. Delgado *et al*. (2020) stated that when it comes to interoperability between BIM systems and augmented reality (AR) and virtual reality (VR) models, it is difficult to automatically update BIM models and construction schedules from AR and VR systems. Thus, the lack of integration between data standards makes it challenging to integrate BIM data photogrammetry and CI VR platforms. Qi and Costin (2019) further submitted that the high cost of purchasing both hardware and software of these innovations challenges stakeholders in their quest to use them in various walks of the construction process. Another concern that Delgado *et al*. (2019) raised is the unclear value that construction companies can get from adopting these technologies. More specifically, there is very little in the way of cost-benefit studies for adopting these innovations as reported in the literature (Pan *et al*., 2018). It is widely noticed that the adoption of these innovations can minimise costs related to labour and injuries. At the same time, these technologies are considered expensive and the cost includes the technology systems, software, skilled engineers and training (Delgado *et al*., 2019).

Afolabi *et al*. (2017) reported on the economies of cloud computing in project delivery. However, they made mention of poor network connectivity among the challenges to cloud adoption by the construction industry. Project sites, at times, might be in an underdeveloped area or a rural area, usually with low or no internet connectivity. Power infrastructure projects, such as underground cabling, overhead lines or substations are prime examples that span larger geographical areas with poor connectivity across the construction route (Bello *et al*., 2021). Kabra *et al*. (2017) argue that organisational culture also affects the implementation of these technologies. Applying the scenario in the construction industry, most stakeholders lack the confidence and skills to adopt these technologies and leave them far behind when building reliable data and information processing capabilities. Qi and Costin (2019) added in their study that despite the increase in the systematic adoption of emerging technologies that would improve several things, the prevalence of pervasive conservation in the construction industry may still impede this move.

Hence, the CI is reported to be among the least digitized sectors globally (Gandhi *et al*., 2016). The peculiar characteristics of the construction industry, such as the uniqueness of the products, the variability of expertise and technology, and the tendency for the players in the industry to be risk-averse make the construction industry-unique and very different when compared to other industries (Fadun and Saka, 2018). Thus, the decision to adopt and deploy technology in the CI is affected by a variety of influencing factors (Nnadi *et al*., 2018).

2.3 Emerging Technology Adoption Behaviour of Construction Project Managers

Several studies have shown the high rate of failed projects within the Nigerian construction sector due to poor coordination of complex tasks as expected by the project managers (Afolabi, *et al*., 2018). A deeper understanding of the barriers confronting construction project managers in Nigeria to adopt new technologies for improving decision-making processes to lower the rate of failed and abandoned construction projects remains poorly understood (Muhammad *et al*., 2018).

The lack of application of technology and the use of obsolete and inappropriate technology influenced PM practices in Nigeria, which hindered successful public project delivery (Afolabi *et al*., (2018)). Technology leads to improved business decisions and quality of construction project delivery (Kamaruddin *et al*., 2016). But paucity exists in the technology adoption behaviour among construction PM in the Nigerian Construction Industry (NCI), with five years' lag in their adoption spectrum on new technology when compared to PM in developed countries (Hamma-Adama *et al*., 2018). Although, ET are available to improve project performance, PM in the Nigerian construction sector avoid their adoption (Akande *et al*., 2018; Ozumba & Shakantu, 2018), there is a gap in the literature on why construction project managers in the NCI remain slow to adopt new technologies (Akande *et al*., 2018).

3. Methodology

The study is primarily a desk research and secondary data was used in the study. Thus, various journals, conference proceedings, textbooks, thesis and policy documents were perused. Published literature were searched. Databases such as Science Direct, Taylor and Francis, Emerald Insight, Google and Google Scholar were consulted. The search expression includes a combination of the following keywords: "Project Manager", "Technology", "adoption", "Emerging Technologies", "Construction Industry" and "Developing Countries" The inclusion criteria applied were all types of articles related to construction technology, peer-reviewed articles, and articles published seminar

papers. this is to ensure that studies are searched as extensive as possible in order to reduce risk of publication bias and to identify relevant evidence as much as possible to purposefully extract published scholarly literature in the last twenty years (2004-2024). The exclusion criteria were articles written in languages other than English, and articles for which full text was not available.

3.1 Data Analysis

This study used thematic analysis. The potential themes are identified through database searching and theme familiarization in the literature.

4. Results

The results of this research are discussed in the subsequent sub-sections.

4.1 Project Manager and Technology Adoption in Nigeria's Construction Sector

The Nigerian construction industry is still at the lowest ebbs in its adoption. The result of a recent study revealed that out of the 59% of the project managers in the Nigerian construction industry that are aware of BIM technology, only 23% are using the BIM technology and the usage is still far below BIM full capability (Hamma-Adama *et al*., 2018). Although ET are available to improve project performance, scholars have identified that PM in the Nigerian construction sector avoid their adoption (Akande *et al*., 2018; Ozumba and Shakantu, 2018). Whereas the adoption and utilization of cutting-edge technology have advanced among PM in developed countries, project managers in the NCI are still generally about five years behind in the adoption spectrum of ET (Adebisi *et al*., 2018; Hamma-Adama *et al*., 2018).

Ejohwomu *et al*. (2017) avow that PM in the NCI are not inculcating technologies in project monitoring and evaluation. Consequently, Adebisi *et al*. (2018) posit that it leads to delay in the issuance of project reports and ineffective reporting. Furthermore, Olaniyan (2019) found that the task of monitoring and evaluating project performance using an automated approach has not been given serious attention by PM. The lack of technology and the use of obsolete and inappropriate technology for the execution of construction projects in Nigeria hindered project managers' effectiveness towards successful project delivery (Fadun & Saka, 2018).

4.2 Factors Influencing Project Manager Adoption of Emerging Technologies

Many factors have been offered in the literature as influencing emerging technology adoption among project managers, which is categorized into technology, organizational, and environmental-related factors (Waziri *et al*., 2017), and sociocultural related factors (Ojoko *et al*., 2018). Technology related factors include a feature of the ET to be adopted about its ability to meet the needs of the project and the organizational objective (Sepasgozar and Davis, 2018), difficulty in demonstrating the evidence of benefits an organization will derive from adopting technology (Aduwo *et al*., 2016), and deficiency in the technical skill required to support the use of the technology by PM (Muhammed *et al*., 2015).

Organizational related factors include internal policy and bureaucratic procedure inherent in the decision-making process towards technology adoption (Usman & Said, 2014), criteria for evaluating the technology for project objectives and needs (Sepasgozar and Davis, 2018), the readiness of the members of the adopting organization to accept and embrace a change from the old ways of doing things (Waziri *et al*., 2017), and high investment cost associated with the adoption of new technology (Aduwo *et al*., 2016).

Environmental factors are factors external to the adopting organization and of which the adopting organization has little or no control. These include lack of effective government policies and dysfunctional regulatory environment (Waziri *et al*., 2017), a general state of infrastructural deficiency (Chete *et al*., 2014), and constraints of sourcing fund for technology investment within the domestic banking environment (Sepasgozar & Davis, 2018; Usman & Said, 2014).

Sociocultural factors include the general state of cyber insecurities in developing countries (Amusan *et al*., 2018; Waziri *et al*., 2017) combined with tendencies of people in the workplace to conform to unethical practices during technology utilization (Oladinrin and Ho, 2016; Ogunyemi and Laguda, 2016).

5. Conclusion

The potentials of adopting ET in the construction industry in developing countries such as Nigeria cannot be overemphasized. However, the adoption of ET by project managers in Nigerian construction industry is lagging behind due to; technology, organizational, environmental and sociocultural related factors. Additionally, ET adoption is hampered by the level of readiness of the members of the adopting organization to accept and embrace a change from the old ways of doing things and high investment cost associated with the adoption of new technology.

The effectiveness of the ET largely depends on the activities and roles performed by the project managers in the sector. Thus, the study suggests that ET influence the performance of project managers positively in enhancing project cost, duration quality and overall, the client satisfaction. Consequently, project managers avoidance behaviour will result in project abandonment, continued inadequate automated evaluation, monitoring of construction project performance and hence, ineffectiveness of project managers in project delivery.

6. Recommendations

The study recommends the following:

i. Construction firms should provide training and incentives to project managers to encourage the adoption and use of emerging technologies.

ii. Awareness is necessary, but it is not enough to lead to adoption, being technologically ready to adopt is the sine qua non to technology adoption by construction project managers in Nigeria

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Barriers Influencing Construction Firms' Adoption of Emerging Technologies in Supply Chain Management

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Abstract

The construction industry plays a critical role in the economic development of nations and efficient supply chain management is crucial to its success. However, the construction sector remains one of the least digitized sectors despite the benefits of emerging technologies This study investigates the barriers influencing the adoption of emerging technologies in construction supply chain management. The study adopted a quantitative approach using a closed ended questionnaire. Data was collected via simple random sampling from 73 construction firms, though 52 were properly filled and returned for the analysis. The data was analysed using mean score item to ascertain the degree to which barriers influence the adoption of emerging technologies by construction firms. The barriers were grouped into three categories, technological, organisational and environmental barriers. The study revealed that the major technological barrier is lack of technical expertise within the organization, organisational barriers is resistance to change from employees and for to environmental regulatory compliance issues. Therefore, it becomes imperative to invest in training and developing partnerships with educational institutions for continuous learning and government to review and update local content requirements to balance domestic growth with technological advancement.

Keywords: Digital transformation, Emerging technologies, Supply chain management, Technology adoption

1. Introduction

The global construction industry is a crucial economic sector, contributing approximately 13% of global GDP (World Economic Forum, 2023). Despite its economic importance, the industry has historically lagged behind other sectors in technology adoption. This is buttress by the finding of McKinsey Global Institute (2021), that the construction remains one of the least digitized sectors, with only agriculture having lower digital technology adoption rates. Furthermore, the construction industry plays a critical role in the economic development of nations and efficient Supply Chain Management (SCM) is crucial to its success (Tisha and Joe 2021). SCM aims to optimize profits and keep a firm ahead of the competition by coordinating activities between suppliers and consumers (Baha, 2023). Primarily, the organization's planning, sourcing, and logistics departments will benefit from increased digitalization in SCM via enhanced communication, workflow automation, and information use (Saberi, 2019; Andrew and Armin, 2021). SCM is tedious and time consuming for maintaining the Supply Chain (SC) activities and hence the need to use Emerging Technologies (ET) to aids the collaboration and integration of supply chain partners (Tisha and Joe, 2022).

In recent years, the adoption of ET in SCM for Construction Firms (CF) has gained momentum, aiming to enhance productivity, reduce costs, and optimize resource utilization (Chen *et al*., 2021). With the rapid advancement of technology, CF are embracing emerging solutions to improve their Construction Supply Chain Management (CSCM) practices. ET are digital innovations like Internet of Things (IoT), Building Information Modelling (BIM), and blockchain which hold great potential for revolutionizing CSCM in CF (Kissi *et al*., 2023). Ghada (2021) revealed a positive correlation between technology adoption and improved supply chain management efficiency, cost reduction, and project success.

Despite these advancements and benefits, challenges persist. Studies such as Chen and Zhang (2018) and Ben-Daya *et al*. (2020) emphasized issues like initial investment costs, technology adoption, interoperability concerns, the need for skilled personnel and organizational preparedness. These challenges hinder the seamless integration of ET into the construction supply chain management. Therefore, to overcome this challenges Nanyang *et al*. (2023) and Baha (2023) stressed the need for construction firms to prioritize readiness to embrace these innovations.

2. Literature Review

2.1 Barriers to emerging technologies adoption in supply chain management

The ET barriers encompass organisational barriers which are related to lack of top management support and strategic orientation and the lack of organizational readiness (Agrawal *et al*., 2019; Moktadir, 2019). Additionally, Kabra *et al.* (2017) argue that organisational culture also affects the implementation of these technologies. The study of Moktadir *et al*., (2019) reveal technological barriers which refer to lack of digital skills and infrastructural facilities, privacy and security concerns, low maturity levels of ET technologies, and scalability challenges. Afolabi *et al*. (2018) report on the economies of cloud computing in project delivery. Bello *et al.* (2021) discover poor network connectivity among the challenges to cloud adoption by the construction industry. Project sites, at times, might be in an underdeveloped area or a rural area, usually with low or no internet connectivity (Kabra *et al.,* 2017). Power infrastructure projects, such as underground cabling, overhead lines or substations are prime examples that span larger geographical areas with poor connectivity across the construction route (Bello *et al*., 2021).

Financial barriers which are related to high implementation and running cost, high sustainability cost, and Return on Investment (ROI) issues (Saberi *et al*., 2019). Qi and Costin (2019) further submit that the high cost of purchasing both hardware and software of these innovations challenges stakeholders in their quest to use them in various walks of the construction process. Another concern that Andrew and Armin (2021) raise is the unclear value that construction companies can get from adopting these technologies. More specifically, there is very little in the way of cost-benefit studies for adopting these innovations as reported in the literature (Pan *et al.,* 2018). It is widely noticed that the adoption of these innovations can minimise costs related to labour and injuries. At the same time, these technologies are considered expensive and the cost includes the technology systems, software, skilled engineers and training (Li *et al*., 2019).

External barriers which reflect the market competition and demand uncertainty, lack of stakeholder involvement in ET adoption, lack of industry commitment to ethical and safe practices, legal and regulatory uncertainties, and velocity of technological development (Chaouni *et al*., 2023; Ghobakhloo *et al*., 2021; Moktadir *et al*., 2019).

Social and environmental barriers which are related to low environmental regulations, wasted resources, lack of qualified human resources, lack of information sharing quality, lack of understanding of the interplay between technology and human beings, lack of collaboration between stakeholders and lack of supply chain partners' awareness about social and environmental concerns and digital transformation technologies (Singh and Maheswaran 2023; Chaouni *et al*., 2023; Bag *et al*., 2021). Qi and Costin (2019) allude in their study that notwithstanding the increase in the systematic adoption of ET that would improve construction process, the prevalence of traditional method in the construction industry may still impede the adoption of ET.

3. Methodology

This research employed the survey approach through the use of closed ended questionnaires. The construction organisations considered for the research were civil and building organisations registered with Federation of Construction industry (FOCI) and actively practicing in Abuja, Nigeria. The quantitative method was used to examine the barriers influencing construction firms' adoption of emerging technologies in supply chain management. The targeted population for this study from FOCI directory were eighty-four (84) as at the time of conducting this study. Using the Krejcie and Morgan table at margin of error .05 and 95% level of confidence, the sample size arrived at was seventy-three (73). Simple random sampling was chosen to select the construction firms. The number of questionnaires distributed were 73 and the number retrieved were 52; this gave a response rate of 72% and this was used for the analysis. The questionnaire was in two sections, section A and B section. Section A was demographic information of the respondents, while section B was the list of barriers influencing construction firms' adoption of emerging technologies in supply chain management. the barriers were grouped into three, technological, organisational and environmental barriers. The barriers were scaled from 1 to 5 using the following scale; 1 = Not a barrier at all, 2 = Minor barrier, 3 = Moderate barrier, 4 = Significant barrier and 5 = Major barrier. Mean Item Score (MIS) was used for the analysis.

4. Results and Discussion

4.1 Respondent Demographics

The demographics data of the respondent collected through questionnaire survey is provided in Table 1. Female respondents constitute just 26.92% of the sample. Thus, the male respondents form the majority with 73.08%. this is the reality as the construction industry is a male dominated industry. Majority of the procurement's officers were quantity surveyors and engineers with 32.69% and 25.00% respectively. The majority of the respondents were degrees and higher national diplomas graduates 55.77% and 23.08% correspondently. For the years of work

experience, 6-25 years have the highest frequency of 39, making up 75% of the total respondent. This implies that a rich response will be achieved.

Table 1: Demographic analysis of questionnaire survey results

Demographic parameters		Frequency	%
Gender	Male	38	73.08
	Female	14	26.92
	Total	52	100
Profession	Builder	12	23.08
	Architect	10	19.23
	Quantity surveyor	17	32.69
	Engineer	13	25.00
	Total	52	100
Education	ND	-	-
	HND	12	23.08
	B.sc	29	55.77
	M.sc	9	17.31
	Ph.D	2	3.84
	Total	52	100
Experience	Less than 5 yrs	5	9.62
	6-15 yrs	18	34.62
	16-25 yrs	21	40.38
	More than 25	8	15.38
	Total	52	100

Researcher analysis (2024)

The Barriers influencing Construction Firms' Adoption of Emerging Technologies in Supply Chain Management as shown in Table 4.18 reveal the ranking of the variables as follows:

For Technological barriers, lack of technical expertise within the organization, compatibility issues with existing systems, inadequate IT infrastructure, poor power supply, concerns about data security and privacy, limited availability of local technology vendors or support and complexity of emerging technologies are ranked 1st, 2nd, 3rd, 4th, 5th, 6th and 7th respectively with mean item scores ranging from 4.50 to 3.83which represent the barriers that have the most effect on emerging technology adoption among construction. This finding is in line with the findings of Ahmed *et al*. (2022) and Ghosh *et al.* (2021) who have identified the barriers above as the factors that significantly affect the adoption of emerging technologies in supply chain management for construction firms. Conversely, two barriers were found not to be significant. These are Insufficient integration capabilities and poor scalability, ranked 8th and 9th position with confirmatory mean score item of 2.67 and 2.34.

Organizational barriers that have significant impact on emerging technologies adoption in supply chain management for construction firms are; resistance to change from employees, lack of top management support, lack of skilled personnel to implement and manage new technologies, unclear benefits or value proposition and uncertainty about technology trends and future developments ranked 1st, 2nd, 3rd, 4th and 5th with matching mean score item of 4.28, 4.39, 4.33, 4.24 and 4.22. These organizational barriers in the studies of Kim and Park (2023), Ahmed *et al*. (2022) and Ozturk and Yilmaz (2020) were found to be the core reason for the low adoption of emerging technologies in supply chain management for construction firms. Contrariwise, insufficient time for implementation and training and unclear return on investment (ROI) for emerging technologies were found to have the least impact.

Environmental barriers have regulatory compliance issues ranked 1st, followed by lack of government support, unclear policies regarding emerging technologies and limited industrial support ranked 2nd, 3rd, 4th as significant barriers mitigating the adoption of emerging technologies in supply chain management. The result also lends credence to the study of Adebayo *et al.* (2022) which found environmental guidelines such as regulatory policies and government support are key drivers for technological adoption. Contrarywise, Economic conditions (e.g., market volatility, inflation), The lack of industry-wide standards and Competitive pressures have the least influence.

Table 2: Barriers influencing Construction Firms' Adoption of Emerging Technologies in Supply Chain Management

Barriers	MIS	Rank
Technological		
Lack of technical expertise within the organization	4.50	1
Compatibility issues with existing systems	4.28	2
Inadequate IT infrastructure	4.28	2
Poor power supply	4.11	4
Concerns about data security and privacy	4.06	5
Limited availability of local technology vendors or support	3.94	6
Complexity of emerging technologies	3.83	7
Insufficient integration capabilities	2.67	10
Poor scalability	2.34	11
Organizational		
Resistance to change from employees	4.28	1
Lack of top management support	4.39	2
Lack of skilled personnel to implement and manage new technologies	4.33	3
Unclear benefits or value proposition	4.24	4
Uncertainty about technology trends and future developments	4.22	5
Limited financial resources for technology investment	2.55	6
Insufficient time for implementation and training	2.43	7
Unclear return on investment (ROI) for emerging technologies	2.27	
Environmental		
Regulatory compliance issues	4.67	1
Lack of government support	4.43	2
Unclear policies regarding emerging technologies	4.08	3
Limited industrial support	4.00	4
Economic conditions (e.g., market volatility, inflation)	2.76	5
The lack of industry-wide standards	2.61	6
Competitive pressures	2.23	7

Researcher analysis (2024)

5. Conclusion and Recommendations

The study revealed that emerging technologies can enhance construction supply chain management. However, there are barriers mitigating it implementation and thus, the low level of adoption by construction firms. The most significant barriers identified are lack of technical expertise within the organization for technological factor, resistance to change from employees for organisational factor and regulatory compliance issues correspond to environmental. Therefore, for construction firms to leverage the benefits of emerging technologies, it becomes imperative to invest in training and developing partnerships with educational institutions for continuous learning and government to review and update local content requirements to balance domestic growth with technological advancement. Therefore, the study will help construction firms, policy makers and other stakeholders understand how to enhance the efficiency and effectiveness of supply chain management to reduce cost and delays in project delivery.

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Application Of Green Architecture in The Design of Cancer Center, Akure-Ondo State

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Abstract

Cancer is a major global health challenge. In Nigeria alone, approximately 100,000 new cases are reported annually, with projections forecasting a fivefold increase by 2040. The need for improved cancer care is urgent and undeniable. While existing oncology centers are crucial, they primarily focus on medical treatment, often neglecting the psychological, social, and spiritual well-being of patients, who frequently face emotional and physical trauma. Cancer treatments can also result in lasting physical and psychological effects, underscoring the importance of comprehensive rehabilitation. Green architecture integrates sustainable design principles to minimize the negative environmental impact of buildings while fostering healing environments for patients. The study employs a mixed-methods approach, combining case studies and questionnaire. The results show that 82.3% of respondents identified space optimization as a critical strategy for improving patient care. Energy efficiency is also vital for reducing environmental impact, and 77.9% emphasized the role of indoor air quality in promoting patient health. Green elements, such as natural lighting and green spaces, are widely recognized for their healing benefits. Green architecture not only enhances environmental sustainability but also fosters healing environments in cancer care facilities. Future cancer centers should prioritize the use of natural elements, sustainable materials, and energy-efficient technologies to support patient recovery.

Keywords: cancer center, eco-friendly building, green architecture, patient well-being, rehabilitation.

1. Background of study

Cancer poses a significant global health challenge, claiming millions of lives annually. The situation in Nigeria is especially concerning Fatiregun *et al*. (2020). The World Health Organization (WHO) reports approximately 100,000 new cancer cases in Nigeria each year, with projections indicating a fivefold increase by 2040 World Health Organization. (2021). Women are disproportionately affected, with breast and cervical cancers being the leading causes of death. Clearly, a new approach to cancer care is urgently required in Nigeria. In addition to the medical challenges, the emotional impact of a cancer diagnosis can be devastating. While some struggle to cope, others find strength and resilience Leão. (2022). However, appropriate treatment and supportive environments are essential. Current hospital designs often contribute to a sense of isolation and fear Ponti. (2019). Physical, emotional, and spiritual comfort for all user groups especially cancer patients is being prioritized in hospital planning, which is moving toward a patient-focused approach. This change also applies to outdoor settings, since being open air should send a message of acceptance and reduce their isolation as disparate parts of metropolitan networks. A warm, secure, safe, and non-threatening atmosphere can be produced with the aid of green concepts. Environmentally friendly and patient-centered design are combined in green architecture, a subtype of sustainable architecture. In order to minimize a building's negative environmental impact while maintaining functioning, green design employs sustainable construction techniques and eco-friendly materials. Running water and other natural noises can be soothing, and the physical surroundings should promote healing illnesses Shakti. (2020). By preserving natural ecosystems, watersheds, habitats, air and water quality, cutting greenhouse gas emissions, improving interior and outdoor environments, and lessening the detrimental effects of the built environment on human health, green buildings contribute to the world's environmental issues. Green buildings enhance public health by protecting its occupants, especially youngsters who are susceptible to respiratory ailments, by the use of non-toxic materials. Furthermore, green buildings are more resilient, which lowers maintenance and replacement costs, and they consume less energy, which lowers operational expenses. For severe cancer patients, Nigeria lacks specialist hospitals, and conventional hospitals with oncology departments are unsuitable for providing comprehensive cancer care Alohan & Oyetunji. (2021). The absence of stimulating and high-quality surroundings in these institutions is detrimental to patients' overall well-being and rate of recovery. Clinical practice lacks green infrastructure for psychological, social, and spiritual comfort, and is primarily focused on treating cancer Esan *et al.* (2023). Green design could improve healing processes by emphasizing elements that promote speedy recuperation

and lower artificial energy usage.

The aim of the research is to investigates the application of green architecture in cancer treatment and management to create a therapeutic, supportive, and restorative environment, fostering a positive patient attitude. Over 100,000 new cases of cancer are reported each year, making it one of the leading causes of death in low- and middle-income countries Bray *et al*. (2022). For more than 23 years, the Nigerian government has pushed for the establishment of cancer centers in each of the country's six geographical zones Ndoh *et al. (*2022). The study of green architecture in hospitals, the investigation of cancer causes, manifestations, and therapies, and the creation of cozy surroundings all contribute to the goal of the research. Case studies will be carried out in particular oncology departments or teaching hospitals, and the proposed National Cancer Centre will cover administrative, hospital, and research services. With results restricted to the site's ecological affordances, the study will concentrate on green concepts to promote a healing environment and lessen the detrimental effects of built environments on human health Melchionni. (2021).

2. Literature Review

2.1 Hospitals

Hospitals have a long history, dating back to ancient Greece and India. They were first established as places of healing for the poor and travelers, with temples of ancient gods serving as refuges and training schools for doctors Uju. (2016). In the 4th century AD, hospitals were founded in Caesarea and Rome under the direction of the Roman Catholic Church. Crusades and religious orders led to the construction of numerous hospitals, particularly in the Mediterranean area. Municipal hospitals began to appear in the 18th century, particularly in England, and private hospitals emerged in the United States. The demand for modern hospitals increased in the 20th century due to economic prosperity and medical science discoveries Nagasawa. (2020). Western medicine was not introduced formally in Nigeria until the 1860s when the sacred Heart Hospital was established by Roman Catholic missionaries in Abeokuta. Religious missions played a major role in supplying modern healthcare facilities in Nigeria, with the Roman Catholic Mission accounting for about 40% of the total number of mission-based hospitals by 1960. Mission hospitals were concentrated in certain areas, depending on the religious and other activities of the mission Faleye. (2023).

By 1979, Nigeria had 562 General Hospitals, 16 Maternity and Pediatric Hospitals, 11 Armed Forces Hospitals, 6 Teaching Hospitals, and 3 Prison Hospitals. Health services were available from the government, private companies, and missionaries Ineke *et al*. (2023). Ownership of health establishments was divided among Federal, State, and Local Governments, with private hospitals growing through the 1980s. However, issues of geographic misdistribution of medical facilities among regions and inadequacy of rural facilities persisted. services, while specialist hospitals focus on specific diseases or treatments. Community hospitals serve local communities, while long-stay hospitals provide care for chronic illnesses. Hospitals can be not-for-profit, for- profit, or government-owned Khatun *et al*. (2024).

Hospital organization and staff are a complex system that requires the coordinated efforts of various staff members. Administration oversees financial health, strategic growth, and daily operations, while medical staff organize by department or specialty, with a Chief of Staff leading the medical team. Nursing staff provide the bulk of patient care, while support staff include social workers, nutritionists, pharmacists, and technicians.

2.2 Definition of Green Architecture

Green architecture, a philosophy of architecture that advocates for sustainable energy sources, conservation, reuse, and safety of building materials, has been around since ancient civilizations. It has evolved over time, with modern convenience leading to a focus on energy consumption and a significant impact on our carbon footprint Bungau *et al*. (2022). In the early 21st century, building construction consumed over half of the world's resources, including 16 percent of Earth's freshwater resources, 30-40% of energy supplies, and 50% by weight of raw materials withdrawn from Earth's surface. Architecture was also responsible for 40-50% of waste deposits in landfills and 20-30% of greenhouse gas emissions. Green building, also known as sustainable or high-performance buildings, aims to reduce the overall impact of the built environment on human health and the natural environment by efficiently using energy, water, and other resources, protecting occupant health, improving employee productivity, and reducing waste, pollution, and environmental degradation.

2.2.1 The Principles of Green Building Design

The goal of green building design is to integrate systems with the natural ecological processes of a place while appreciating its beauty and complexity. This method collects, filters, and stores water in addition to providing habitat and reacting to changes in the sun Daugelaite *et al*. (2021). In order to promote biodiversity and a healthy ecosystem, architects might incorporate elements into their structures that replicate the roles of specific eco-

systems. Sustainable site design, energy and environment, indoor environmental quality, conservation of materials and resources, and water conservation and quality are the five main components of green building design.

1. Water systems are essential to the construction of green buildings because only 6 percent of water is utilized for drinking. Grey water systems, rainwater collection, and living pools are a few ways to reduce water use and increase energy efficiency.
2. Natural building places a strong emphasis on sustainability by using abundant, renewable resources that have undergone minimum processing and sustainable architectural design. Living rooms can be heated and cooled by passive solar architecture, which requires less maintenance and lowers heating and cooling expenses.
3. Green building materials are made of ecologically friendly, renewable resources, which lowers maintenance and replacement costs while saving energy and enhancing tenant well-being and productivity.
4. Living architecture: In order to address biophilia and incorporate ecological functions into buildings.
5. Green roofs A structure can benefit from a green roof in a number of ways, including increased kindness and reduced stress, insulation, wildlife habitat creation, temperature reduction in urban areas, and reduction of the heat island effect**.**
6. Vertical greenery or green walls cover more exposed hard surfaces in the built environment by introducing plants onto the building façade. The conventional approach is wall climbing; hanging-down and modules are more intricate and costly.

2.3 Case Studies of Green Architecture in Cancer Centers.

Smilow Cancer Hospital at Yale New Haven Smilow Cancer Hospital is an example of a healthcare complex that effectively incorporates green architecture. This is one of the selected networks of 38 comprehensive Cancer Centre in the World. Yale Cancer Center combines a tradition of innovative cancer treatment and quality care for our patient Rupert *et al.* (2021). High-efficiency HVAC systems, low-flow plumbing, rainwater harvesting systems, energy-efficient LED lighting, and a high-performance building envelope are all elements of the hospital. To foster a therapeutic atmosphere, the hospital places a high value on acoustics, low-VOC materials, natural light, and outdoor views. Energy efficiency is enhanced by the use of solar panels, green roofs, and locally and repurposed materials. The hospital's environmentally friendly design practices save money and have a smaller negative impact on the environment, encouraging stewardship and lowering the carbon footprint of the building.

Figure2.1: Yale-New Haven Hospital: Environmental Support
Source: Tighe and Amp; Bond, 2021

3. Methodology

This chapter explores the concept of "green hospitals" and the application of green architectural principles in cancer treatment centers. The research focuses on the case studies of selected cancer centers, which were chosen through purposive sampling based on their purpose and scope of facilities. The case studies were evaluated based on their direct experience of nature, indirect experience of nature, and symbolic experience of nature. The study used three approaches to assess the application of green architecture in cancer centers: direct experience of nature (dependent variables), indirect experience of nature (dependent variables), and symbolic experience of nature (independent variables). The primary methods for collecting data included case studies, visual surveys, oral interviews, and literature review on the extent to which green architecture is applied in cancer treatment facilities to promote the healing process. Data collection methods included visual surveys, literature review, case studies, oral interviews, and internet sources. The procedure for data collection involved visiting notable oncology departments within Nigeria hospitals, interviewing administrative staff, nurses, doctors, and patients to obtain detailed information on

the functionality of the building, and browsing related websites of the research topic under study. The data collected was for the research were analyzed and represented in different forms, including photographs, tables, figures, and descriptive analysis. Photographs showed the existing green buildings and cancer centers, while tables documented the hospital facilities and how green design elements were applied. Figures documented the estimated statistics of cancer in Nigeria, Africa, and the world by incidence and mortality. Descriptive analysis showed the extent by which elements of green architecture have been applied in the cancer centers to achieve green hospital settings that foster activities of the center to enhance the healing process.

4. Result and Discussion

With an emphasis on sustainable design principles to enhance environmental performance and therapeutic potential, the research assesses green architecture in cancer facilities. The respondents place a high value on patient-centered care, environmental sustainability, and space optimization. They prioritize elements that promote well-being, sustainable materials, and energy-efficient solutions. The study highlights how crucial it is to combine accessibility and technology in order to create contemporary, inclusive healthcare settings. The research emphasizes how biophilic design concepts are used in contemporary hospital architecture.

4.1 Strategies for Functional Architectural Design in Healthcare Facilities

In healthcare design, the majority of participants (82.3%) emphasized the importance of space optimization, demonstrating the necessity of designing thoughtful environments that facilitate staff workflows and patient care. Effective circulation routes are also crucial for reducing traffic and making areas simpler to navigate, according to 64.9% of respondents. Seventy-three percent of the participants cited accessibility as a top priority, highlighting the necessity for inclusive designs that can accommodate all users. The fact that 66% of respondents mentioned technology integration further indicates the rising desire for contemporary healthcare environments that use cutting-edge solutions to enhance operations and treatment.

Table 8: Strategies for Functional Architectural Design

Strategy	Frequency (f)	Percentage (%)
Space optimization	190	82.30
Efficient circulation paths	150	64.90
Accessibility features	170	73.60
Integration of technology	140	60.60
Others	30	13.00

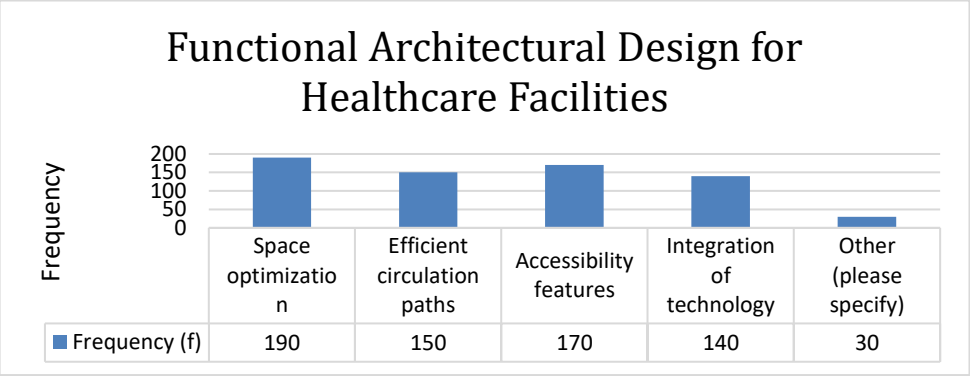

Figure 1: Functional Architectural Design for Healthcare Facilities

4.2 Application of Green Architecture Principles in Healthcare Facilities

The survey emphasizes that energy efficiency methods are widely adopted (82.3%), indicating a significant desire for lowering environmental impact and operating expenses. Using sustainable materials (73.6%) and improving

indoor air quality (77.9%) were found to be essential strategies for creating healing settings. This suggests that using greener materials not only lessens environmental impact but also improves patient health. Natural lighting (69.3%) and water conservation (64.9%) were also seen as important factors that support patient healing and environmental sustainability. These results support the significance of holistic architectural strategies that give the same importance to environmental stewardship and patient-centered treatment.

Table 9: Applicability of Green Architecture Principles

Principle	Frequency (f)	Percentage (%)
Energy efficiency	190	82.30
Use of sustainable materials	170	73.60
Indoor air quality	180	77.90
Water conservation	150	64.90
Natural lighting	160	69.30
Others	20	8.60

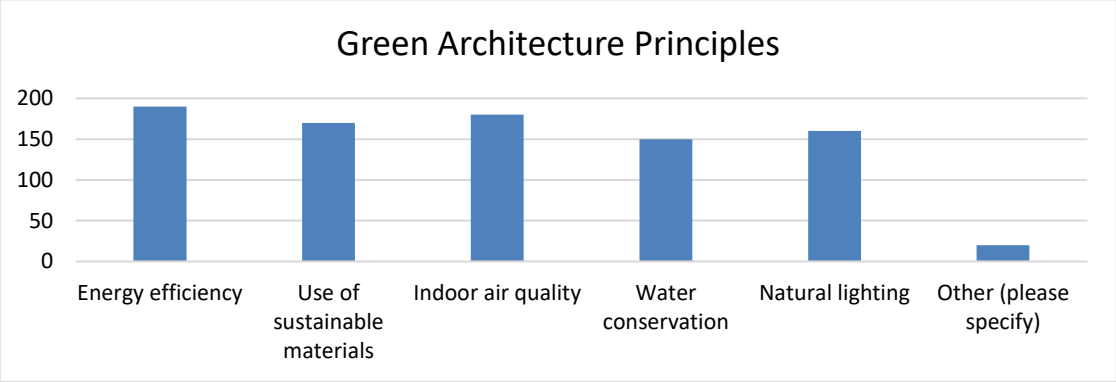

Figure 2: Application of Green Architecture Principles

4.3 Key feactures enhancing the Healing Environments in Healthcare facilities

According to the results, green areas (73.6%) and natural light (82.3%) are highly appreciated in hospital settings for their therapeutic benefits, supporting previous research on the beneficial impacts of natural surroundings on patient outcomes. Additionally acknowledged for their contributions to stress reduction and mental health promotion were art and aesthetics (64.9%) and peaceful spaces (69.3%). Further highlighting the importance of designing warm and welcoming environments that meet patients' physical and emotional requirements is the usage of cozy furniture (60.6%). Modern biophilic design concepts, which use nature to enhance the healing process, are in line with this.

Table 10: Features Enhancing the Healing Environment

Feature	Frequency (f)
Natural light	190
Green spaces/gardens	170
Art and aesthetics	150
Quiet zones	160
Comfortable furniture	140
Others	30

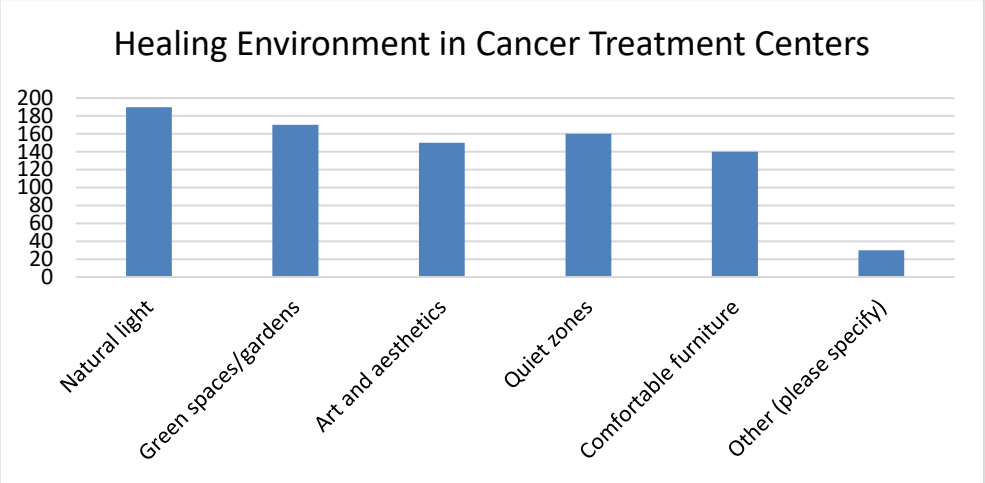

Figure 3: Key feactures enhancing the Healing Environments in Healthcare facilities

4.4 Architectural Features Promoting Appeal through Green Architecture

Eco-friendly materials were acknowledged by the majority of respondents (82.3%), while natural landscaping (77.9%) and green roofs/walls (73.6%) were cited for their combined benefits of enhancing both environmental performance and aesthetic appeal. The focus on innovative design (69.3%) indicates that there is an increasing need for creative architects in healthcare settings, where design may improve operational effectiveness and patient experience. According to the research, including green architecture features not only increases sustainability but also enhances the environment's therapeutic qualities by encouraging a healing relationship between patients and the natural world.

Table 11: Architectural Features Enhancing Appeal through Green Architecture

Feature	Frequency (f)	Percentage (%)
Eco-friendly materials	190	82.30
Green roofs/walls	170	73.60
Natural landscaping	180	77.90
Innovative design	160	69.30
Others	20	8.60

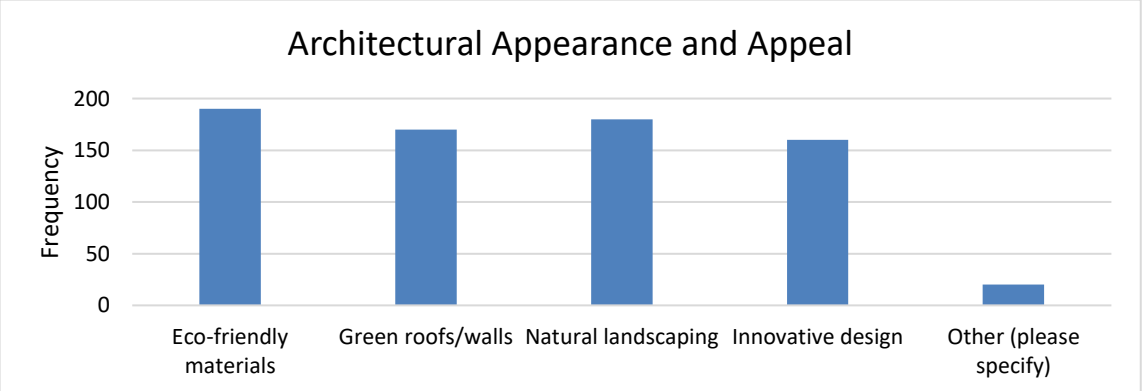

Figure 4: Architectural Features Enhancing Appeal through Green Architecture

5. Conclusions

This study highlights the importance of integrating green architectural principles into cancer care facilities. Green design not only enhances the environmental sustainability of healthcare buildings but also promotes patient recovery by creating therapeutic spaces. Future cancer centers should prioritize eco-friendly materials, natural elements, and energy-efficient systems to foster healing environments. This study shows how including green areas, natural lighting, and energy-efficient equipment may improve environmental sustainability and patient healing. The results show that 82.3% of participants gave space optimization top priority, which is crucial for improving patient experience and easing traffic. In addition, 64.9% of respondents stressed the value of effective circulation routes, which improve mobility inside the building and foster a feeling of security and comfort. 73.6% of participants said that accessibility elements were essential, emphasizing the need for inclusive design that takes into account all patients, including those who have mobility challenges. According to research, adding natural components like daylight and greenery can lower stress and aid in the healing process. This is consistent with the findings that 66% of respondents said technological integration was essential to the delivery of contemporary healthcare. In addition to lessening the impact on the environment, using energy-efficient technology and sustainable materials, which also minimize environmental effect and lower operating costs. Future research should examine the long-term effects of green architecture on patient outcomes, especially with reference to mental health, recovery rates, and overall healthcare efficiency, even if the findings highlight the immediate advantages of this design.

6. Recommendation

Chapter 3 The Cancer Center in Akure, Ondo State, is being designed to improve cancer care in Nigeria. The center is envisioned to incorporate green architecture principles, incorporating natural elements, patient-centered design, and training for healthcare personnel. The center will prioritize natural elements, maximize natural light, and incorporate green spaces to create a calming environment. It will also prioritize patient comfort and accessibility, catering to all patients, including those with disabilities. The center will also implement a continuous evaluation system to monitor its impact on patient recovery and satisfaction. The center will involve the local community in the design process to ensure the facility meets the specific needs of its population. This approach will serve as a model for future healthcare facilities in Nigeria, enhancing patient care and environmental sustainability.

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Integration of Ebira Cultural Architectural Elements in the Design of a Cultural Centre in Okene, Kogi State.

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Abstract

Cultural centers are venues for a range of cultural events; this is what defines them from places for particular cultural activities. Without a cultural centre that integrates and highlights these cultural elements, the community misses out on significant opportunities for economic development, cultural tourism, and social cohesion. This study addresses the critical need for a cultural center that integrates and preserves the unique elements of Ebira culture in Nigeria, aiming to enhance community identity and promote cultural tourism. By incorporating these elements into the design, the cultural center will become a symbol of cultural pride and identity for the Ebira community. This study used a mixed-methods approach to its research, to capture the essence of Ebira culture and how it can be incorporated into the design of a cultural center, the study will use a descriptive method. A case study involving six functioning cultural centers was studied and a total of 350 questionnaires were distributed, and 229 valid responses were retrieved successfully. The findings revealed a strong preference for incorporating traditional Ebira patterns, materials (like clay and wood), and spatial arrangements in the design of the cultural center. The highest-ranked elements included traditional motifs and sculptures depicting Ebira legends, emphasizing their significance in reflecting the community's identity. Additionally, the study highlights the importance of using local materials such as stone and brick to ensure authenticity and cultural relevance. These insights contribute to the field of architectural design by demonstrating the effective integration of cultural elements in creating spaces that resonate with local heritage, ultimately supporting the revitalization of the Ebira community's cultural fabric. Sustainable methods that make use of locally derived resources guarantee ecological balance and represent the community's engagement with its surroundings.

Keywords: architectural design, cultural centre, design, Ebira culture, heritage preservation, Integration.

1. Introduction

Nigeria is a multicultural country that can successfully balance diversity and conflicts. With over 250 ethnic groups, Nigeria's diversity presents a unique opportunity to integrate cultural heritage into modern architectural design It provides an ideal environment for showcasing the diverse skills and socioeconomic statuses of different people (Omotosho *et al.*, 2020). The world is diverse and people desire to experience different cultured leading to the concept of tourism (Ediae *et al*., 2022). Art and Cultural Centres are important venues that showcase the way of life of various people and attract both locals and visitors (Kay Smith *et al*., 2022). Due to the multiple cross-cultural applications brought about by globalization, certain architecture cannot be classified as traditional or vernacular when cultural transfers have a significant influence on it (Akinmolayan, 2023); Anthony & Pearl, 2020). According to (O'Donnell, & Tharp, 2012), the cultural centre's authenticity and visual appeal may also be improved by this integration. It is further important to incorporate Ebira cultural features into the design (Syamwil, 2012), because environment behaviour research, especially in Nigeria, need to take the social development context into account.

A cultural centre that integrates and highlights these elements is crucial for the community to seize opportunities for economic development, cultural tourism, and social cohesion (Ezenagu, 2020). This gap in infrastructure hinders the effective showcasing and preservation of Ebira culture for future generations. Establishing a cultural centre that integrates these elements is crucial for restoring and revitalizing the community's cultural fabric (Dharmasiri & Saptarshi, 2022). The study focused on identifying key cultural elements of the Ebira people, such as architectural styles, traditional motifs, materials, and spatial organization. By incorporating these elements into the design, the cultural center will become a symbol of cultural pride and identity for the Ebira community. This research will contribute to the field of architectural design by providing insights into the integration of cultural elements in the design of cultural centres. It will also serve as a reference for architects, urban planners, and cultural heritage professionals interested in designing culturally sensitive spaces.

2. Literature Review

The integration of Ebira cultural elements into architectural design is a critical aspect of preserving cultural heritage and fostering community identity. This literature review explores recent developments in this field, focusing on cultural centers and their role in reflecting and preserving cultural identity.

2.1 Overview of Cultural centre

Cultural centers are multifaceted venues designed to host a variety of cultural activities, including fine and industrial arts, music, dance, theater, and film. According to (Kolodrubska *et al*., 2022), cultural centers are distinguished by their ability to accommodate diverse cultural events, setting them apart from venues dedicated to specific cultural purposes. Typically, these centers are constructed around a theater or concert hall and include multipurpose amenities such as libraries, art galleries, museums, and resident performing groups (Pfeifere, 2022). The significance of cultural centers varies across civilizations, but they universally serve as hubs for cultural expression and preservation (Kovalenko, 2023).

Nigerian cultural centers are distinguished by their exquisite architectural designs, which are typically found in the city centers of state capitals. These organizations undoubtedly have goals, among them the development, promotion, publicizing, and encouragement of the arts and culture of the state.

2.2 Traditional Architectural Elements in Ebira Culture

Architecture serves as a testament to the customs and cultural heritage of the societies that create it, ensuring the transfer of knowledge to future generations. The Ebira community's rich cultural heritage and traditions are evident in various architectural components, often incorporated into building designs, including essential elements such as these culturally significant elements:

- **Traditional Materials**
  Traditional Ebira architecture uses mud and clay for natural insulation against hot weather, while thatched roofs, made from grass or palm leaves, promote environmental awareness and cooling.
- **Symbolic Decorations**
  Adire cloth patterns are a classic textile used in Ebira architecture for wall decorations and patterns. Interior areas and entry designs often feature wood carvings and sculptures that depict power symbols or ancestor figures.
- **Spatial Layout**
  A central courtyard is a common feature of many traditional Ebira homes, providing a gathering place for families and cultural events. With more secluded spaces set aside for elderly people or distinguished visitors, the arrangement frequently mirrors the social hierarchy.
- **Cultural Significance**
  The architectural style of the Ebira community emphasizes cooperation and connection by incorporating spiritual areas like community halls and shrines. The connection to the land and ancestors is symbolized by the use of geometric designs and red earth tones in building materials and decorations.
- **Environmental Orientation**
  The buildings in the region are oriented to optimize natural light and circulation, demonstrating an understanding of the local environment. High ceilings, huge windows, and ventilation apertures are designed to accommodate the hot climate of the region.

2.3 Recent Developments in Cultural Integration in Architectural Design

Recent studies have emphasized the importance of integrating cultural elements into architectural design to preserve cultural identity and enhance community engagement. For instance, (Yang *et al*., 2022) highlights how architecture can express and reinforce cultural identity through its aesthetics, functionality, and connection to local traditions. This approach ensures that buildings resonate with the community's values, history, and aspirations. The concept of vernacular architecture, which refers to traditional building styles and techniques developed in response to local climate, materials, and cultural practices, is crucial in this context. Vernacular architecture showcases the intimate relationship between people and their surroundings, demonstrating their ability to live in harmony with nature. By preserving and conserving vernacular architecture, communities can safeguard their cultural heritage and maintain traditional skills and knowledge (Rashdan & Mhatre, 2022).

In the era of globalization, architects face the challenge of balancing global relevance with the preservation of local cultural identity. (Khasraghi & Mehan, 2023) discuss the impact of globalization on architectural design, emphasizing the need for context-sensitive design that incorporates elements reflecting local culture, history, and

environment. This approach ensures that architecture remains a reflection of the community it serves, celebrating and preserving cultural identity.

2.4 The benefits of cultural centre to the economy

1) It also generates job possibilities in the culture-related services sector of the economy. These service sectors include hospitality and transportation services.
2) cultural centre can draw in foreign investments, boost a country's foreign exchange revenues, and foster economic growth.
3) Culture is a broad industry with the capacity to assist other forms of economic activity.
4) Cultural centre promotes economic progress which in turn successfully reduces poverty.
5) In the educational sector, traveling to another nation or region and learning about its culture is the primary goal of the trip or leisure activity.

3. Methodology

This study used a mixed-methods approach to its research, integrating qualitative and quantitative research methods. To capture the essence of Ebira culture and how it can be incorporated into the design of a cultural center, the study will use a descriptive method. A questionnaire survey was administered to collect data from cultural experts, architects, designers, community members, artisans, and local artists in Kogi State, Nigeria. The survey approach which was recommended by (Rahman, 2023) was selected because it was quick to collect data, easy to design, and could be used to discover characteristics of a large group.

A case study involving six functioning cultural centers was studied and a total of 350 questionnaires were distributed, and 229 valid responses were obtained successfully. The data was entered into the Statistical Package for the Social Sciences (SPSS) and analyzed. Descriptive approach of data analysis is utilized to achieve the study's objectives. The demographic data was summarized using descriptive analysis, which included tables, pie charts, and bar charts analyzed to achieve the study's objectives.

Table 3.1: Summary of Data Preparation and Reliability

Location	Total Responses Sent	Received (No)	Response Rate (%)
Kogi	350	229	65.43
Total	350	229	65.43

Source: Author's Field work, (2024)

4. Result and Discussion

4.1 Preference on Ebira Architectural elements to be integrated to a contemporary cultural centre.

The preference for various elements of Ebira culture was examined of the respondents. A breakdown of the opinions of the participants for the various cultural aspects for appropriate use of a cultural center in Kogi state is provided in Figure 4.1 below:

Table 4.1: Ebira cultural elements for integration into a cultural center design

S/NO	Element	VL (1)	L (2)	M (3)	H (4)	VH (5)	Mean	Rank	Decision
P1	Traditional Ebira patterns and trends	12	20	45	85	67	3.83	1	High
P2	Sculptures depicting Ebira legends	18	25	63	78	45	3.76	2	Moderate
P3	Traditional materials (e.g., wood, clay)	10	18	85	55	61	3.69	3	High
P4	Murals reflecting Ebira folklore	14	22	50	78	65	3.61	4	High
P5	Ebira traditional architecture styles	7	42	88	17	75	3.49	5	Moderate
P6	Decorative textiles and weaving	11	19	48	71	80	3.47	6	High

Respondents prioritized traditional Ebira patterns and trends, sculptures depicting Ebira legends, traditional materials such as clay and wood, murals illustrating Ebira folklore, traditional architectural forms, and ornamental fabrics and weaving in the design of the cultural center. A high preference for including these features is shown by

the highest mean score. While sculptures representing Ebira legends have a high mean score, they are regarded as less important than traditional patterns. Traditional materials, including clay and wood, are given importance because of their community's appreciation for locally obtained resources and their authenticity. Ebira folklore murals are highly valued because they act as a link between the past and present and emphasize the significance of folklore in modern cultural expressions. Given the lower mean score, it appears that respondents might be open to modern perspectives. Figure 4.1 below shows a breakdown of how respondents rated the various cultural elements for contemporary cultural centre.

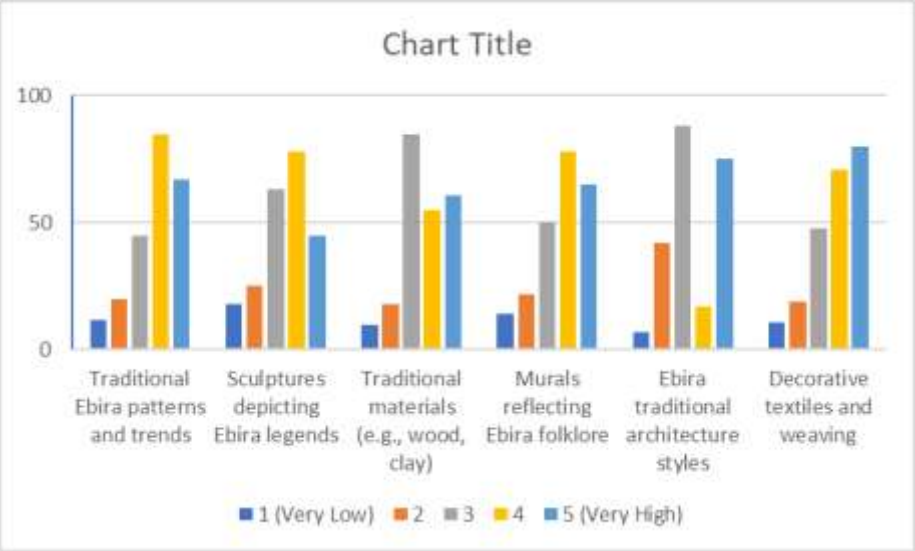

Figure 4.1: Ebira Architectural elements to be integrated to a contemporary cultural centre. Source: Author's work, (2024)

4.2 Preference for Inclusion of Architectural Materials and Design Elements

The results of the study show that the Ebira population strongly prefers traditional materials and design features. These include stone mosaic design, wood, and stone, all of which represent the Ebira people's cultural identity and legacy. Table 4.2 shows that Stone mosaic design had the highest mean score of 3.73, indicating a strong inclination toward its inclusion as an Ebira Architectural Elements in the Design of a Cultural Centre. This choice acts as a basis for incorporating these components into a cultural center's architecture, guaranteeing that it represents the Ebira community's values, social structures, and creative manifestations. The high mean scores for materials such as stone mosaic design and stone indicate their importance in the Ebira culture, which reflects the historical and environmental background of the community. Additionally, the use of bamboo and thatch highlights the value of local workmanship and environmental methods in Ebira architecture.

Table 12: Inclusion of Architectural Materials and Design Elements

Variable	VL (1)	L (2)	M (3)	H (4)	VH (5)	Mean	Decision
Stone	6 (2.4%)	22 (8.7%)	99 (39.3%)	73 (29%)	52 (20.6%)	3.567	High
Bamboo	9 (3.6%)	42 (16.7%)	96 (38.1%)	66 (26.3%)	39 (15.5%)	3.333	Moderate
Thatch	16 (6.3%)	52 (20.6%)	101 (40.1%)	58 (23%)	25 (9.9%)	3.095	Moderate
Wood	8 (3.2%)	25 (9.9%)	90 (35.7%)	82 (32.5%)	47 (18.7%)	3.536	Moderate
Stone (Mosaic design)	5 (2%)	19 (7.5%)	85 (33.7%)	73 (29%)	70 (27.8%)	3.73	High
Bricks	8 (3.2%)	22 (8.7%)	89 (35.3%)	72 (28.6%)	61 (24.2%)	3.61	High

According to the research, bricks and Stone mosaics design are given priority when it comes to incorporating traditional materials into the design. In addition to using these materials, adding colorful mosaic patterns might improve the center's visual appeal and cultural significance. The high grades for brick and stone indicate that these materials have to be given priority when it comes to the structural and ornamental components of the structure. On the other hand, bamboo and thatch received intermediate grades, indicating that their use may be less popular and should be handled carefully. Bricks, stone, and stone mosaic design should be the main materials used to produce a design that complements the architectural preferences of the community.

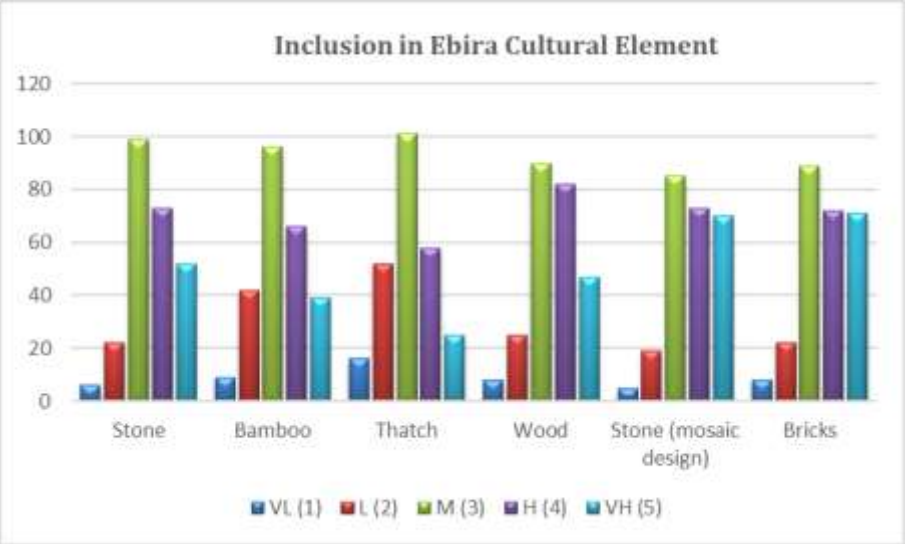

Figure 2: Inclusion of Architectural Materials and Design Elements

4.3 Case Studies

Case studies observed for this study are discussed in detail below:

4.3.1 New Culture Studio Ibadan

The Nigerian public building known as the Cultural Centre Ibadan was created by Strabag Construction Company in 1977 after being designed by Professor Demas Nwoko. In order to highlight the old city's cultural landscape and legacy, its primary objective is to draw in tourists and artists. With elaborate sculptures adorning the walls, wooden and metal adornment in the lobby and hallways, and a fusion of geometric shapes and patterns in the façade, the building is a daring example of the merging of art and architecture.

Figure 6: Approach view of the Cultural Centre Ibadan.

There are eight segments of relief sculptures at the Cultural Centre Ibadan, and they each depict a different theme from Yoruba traditional culture, like dance, entertainment, festivals, and religion. African traditional art and architecture are showcased and promoted in the Cultural Centre Ibadan, a notable masterpiece that supports FESTAC 77's goals of promoting the integration of African arts and culture into all aspects of national life.

5. Conclusions

The importance of incorporating cultural elements into architectural plans is highlighted by this, particularly in light of the proposed Ebira cultural elements in the design of art galleries in Okun, Kogi State. The results show a strong preference for materials that align with the community's cultural identity and values, such bricks, stone, and mosaic.

These show the value of using culturally suitable elements in public buildings while also reflecting the architectural traditions of the Ebira people. The research highlights the importance of incorporating culturally significant architectural materials into future designs, emphasizing community engagement in the design process. It advocates for a collaborative approach that respects local values and identities. Ebira cultural centre plays a crucial role as a symbol of cultural pride and identity by showcasing the distinctive architectural styles, traditional themes, and spatial arrangement of the Ebira people. In order to ensure that future generations can respect and interact with their heritage, a well-designed cultural center may revive the community's cultural fabric Involving local stakeholders, emphasizing sustainable practices, encouraging cultural education, improving accessibility, utilizing technology, and assessing and modifying the center's influence on the community and tourism.

For integrity, Ebira cultural centre's architecture should emphasize brick, stone, and stone mosaic design while minimizing the use of bamboo and thatch. Community workshops may foster pride and ownership by obtaining information about cultural narratives and design preferences. Mosaic displays and other architectural elements can enhance community interaction by telling the history and cultural tales of the Ebira people. Sustainable methods that make use of locally derived resources guarantee ecological balance and represent the community's engagement with its surroundings.

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Cadastral Surveying in Niger State, Nigeria: An overview

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Abstract

Governments throughout the world have created and implemented cadastral systems in a unique way. These systems are intended to aid making decisions on land and property among government, industry, and society. This research seeks to present the technical aspect of cadastral practices in the department of survey, Ministry of land and housing Minna, Niger state Nigeria. Questionnaire was designed and shared to respondent which comprises of staff of the department of land survey in the Ministry and the general public. The sample size was estimated using fisher's formula to be 87. The questionnaire consists of four sections which includes: cadastral awareness and knowledge, land registration, and cadastral mapping and survey. From the field survey, it was recorded that about 45% of the respondent indicates lack of awareness of cadastral practices system while 49% of the respondent indicates not understanding the needs for deeds registration. 64% of the respondent (staff) uses handheld instruments whose accuracy is within the radius of 3m-5m to carryout survey operations. The outcomes of the research indicate a clear fact that the Niger state (Minna) cadastral practices is in serious challenges as it practices have deviated from the norm and professional ethic of the profession. However, to overcome these challenges, there is need to organize workshop especially for staff of the department of survey of the Ministry basically in two directions "Instrumentation and Mapping" and also to enlighten the general public on the relevant of survey operations in general.

Keywords: Cadastral System, Cadastral Practices, Land Registration and Cadastral Mapping and Survey Operation

1. Introduction

The need for more "space" resulting from population growth, urbanization and industrialization has increased the pressure on land-use planning and development. As a result, space above and below ground level is increasingly used (Ali, 2013). Examples include underground developments, infrastructure facilities, high-rise buildings, and apartments. To extend the use and functionality of the land, complex infrastructures are being built, both vertically and horizontally, layered and stacked. These two-dimensional (2D) developments affect the interests such as ownership rights attached to the underlying land. Governments and authorities need to manage land by registering and securing land interests to utilize and develop them in a sustainable and efficient manner (Isikdag *et al.,* 2014). In the modern era, cadastral surveying plays a critical role in supporting various societal needs, including property ownership, land use planning, infrastructure development, and environmental conservation (Edward, 2019). At its core, cadastral surveying is concerned with delineating property boundaries and documenting them in a systematic and legally recognized manner. This process begins with extensive fieldwork, where surveyors use a combination of traditional tools like theodolites and modern instruments such as GPS and total stations to gather precise measurements (Dashe, 1987: Barbour *et al* 1982). These measurements capture the dimensions, angles, and coordinates of land parcels, which are then used to create detailed maps and plans (Agor, 2008). These maps, often referred to as cadastral maps, serve as the official record of property boundaries and are crucial for resolving disputes, conducting land transactions, and managing land resources (Carneiro *et al.,* 2011). One of the primary functions of cadastral surveying is to establish a clear and undisputed record of land ownership (Hisham *et al.,* 2015). This is achieved through the creation of a cadastre, a comprehensive public register of property boundaries and ownership details.

The cadastre includes various elements such as land parcel identifiers, boundary descriptions, ownership information, and sometimes even land value assessments (Carneiro *et al.,* 2011; Elizarova, *et al*., 2012). By providing a transparent and accessible record of land ownership, the cadastre plays a vital role in ensuring security of tenure, facilitating property transactions, and supporting effective land administration. In many countries, cadastral systems are integrated with legal frameworks to provide a robust mechanism for property rights management.

These systems often operate under the jurisdiction of governmental or municipal authorities, which oversee the registration and maintenance of cadastral records. Legal instruments such as deeds, titles, and easements are linked to the cadastral system, providing a legal basis for land ownership and usage rights.
The registration of property rights is one of the key factors around the world that determines economic performance and business activity (Kadaster, 2010). Land administration systems assist in this context. Management of stratified land rights, restrictions and responsibilities (RRRs) is one of the most important challenges in the current land administration systems, which are equipped with cadastres that are only able to maintain 2D spatial information. Land administration systems are processes to regulate land management policies to manage land by maximizing social, economic and environmental benefits for people (Enemark, 2005). Cadastre as an engine of land administration systems plays a significant role to register property rights, restrictions and responsibilities. Niger state is cadastre system is on two dimensional (2D) survey, though it face serious of the challenges ranging from it land processing to the management stage. Part of the challenge is instrumentation for data collection, reference datum and its local reference system, land administration system. These are some of the challenges facing the system. This research intends to investigate the 2D cadastre system practices in the state capital of Niger state, Nigeria

2. Study Area

Chanchaga local government area (C. L.G.A) is located in Niger State, Northcentral Nigeria and has its headquarters in the town of Minna. Chanchaga LGA comprises several towns and villages which include Bako, Kangwa, Nagun, Zakwogi, Pette, Shana, Kuka, and Babeji etc. The population of Chanchaga LGA is put at 138,434 inhabitants with the majority of the area's dwellers being members of the Nupe and Gbagyi tribes (NSG, 2006).

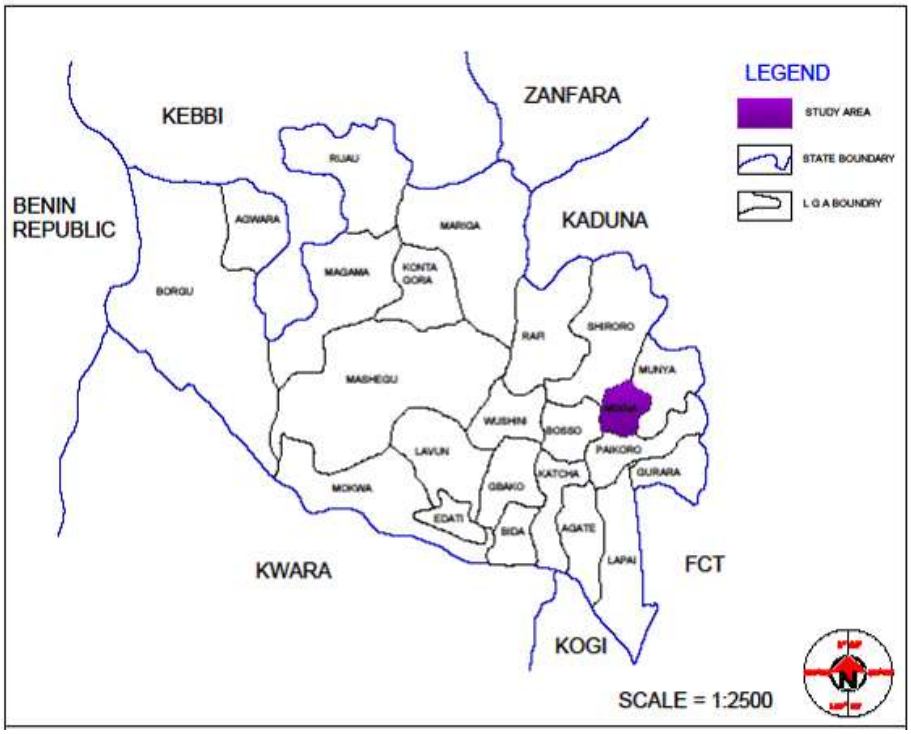

Figure 1: Map Of Niger State Depicting Chanchaga Local Government Area

3. Method

3.1 Data Acquisition

In this research work, data was collected via field survey. The instrument of data collection used in the research was questionnaires. It was administered to staff of the Ministry (department of land and survey), the researcher also interviewed some Departmental Heads of other related department such as cartography, planners and also the indigene of the local government area. This is aimed at getting wide range of information for the research. Telephone interview was also deployed in few cases where the respondents were away on official assignment. The researcher also deployed the direct observation method of data collection. The questionnaires consist of about three main sections namely: cadastral awareness and knowledge, deed registration, and cadastral mapping and survey.

According to Sin-Ho (2014), the sample size of the research was determined using fisher's model. Equation 1, depicts the model

$$n = \frac{N}{(1+N(e)^2)} \quad 1$$

Where:

N: Total population

n: Minimum sample size required

e: Standard normal deviate at 95% confidence level, 1. 96 from the normal distribution.

The total number of 87 respondents was recorded out of two hundred questionnaire shared. However, some of the questionnaires were not returned not filled, some were not properly filled while some were turn off. The data were presented and analyzed using simple percentages/pie charts and content analysis techniques respectively.

4. Results and Discussion

The result obtained from the distributed questionnaires were discussed in this chapter. The researcher concentrated on three measure issues amidst others, associated with cadastral practices in the state. These issues seem as most pressing as at the period of compiling the research work. Below are list of the major issues.

i. Cadastral Awareness and Knowledge:

The outcome from the field survey indicates that 45% of the respondent from the LGA and other staff member of the Ministry do not know what cadastral system of land management and administration is all about neither do they have knowledge of the system. Figure 4.1 depicts the data representation from the field survey.

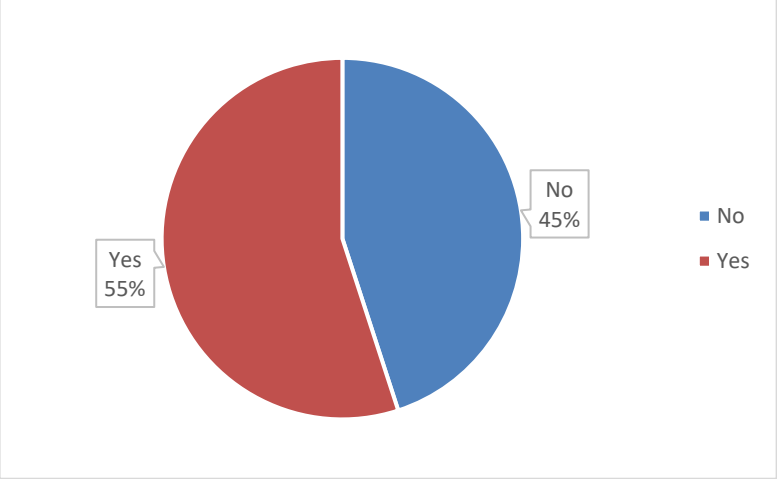

Figure 4.1 Percentage of Cadastral awareness in the state capital

Figure 4.1, the outcome of the graph shows the level of awareness of survey practices in the Minna, state capital. Nothing is essential to people's lives as the land and everything connected with it. Land is an independent asset which supports our overall existence and without which no living thing would have been on earth Dale (1991), this has stress the need for cadastral knowledge to the people. Also, Yinka and Olamide (2020), the maintenance and management of cadastral system is an important issue that increase the internal generated revenue of a country if only the relevance information is shared about it tenure system. There is need for the surveyors land administrator and management officers to go around the nooks and cranny of the state to enlighten indigene on matters that has to do with land management.

ii. The Deed Registration:

Land registration can be described as 'the process of recording legally recognized interests (ownership and/or use) in land' (Dale and McLaughlin 1989). This process forms an important part of the system of land registration. Figure 4.2 shows the percentage of people in the state that their land is registered with a certificate of occupancy (C of C).

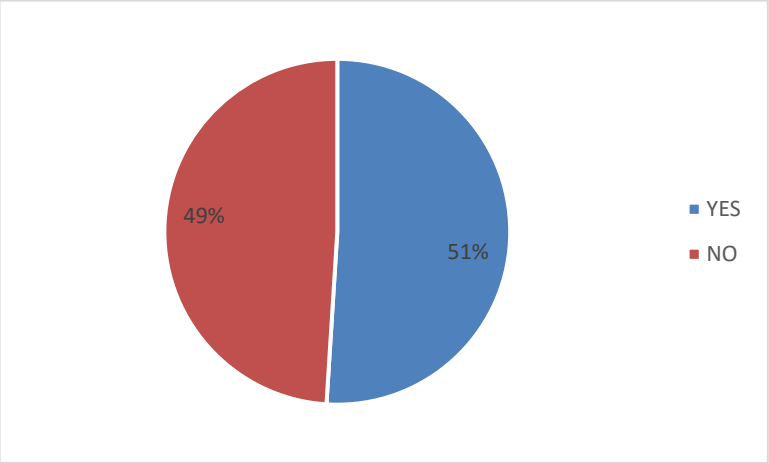

Figure 2. Percentage Responded to Deed Registration

This is a clear fact that the awareness ratio of deed registration in the state capital is poor. 49% of the structures (buildings) do not have deed registration. The amazing fact here is that, this figures are recorded in the state capital, how about in other local government areas. This could tell the amount of under-tax revenue the state is losing from land properties tax. Ezekwere *et al.,* (2022), land taxes improve country growth by 23.06%. This shows the need for the government to collaborate with the ministry of land and survey to implement policies that will ensure all land properties owners to fulfilled land registration processes.

iii. Cadastral Mapping And Survey

The survey registration council of Nigeria (SURCON), clearly stated the specification for cadastral survey measurement as follows. (See table 4.1), At semi-major axis 95% eclipse error should have the following specification.

Table 4.1. Specification for cadastral measurement by SURCON

Cadastral Error	Tolerance level
Linear measurement	1: 10,000
Angular measurement	$^{1}/_{3600\ of\ a\ degree}$
Closure	1: 10,000

Source: SURCON, (2020)

Table 4.2: Cadastral Measurement Specification for United State of America.

Cadastral Specification	
Less than 0.025 (m)	Cadastral Project Control
Less than 0.050 (m)	Cadastral Corner Measurement

Source: US, GNSS (2020)

The outcome of the field survey is disturbing. It recorded that about 64% of the respondents depicts that handheld GPS are mostly used by the staff of the department of survey to carryout survey measurement. This is far against the SURCON specification (see table 4.1 and 4.2). Figure 4.3 shows the graphical representation of outcomes from field survey. Mostly, handheld instrument are implore for reconnaissance survey to pick the predicted location of features not the actual. Consequently, handheld GPS accuracy are within the radius of 3-5m of the location of point (kamruzzaman *et al.,* 2014).

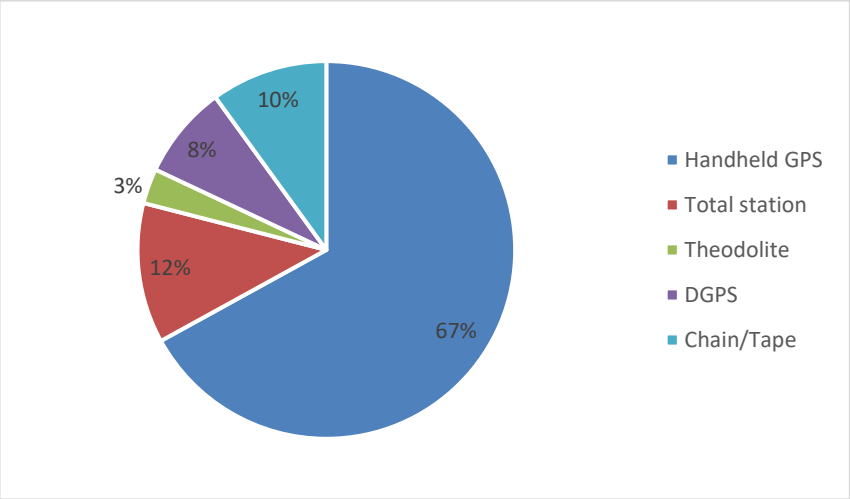

Figure 4.3. Instrument for Site Measurement.

Using such instrument for final survey could be disastrous as it can introduced error of more than 2m. The extended effect could result to Land dispute, boundary problems, community clashes, imbalance charting of the base map are some of the issues that are associated with going against the SURCON specification.

5. Conclusion

The major problem of the implementation of Cadastral Information System (CIS) in Nigeria is identifying land use pattern and modeling the user's requirement such that the system will be capable of answering some questions such as "where is what" and "what is where" Adeoye, (1998). The need for the development of these models became necessary so that the digitally acquired data could be modeled for storage in a database. CIS has received a boost over time and considering the emphasizes placed on information management, every effort must be made by concerned organization in implementing the cadastral land information system for better land management in Niger State.

However, Cadastral surveying system in Niger state require a complete overhaul. Acknowledging the fact that it generate revenue for the government and it also support the economy of the state if properly harness. The outcome of the research indicates that there are serious challenges facing the practices and the profession in the states. The department of survey and mapping needs to collaborate with the government to make stringent policies in regard land procurement process. Most importantly, there is need to create awareness to the public on why all land properties need to have deed registration. Standard of operation of practices need to be adhered to. These calls for training of the staff of the department of survey and mapping, exposing the staff of the department on how to operation survey equipment such as total station, differential global positioning system (DGPS) etc and the need to adhered to professional ethic of the profession.

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Effects of Natural Environmental Attributes on Residential Property Values: A Literature Review

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Abstract

The natural environment is one of the major determinants of human settlement, particularly, the urban area. This review examines the impact of natural environmental attributes on residential property values, based on 44 academic sources from 2012-2024. The literatures were sourced using keywords such as impact of natural environment on property values, natural environmental attributes and real property values, among others. The selected literatures have precise focus, location, variables and clear methodology. The study identifies both positive and negative impacts, such as increased property demand in areas with desirable natural features, and value reduction due to environmental hazards. It was also found that the positive impact of the natural environmental attributes has been felt through a rise property values and demand for properties in locations where certain natural environmental attributes are available, while the negative impacts are however being experienced through a reduction in property values, vacancy rates and low demand for properties in locations where the natural environmental attributes is common. The study, therefore, concludes that it is essential to understand the complex relationship between the natural environmental attributes and property values, because it will provide guide to real estate professionals, property developers, policy makers and urban managers. These thereby form a basis for further studies on the growing impacts of the natural environmental attributes on the property values.

Keywords: Natural environmental attributes, Residential property value, Urban green spaces, Waterfront properties

1. Introduction

The natural environment is one of the major determinants of human settlement, particularly, the urban area (UN-Habitat, 2015). Natural environmental attributes influences the human health (WHO, 2022), property market (Arslan *et al*., 2022), social cohesion (UN-Habitat, 2015), environmental sustainability (Mahmoud *et al*., 2022) and climate resilience (UNFCCC, 2019), among others. The urban natural environment has a considerable impact on residents' quality of life and neighbourhood preferences. Natural attributes such as the green spaces (i.e. parks and gardens), are vital components of urban life, providing residents with opportunities for recreation, relaxation, and social interaction. According to research, having access to green spaces can reduce stress, improve mental health, and increase general well-being, making neighbourhoods with greener spaces more appealing to potential residents (McCormick, 2017).

Furthermore, natural environmental features contribute to better living conditions, which are important factors in determining a desirable neighbourhood of residence (WHO, 2022). The presence of plants and trees can also help to reduce the urban heat island effect, resulting in cooler and more comfortable living conditions, which is especially essential in densely populated cities (UNFCCC, 2019). In addition, aesthetically pleasant landscapes and beautiful scenery provided by natural elements such as hills and rivers can attract inhabitants looking for a better quality of life and influence property values (Wen *et al*., 2017).

Property values are determined by several factors (Mohammed and Sulyman, 2019). However, the natural environment is one of the most important determinants of property value, particularly, the residential property value (Mohammed and Sulyman, 2019). Recent studies found that the natural environment influences residential property values through factors such as vegetation, climate, terrain, proximity to water bodies, and visually appealing features such as hills and mountains (Adewusi, 2024; Ayeni *et al*., 2023; Miljković *et al*., 2023; Yeh *et al*., 2022). For example, flat terrains often facilitate development and attract higher property values, whereas steep terrains may attract certain residents seeking spectacular vistas despite higher construction costs (Wang *et al*., 2017). Waterfront properties consistently demand higher rentals due to their visual and recreational appeal (Miller

et al., 2019). Climate comfort has a substantial impact on desirability, with temperate zones having greater property values (Miljković *et al*., 2023).

In the developing world, particularly in Nigeria, natural attributes is one of the determinants of neighbourhood choice and affect the property values (Ayeni *et al*., 2023; Babalola *et al*., 2020). For example, in Lagos city of Nigeria, neighbourhoods around Lekki Lagoon and Banana Island attract higher property values due to their waterfront vistas and exclusivity. Areas prone to natural hazards like as flooding, which is common in Lagos and Delta State, have lower property values and are less attractive for residential uses (Babalola *et al*., 2020). In Abuja, natural attributes contribute up to 60% in the determination of property value (Ayeni *et al*., 2023). Thus, while natural aesthetic and recreational opportunities might increase neighbourhood attractiveness and property values, environmental concerns and hazards can dramatically reduce their desirability and economic value.

There is growing literature on the impact of natural environment on the property values (Silva *et al*., 2020; Ayeni *et al*., 2023). For example, Silva *et al*. (2020) found that vegetation, surface water, noise impacts, and landscape components all had a significant effect on property values. Holligan (2022) underlined the importance of environmental factors on the property market, such as topography and urban green spaces. Kowalewski *et al*. (2023) supported these findings by highlighting the large positive price premium associated with access to open spaces and water bodies. In contrast, Pathmasiri and Perera (2022) observed that the presence of water bodies and certain types of open space preservation can have a negative impact on property values.

Presently, there is a dearth of literature on the global impact of natural environment on the property values. It is against this backdrop that it becomes imperative to review some empirical studies on natural environmental attributes and property values on a global scale considering each of the natural environmental attributes and they affect property values either natively or positively which will eventually form a basis for further research.

2. Methodology

An archival research was utilised to assess the impact of natural environment on the property market. The data required for the study were mainly sourced from secondary sources, including journals, textbooks, conference papers, thesis and other online sources. Online data sources were mainly from the academic electronic database utilising Science Direct (Elsevier), Emerald Insight, Google Scholar and Research Gate. Studies on impact of natural environmental attributes on property values with clear focus were included in this research. The search keywords include the property value, rental value, rental price, natural environment, environmental attributes, green spaces and parks, water bodies, geology and topography, land surface temperature, and wetland. However, researches that could not meet the required criteria were excluded of time frame (i.e. 2012-2014) were not included. Therefore, a total of one hundred and four (104) papers were gathered, out of which only forty four (44) met the criteria for selection. Studies with a clear focus on the impact of the natural environment on the property values were then selected, sorted and grouped accordingly (see Figure 1).

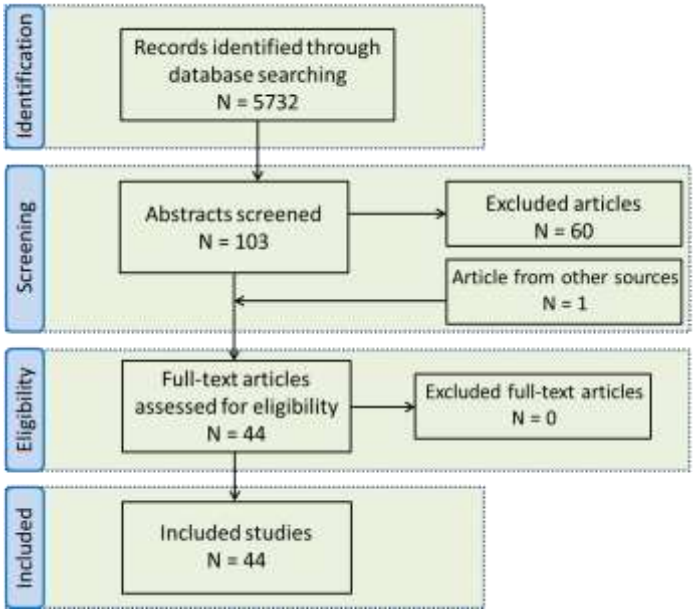

Figure 1: Review process flow chart

3. Impact of Natural Environmental Attributes on Residential Property Value

Reviewing the impact of natural environmental attributes on residential property value, this study focussed on several key aspects. These included impact of green spaces and parks on property value, relationship between water bodies and property values, impact of geology and topography on property values, relationship between land surface temperature and property values, and impact of natural disasters on property values.

3.1 Impact of green spaces and parks on property value

Several studies were conducted on how green spaces and parks influences property values. For instance, Brasington (2023) focused on Ohio, USA, examining the effect of open space maintenance spending on house prices. The findings indicated that cutting funding for park maintenance can lead to a decrease in house price. In Dhaka, Bangladesh, Sharmin (2020) investigated the impact of open spaces, specifically green parks, on property values. The study discovered that homebuyers are willing to pay a premium for scenic views and living in close proximity to open spaces. Bottero *et al*. (2022) conducted research in Brisbane, Australia, focusing on the impact of urban parks on real estate prices. Their findings highlighted that recreational and sport parks have different effects on housing prices. Similarly, Greening and Pomeroy (2019) explored the impact of parks, recreation, and other open space areas on property values in South Middleton Township in South Central Pennsylvania, USA, where parks, recreation, and open space activities have positive impacts on property values.

Mwende (2018) investigated the economic impact of pocket parks on residential property values in Madison, Wisconsin, USA. The study found that pocket parks have a positive impact on residential property values. In another study in Dhaka, Bangladesh, Sharmin and Nayeem (2015) delved into the impact of open spaces, specifically green parks, on the value of residential properties in urban areas, where it was revealed that the presence of green spaces has a positive effect on residential property value. Vom Hofe *et al*. (2018) focused on Cincinnati, Ohio, USA, to explore whether homeowners are willing to pay more for access to parks and found that decreasing distance to a park increases property values. Iqbal and Wilhelmsson (2018) conducted research across Stockholm, Hong Kong, and the Minneapolis-St. Paul metropolitan area, analysing the impact of proximity to parks and open green spaces on apartment prices. Their findings indicated that proximity to parks has a positive impact on apartment prices.

Lai (2017) explored the effect of parks and green space on housing prices in Kaohsiung, Taiwan. The study found that housing prices are influenced by the proximity to parks and green space. However, a limitation of the study is the assertion that the distance of parks and green space within a 500-meter radius is not a main factor in transaction cases. Wu *et al*. (2015) focused on Shenzhen, China, investigating the impact of urban green space on residential housing prices. The study found a positive impact of green space on property values. Biao *et al*. (2012) conducted a study in Beijing, China, examining the effects of public green spaces on residential property values. The findings indicated a positive impact of parks and open spaces on property values. Tekel and Akbarishahabi (2013) explored Ankara, Turkey, determining the effect of open-green space on house prices. The study found that proximity to a park increased house prices, contributing to the understanding of the economic value created by specific parks.

Farja (2017) investigated the impact of privately conserved open spaces on housing prices in San Francisco, USA, where it's found that private land conservation has a significant effect on housing prices. Evangelio *et al*. (2019) in Victoria, Australia, studied the effects of parks on house prices. The study found that parks have a stronger positive effect on house prices. Shi (2020) examined the impact of various landscapes, including parks, on housing prices in Hangzhou, China. The study found that various landscapes, including parks, have a positive impact on residential prices. Jabbar (2016) conducted a study in Peshawar, Pakistan, focusing on the willingness to pay for public parks, waste disposal, and wide roads. The study found that the presence of parks increases house rents.

3.2 Relationship between water bodies and property values

The relationship between water bodies and residential property values has been extensively studied in the literature, revealing nuanced insights into the economic impacts of natural water features on real estate markets. Studies reviewed provide the diverse ways in which water bodies influence property values globally. For example, Pathmasiri and Perera (2022) investigated the impact of water bodies on residential property market values in Colombo, Sri Lanka. The study found that properties with a scenic view of a lake commanded a premium market value, whereas properties just one meter away from the water body saw decreased value. This study highlights the positive influence of scenic water bodies on property market values. Similarly, Nicholls and Crompton (2018) examined property values influenced by scenic water views and proximity to lakes in the Murray-Darling Basin, South Australia. The study revealed that scenic views and proximity to lakes and reservoirs significantly increased property values. This study further corroborates the importance of scenic water views in enhancing property values. Ayres and Meng (2018) focused on the impact of groundwater rights on land values in the Mojave Basin, Southern California. Using spatial regression discontinuity designs, the study provided the first estimates on the effect of groundwater property rights on land values, concluding that groundwater rights increased land value. This study

emphasise the economic benefits of securing groundwater rights. Klemick *et al*. (2018) analysed the property value impacts of bay water quality in Chesapeake Bay, USA, using a hedonic model. The study found that water quality improvements led to increased property values, emphasizing the economic advantages of implementing pollution reduction policies. Vijayan and Job (2020) assessed the impact of the freshwater lake ecosystem on residential property prices in Vellayanilake, Kerala, India. The study revealed that the aesthetic value and scenic beauty of the lake significantly enhanced property values. This study highlights the economic benefits of preserving and enhancing the aesthetic and ecological values of water bodies. Zhang *et al*. (2022) studied the effect of cyanobacterial harmful algal blooms on property values around US inland lakes. Using satellite-derived measures of cyanoHAB frequency, they found that these blooms reduced property values. This study emphasises the negative impact of ecological degradation on property values and the importance of maintaining healthy water bodies.

Wen *et al*. (2017) explored the spatial effects of the Grand Canal on property values in Hangzhou, China. The study discovered both positive and negative effects on property values depending on proximity to the canal. This study highlights the complex spatial dynamics of water bodies' effects on property values. Mei *et al*. (2023) investigated the impact of water body restoration on property values in Beijing, China. The study found that water body restoration increased the rental values of residential properties. This study demonstrates the economic benefits of environmental restoration projects.

Li *et al*. (2020) examined the spatial heterogeneity of water system effects on residential property values in Zhengzhou, China. The study showed that accessibility, width, and water quality of rivers positively affected residential prices, with lakes having a greater impact than rivers. Polyakov *et al*. (2022) analysed the impact of waterway renewal on residential property values in Singapore. Their study found that residential property values increased by 1.6% within 500 meters of waterway renovation sites. This study reveals the positive effect of urban water system improvements on property values.

3.3 Impact of geology and topography on property values

There are several studies that explore how geology and topography influences the property values. For example, Er *et al*. (2023) assess the impact of geological factors such as surface water, groundwater, active faults, and karstic collapse on real estate valuation in Turkey. The findings shows that these geological attributes significantly influence property values in Turkey, highlighting a critical aspect often overlooked in conventional property valuation practices. The study provide a structured approach to integrating complex geological data into decision-making processes concerning real estate investments, thereby contributing to more informed real estate development strategies.

In Oklahoma City, USA, Mothorpe and Wyman (2021) investigate the impact of seismic activity on residential property values using the US Geological Survey's Did You Feel It? (DYFI) system. The study reveals a negative correlation between seismic events and property values in the region, offering empirical evidence on how natural hazards can adversely affect real estate markets. The research provides valuable insights into the economic repercussions of induced earthquakes, informing policies and practices aimed at mitigating seismic risks in urban areas. Nygaard (2016) shifts the focus to London, England, exploring how geological and topological features explain variations in median house prices. The study demonstrates that underlying geological formations and local topography play crucial roles in shaping neighbourhood development patterns and socioeconomic structures, contributing to a nuanced understanding of urban spatial dynamics. By linking geological attributes to housing market outcomes, Nygaard's research enhances our grasp of the long-term implications of geological factors on real estate values and investments.

Meen *et al*. (2016) extend this analysis across London, UK, and Melbourne, Australia, examining how rock formations and topography influence property prices through path-dependent development processes. Their findings highlight that historical geological conditions continue to influence modern property values, providing the persistence of geological legacies in shaping urban landscapes and housing markets. This study contributes to the literature by illustrating how past geological events and formations continue to exert enduring effects on contemporary real estate valuations.

In Tehran, Iran, Soltani *et al*. (2021) investigate the impact of topography on property values. The research reveals that topographical features exert both positive and negative influences on residential property values, depending on local terrain characteristics and urban development patterns. By employing advanced spatial analysis techniques, the study provide valuable insights into how topography interacts with urban morphology to shape property market dynamics, informing land use policies.

3.4 Relationship between land surface temperature and property values

The relationship between land surface temperature and property values is explored through various empirical studies, each offering unique insights based on their study location, methodological approach, and specific attributes

under consideration. For instance, Semenenko and Yoo (2019) investigated the German capital cities to understand how weather changes influence direct real estate returns. Employing weather change proxies, climate risk indices, and control variables, their robustness checks revealed that the volatility of daily temperatures is inversely correlated with real estate returns. The study contributes to the body of knowledge by establishing a clear correlation between weather patterns and real estate returns, suggesting that investors and real estate managers must consider climate risks in their financial strategies and property management.

In China, Chen *et al*. (2023) examined the relationship between high-temperature exposure and land transactions using the standard hedonic price method. Their findings indicated that high temperatures lead to an increase in the value of both residential and commercial lands, with heat prompting more aggressive bidding from investors. This study reveals the complex ways in which environmental factors such as temperature can influence economic behaviours in the real estate market, emphasizing the need for adaptive strategies in land investment. In contrast, Ma and Yildirim (2023) conducted a study across the United States to assess the impact of exposure to local heat shocks on residential real estate prices. The study discovered that abnormal temperature increases lead to significant decrease in house prices. Their research highlights the detrimental effects of extreme temperature variability on property values, stressing the importance of integrating climate resilience into real estate valuation and housing market policies.

In Florence, Italy, Guerri *et al*. (2022) employed spatial approach to investigate the relationship between high temperature zones and property values. The study found a positive association, where areas with higher land surface temperatures corresponded with higher property values. This finding contrasts with the previous studies and suggests that in some regions, higher temperatures might be perceived as a desirable attribute, potentially due to climatic locational factors. The research adds a nuanced perspective to the discourse on how thermal patterns influence real estate values.

Adewusi (2024) explored the effect of climate change on residential property values in Lagos, Nigeria. The study revealed that temperature has a significant negative effect on property values in both non-coastline and coastline regions. This comparative analysis highlights the pervasive impact of climate change across different geographical areas within a single city, emphasizing the urgent need for climate adaptation strategies in real estate development.

3.5 Impact of wetland on property values

The impact of wetland on property values has been extensively studied across various geographical locations, each study providing valuable insights into how these events influence real estate markets. This section reviews the empirical findings from a selection of such studies, highlighting the diverse findings, and contributions to knowledge. For example, Athukorala *et al*. (2018) conducted a study in Rockhampton, Queensland, Australia, focusing on the impact of wildfires and floods on residential property values. The study found that natural disasters significantly decrease property prices in affected areas. The research highlights the immediate economic consequences of natural disasters on property markets, emphasizing the importance of disaster risk management and mitigation strategies to protect property values in vulnerable areas.

Apergis (2020) expanded the scope of investigation to a global scale, analysing the impact of natural disasters on housing prices across 117 countries. The study revealed that natural disasters generally lead to lower house prices worldwide, with geological disasters having the strongest negative impact. This comprehensive study revealed the pervasive and severe economic impact of natural disasters on the global housing market, providing critical data for international policymakers and real estate investors.

Shu *et al*. (2022) focused on Miami-Dade County, USA, to examine the effects of flood zone designations on residential property valuation. The study found that changes in flood zone designations significantly impact property values, highlighting the role of flood risk in climate gentrification and property appreciation rates. This study contributes to the understanding of how risk perceptions and regulatory changes influence property markets in flood-prone areas. Eom *et al*. (2018) investigated the effects of Natural Disaster Risk Reduction Districts and restoration projects on neighbouring apartment prices in Umyeonsan, South Korea. The study discovered that the districts have negative effects on apartment prices within a 1,500-meter buffer zone from floodplains. The research provides insights into the localized impact of disaster risk reduction measures on real estate values. Miller and Pinter (2022) examined the impact of urban flooding on residential real estate markets in Benton, Boulder, and Cass counties in the USA. The study identified floodplain discounts before and after flooding events, indicating that properties within floodplains suffer from reduced market values. Their findings revealed the persistent economic disadvantage faced by properties in flood-prone areas, reinforcing the need for robust flood mitigation infrastructure.

Razali *et al*. (2021) explored the effects of flood hazards on residential property prices in Selangor, Malaysia. The study discovered that residential property prices in flood-prone areas are relatively unaffected by flood events. This finding challenges the conventional understanding of flood impacts on property values, suggesting that local factors

and mitigation measures might play a significant role in buffering property markets against flood risks. Similarly, Ismail *et al*. (2019) investigated the impact of flooding on residential property values in Malaysia, focusing on flood control measures. The study estimated the willingness to pay for such measures, providing critical data for evaluating the cost-effectiveness of flood mitigation strategies. This study offers practical insights for policymakers aiming to enhance flood resilience in residential areas.

In Nigeria, Egbenta *et al*. (2015) studied the effects of flood risk on property values in Lokoja. The study found that properties located within floodplains are lower in value compared to those outside these areas. This study adds to the existing literature on the economic impact of flood hazards in developing countries, highlighting the importance of flood risk assessment in property valuation.

4. Discussion

This review has provided substantial insights into the relationship between natural environmental attributes and residential property values, shedding light on how these factors influence real estate markets across various regions. Assessing the natural environmental attributes such as green spaces, water bodies, geology and topography, land surface temperature, and wetlands, the studies collectively provide the significant role the natural environment plays in shaping property values. It was found out that the natural environmental attributes affect property values both negatively and positively.

The study shows that the influence of green spaces and parks on property values has been overwhelmingly positive, with several studies reporting an increase in residential property prices due to proximity to well-maintained parks and recreational areas. For example, research from Ohio, USA, and Brisbane, Australia, demonstrates that the presence of open spaces, whether for sports or recreation, tends to boost property values by creating aesthetically pleasing environments and promoting healthier lifestyles. Similarly, studies from Dhaka, Bangladesh, and South Middleton Township, Pennsylvania, reveal that homebuyers are willing to pay a premium for properties close to green parks. The proximity to water bodies also plays a crucial role in shaping property values, with scenic views and easy access to lakes, rivers, or reservoirs generally driving property prices higher. For instance, studies from Colombo, Sri Lanka, and the Murray-Darling Basin, Australia, show that properties near water bodies are often valued higher due to their aesthetic appeal and recreational benefits. However, proximity to water does not always guarantee an increase in property value. Factors such as water quality and the risk of flooding can significantly influence these relationships. Research in the USA, for example, highlights that ecological degradation, such as harmful algal blooms, can have a negative impact on property values, while improvements in water quality can increase them.

Furthermore, the influence of geological and topographical features on property values is multifaceted. While advantageous topography, such as elevated areas with scenic views, often enhances property desirability, geological risks such as seismic activity or unstable terrain can depress property prices. Research in Oklahoma City, for instance, reveals a negative correlation between seismic activity and property values, reflecting the risks posed by natural hazards. Conversely, studies in London and Tehran show that favourable geological and topographical conditions, such as solid ground or desirable elevations, positively affect property values. The relationship between land surface temperature and property values is complex and often region-specific. In some areas, like Florence, Italy, higher land surface temperatures are associated with increased property values, possibly due to the desirability of warmer climates. However, in other regions, such as Lagos, Nigeria, and across the United States, higher temperatures or heat shocks are associated with decreases in property values, particularly in areas more vulnerable to climate change. Wetlands have a distinct impact on property values, with the risk of flooding often leading to a decline in prices. Studies from Miami-Dade County, USA, and Lokoja, Nigeria, show that properties located in floodplains or designated flood risk areas tend to have lower values compared to those in safer locations.

5. Conclusion

In conclusion, the natural environment has both positive and negative impact on property values. Its positive impact has been felt through a rise property values and demand for properties in locations where certain natural environmental attributes are available. The negative impacts are however being experienced through a reduction in property values, vacancy rates and low demand for properties in locations where the natural environmental attributes are common. It is essential to understand the complex relationship between the natural environmental attributes and property values. This will provide guide to real estate professionals, property developers, policy makers and urban managers. Integrating these environmental factors into property valuation models and urban development strategies will ensure more informed decision-making, promote sustainable development, and enhance resilience to environmental challenges. This paper provides basis for further research in the area of real estate research.

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Empirical Review of Real Estate as an Asset Class in a Mixed Asset Portfolio of Pension Fund; A Global Perspective

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Abstract

The study is aimed at empirically reviewing and exploring real estate as an asset class in a mixed asset portfolio of pension fund; a global perspective. Literature was reviewed empirically across the globe on articles/thesis that have explored on real estate as an asset class in pension fund investment. A total of 37 articles/thesis were empirically reviewed, results indicates that, 34 articles were published while 3 theses are unpublished, also, journal articles have the highest number among the reviewed articles, furthermore, the period of study with the highest articles includes; 2011-2015 and 2021-2024. Moreover, North American region particularly USA is considered the region with the highest number of written articles in the area of real estate as an asset class in pension fund investment followed by African region. Furthermore, performance of real estate as an asset class is the variable with highest consideration from the list of reviewed articles/thesis followed by other areas, diversification potential, real estate allocation and inflation hedging potentials respectively. The study recommends that other areas that have received less attention such as the real estate inflation hedging potential should be well explored in order to determine the significance of investing in real estate in inflationary period especially in an unstable economy.

Keywords: Real Estate, Pension Fund, Mixed Asset, Portfolio, Investment

1. Introduction

Pension fund represent pooled financial assets that are managed by professional fund managers with the aim of supporting the retired workers with a continuous flow of income. This is applicable to retired workers who have contributed to the scheme during their career either in the public or private sector. The term pension fund is used in the UK, US and most other countries including Nigeria. However, in countries like Australia, superannuation fund is the term used to refer to the pension fund. According to Green and Robinson (2012), a good pension is one that will pay an adequate and predictable stream of income after retirement, until death. A survey by Myers (2016) found that, for many pension contributors, the most desirable objective is high investment return, certainty, non-negative performance, low charges and immediate access (liquidity). Pension fund is today considered among the most important institutional investment in the Global Capital Markets (Umeh and Okonu, 2018).

Over the last few decades, institutional investors have significantly increased their exposure to alternative assets such as real estate. for instance, pension funds increased their exposure to real estate, private equity, hedge funds, infrastructure, and commodities from 9% in 1990 to 16% in 2010 (Andonov *et al*., 2015). Real estate is one of the investment options available to investors and fund managers along with publicly listed stocks, bonds, and cash. Investing in real estate provides opportunity for diversification by utilizing correlations between real estate and other asset classes (Habbab and Kampouridis, 2023). Previous studies have documented the positive impacts of holding real estate asset in a mixed-asset portfolio (Pagliari, 2017) also, a survey result indicate that, investors have a strong appetite for real estate (PREA, 2021). Furthermore, real estate is considered as the largest asset class in the world (comprising of more than 54% of global financial wealth) and this has continued to show a significant growth over the years in many countries (Oreagba, 2010). At the beginning of the 21st century, real estate sector turned out to be important in the definition of strategic real estate portfolios; this welcome development led international investors to allocate more of their resources to the real estate sector. Real estate is also perceived as the safety net by the market, this is as a result of the bundle of investment benefits it provides such as a low correlation with stock and bonds, attractive risk adjusted returns and inflation hedge, ensuring stable returns over time (Locurcio *et al*., 2021). the optimal extent of the real estate asset class into a mixed-asset portfolio is influenced by several factors: *a)* numerical concentration and typological and geographical diversification both local and international; *b)* investment period; *c)* volatility and market dynamism; d) investor's risk (Dangl and Weissensteiner, 2018).

After the Global Financial Crisis of 2007-2008, the allocation to real estate as an alternative asset class rise significantly. Motivations for investors to allocate to alternative assets were wide-ranging: from political uncertainties and low-interest rates to an increasing multi-ass*et al*location, to say nothing of the defensive character, higher returns, and the superior overall performance of real estate in comparison to other asset classes (Bals *et al*., 2016; Rock *et al*., 2019). Economic crises, such as the one caused by the Covid-19 pandemic, have resulted in significant intermediate losses for some asset classes (Samson *et al*., 2020) and thus demonstrate the importance of a well-diversified portfolio (Kemper *et al*., 2012; Tai, 2018). Studies have shown that integrating real estate into pension fund portfolio leads to diversification benefits and improved performance (Umeh and Okonu, 2018). Pension funds globally allocate an average of 8.3% to real estate, with a split of 90/10 between private and public real estate (Carlo *et al*., 2021). Increasing the proportion of indirect real estate investments in retirement pension portfolios has been suggested as a way to solve the problem of low returns in Korea (Kim and Park, 2022). Moreover, blending a global listed real estate portfolio with a domestic real estate allocation has been found to increase returns and improve risk-adjusted performance (Ametefe, 2018). By incorporating real estate into a mixed asset portfolio, German pension funds have seen improvements in both returns and the Sharpe Ratio (Carlo *et al*., 2021).

This submits that if investments in real estate are appropriately selected and combined with other investments within a mixed-asset portfolio, the mixed-asset portfolio will perform quite better. To optimize a portfolio, the ideal weights of investments must be determined to reduce risk and/or increase returns (Brabazon *et al*., 2020) Institutional investors have found that a significant allocation to real estate protects their wealth during difficult times, such as the Covid-19 pandemic (Akinsomi, 2020). Despite the advantages real estate investment has in a mixed asset portfolio, evidence from pension investment have shown low funds allocated to real estate investment (Ibikunle, 2022). Effects of non-allocation of significant amount of investment capital to real estate can lead to loss of investment funds as a result of high rise in inflation (Akinsomi, 2020). the inability of the pension operators to utilize the available pension funds is worrisome, as many public organizations find it extremely difficult to secure money to pay entitlements of their retirees and pensioners due to wrong choice of investment strategy (Abere and Abiola, 2020). Studies across the globe have explored on the significance of real estate in pension fund investment, most of the studies measuring the risk adjusted return and diversification benefit while only few investigated on the inflation hedge potentials of real estate. The aim of this study is to empirically review real estate investment as an asset class in a mixed asset portfolio of the pension fund; a global perspective. Therefore, it is imperative to review these previous studies and document their contribution.

1.1 Empirical Review of Real Estate as an asset class in Pension Fund Investment

Many studies were carried out across the globe on the performance of real estate in a mixed asset portfolio of pension fund, these includes; Arnold (2014) studied a global perspective on pension fund investments in real estate. Moss and Farrelly (2015) studied the performance implications of adding global listed real estate to an unlisted real estate portfolio: a case study for UK. simulate the historic performance of portfolios which comprise varying allocations of unlisted pooled real estate funds, global listed real estate securities funds and cash. Findings highlighted rediscovering a role for real estate in Defined Contribution pension schemes". This highlighted both the rationale for real estate in DC funds, and specifically, the use of a blended product, which combined a 70% UK unlisted allocation with a 30% global listed allocation, to provide this exposure. Andonov *et al*., (2015) investigated on Intermediated investment management in private markets: evidence from pension fund investment in real estate, descriptive and inferential statistics were used, it was revealed that delegating real estate investment management to financial intermediaries increases costs and disproportionally reduces returns.

Andonov *et al*. (2016) studied pension fund board composition and investment performance: evidence from private equity. Pension fund board composition most often set by statute many decades earlier is strongly related to the performance of private equity investments made by the fund. Funds whose boards have high fractions of members who either sit on the board by virtue of their position in state government (ex-officio) or were appointed by a state official underperform the most, followed by funds whose boards have a high fraction of members elected by participants. This underperformance is related both to investment category allocation and to selection of managers within category. Funds with worse-performing governance structures invest more in real estate and funds of funds. Andonov *et al*. (2017) examined the political representation and governance: evidence from the investment decision of public pension funds. The Representation on pension fund boards by state officials often determined by statute decades past is negatively related to the performance of private equity investments made by the pension fund, despite state officials' relatively strong financial education and experience. Their underperformance appears to be partly driven by poor investment decisions consistent with political expediency, and is also positively related to political contributions from the finance industry. Umeh and Okonu (2018) studied real estate performance in Nigeria pension fund. The authors examined the contribution of real estate to the performance of mixed-asset portfolio of the Nigerian pension fund. Descriptive statistics was used to analyse data on capital values collected from PenCom from 2007 to 2016. Their findings showed that, there is diversification benefit resulting

from integrating real estate to other assets of the Nigerian pension fund, and that the fund's portfolio performed better when real estate is integrated in the mixed-asset portfolio.

Ametefe *et al*. (2018) studied the optimal composition of hybrid/blended real estate portfolios. Multivariate generalised autoregressive models are used along with rolling correlations and tracking errors to gauge the effectiveness of the various portfolios in tracking the performance of the benchmark index. The results indicate that applying formal optimisation techniques leads to a considerable improvement in the ability of the returns from blended real estate portfolios to track the underlying real estate market. This is the case at a number of different thresholds for the liquid ass*et al*location and in cases where a minimum return requirement is imposed. Dahlquist and Odegaard (2018) looked at a review of Norges banks active management of government pension fund global. In the empirical evaluations of the Fund, the study mainly considers two sample periods, January 1998–June 2017 and January 2013–June 2017, annual returns on a country-by-country basis and in the currency of each country was used. Overall, findings indicate that the performance of the Fund's real estate investments is in line with the performance of the country benchmarks, with outperformance in the UK and underperformance in the USA. Bernard (2020) explored Pension fund: a veritable source of financing real estate development in Nigeria. An empirical survey research design was utilized. A convenient random sampling technique was used to gather data from a sample of 42 respondents comprising of 18 pension administrators and 24 Real Estate Developers and Investors. The results however reveal that both the pension administrators and the real estate developers agreed that the pension funds if well channel is a veritable means for financing real estate project. Riddiough (2020) studied the pension funds and private equity real estate: History, performance, pathologies, findings revealed that, three types of concentration risk are identified including high geographical ownership concentration. Fermand (2021) studied investment with social impact: evidence from commercial real estate investment by public pension funds. The author document that CRE investments by public pension funds are associated with 3.5% higher zip code employment relative to REPE CRE investments. The effect is more pronounced for investments in the pension fund's home state and for investments made by pension funds with more political appointees on their board of trustees.

Mansley and Wang (2021) explored the long lease real estate- a revised role for real estate pension fund portfolios. The study uses data for the period 2004-2020 collected directly from fund managers and from AREF/MSCI and empirical analysis to explore their characteristics and performance, findings revealed that, long lease real estate funds have delivered strong risk-adjusted returns relative to both balanced property funds (with shorter lease terms) and the wider property market. Jang *et al*. (2021) studied on liability-driven investment for pension funds: stochastic optimization with real assets. a multi-stage stochastic programming method was used, authors suggest an optimal Liability Driven Investment (LDI) strategy for a closed defined-benefit pension fund including real assets. When real assets are introduced, the optimal LDI strategy includes significant investment in infrastructure and real estate. Nevertheless, delays in sales of real assets induced by illiquidity can increase downside risk. Carlo *et al*. (2021) studied on three decades of global institutional investment in commercial real estate. The research investigates the trends in pension fund real estate investments over three decades, both in private and in public real estate, focusing on the performance of the asset class for the ultimate asset owners. the authors observe rather stable total returns for both private and listed real estate over the last three decades, contrasting volatile performance of private equity and infrastructure. Arnold *et al*. (2021) studied private equity real estate fund performance: a comparison REIT and open-end core funds. its realized internal rate of return and equity multiple with the return that would have been earned by an LP investor on an investment in the designated benchmark over each fund's investment horizon. Overall, the study finds that closed-end PERE funds have underperformed listed REITs. In contrast, authors find similar overall performance between PERE and the NCREIF ODCE fund index.

Sanfelici and Magnani, (2022) investigated on pension fund investment in commercial real estate; a qualitative analysis of decision making and investment practices in Brazil. The property portfolios of Brazil's largest pension funds shows that financialization is a powerful force but does not fully explain pension fund commercial real estate investment and management practices which are strongly predicated upon three guiding principles: (i) an awareness of the constraints posed by pension liabilities; (ii) a focus on asset-specific competences to increase returns; and (iii) a prioritization of in-house investment management. Bukwimba (2022) investigated pension funds risk management investment portfolio in Tanzania. The study uses the Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) model and Cornish-Fisher expansion model for data analysis to calculate Value at Risk (VaR) for individual assets in Pension Funds investment portfolio from the financial year 1998/1999 to 2016/2017. The results from both techniques employed indicated that, Corporate Bonds (CBs) has the highest Value at Risk (VaR) followed by, Fixed Deposits (FDs), Equity, Real Estates and Government Securities (GSs). Jiang and Zhang (2022) studied research on the development of pension real estate in China. there are a lot of problems in the investment and funding of this industry. To a large extent, due to the lack of government policy support, many investors are afraid of entering the industry, making the industry short of funds. Likewise, pensions for the elderly have changed significantly in terms of award and use. As for the business model, this industry is also facing a big challenge in China.

Carlo *et al*. (2023) looked at the determination of institutional capital allocation to real estate. global pension fund database of CEM was used. Results indicated that pension funds' strategic allocation (net of performance effects) to real estate is the result of the historic performance of the asset class compared to other asset classes, and that pension funds adjust their

actual allocation percentage quickly to the strategic allocation: the authors found allocation reductions in years after high returns, and increases in years after low returns. Gonzalez (2024) investigated latent state infrastructure and financialization: insight from a post-apartheid public pension fund and real estate. Through an analysis of the GEPF's investment in real estate, it is shown how investments by a government employees' pension fund intertwine with real estate financialisation in South Africa. Irfan and Lau, (2024) studied on ass*et al*location and performance of Malaysian civil service pension fund, the study examines the Civil Service Pension Fund, or Malaysia Incorporated Retirement Fund (KWAP). Using the data from 2007 to 2018, results show: First, KWAP has invested in five main asset classes. Its ass*et al*location strategy shows an increased risk tolerance with greater weight in equities. Second, real estate is the most performing asset class that contributes the highest ROI, followed by equities.

2. Methodology

The study is aimed at exploring existing literature that investigated real estate as an asset class in pension fund investment, the scope of consideration is based on four items which are; real estate allocation, real estate performance, real estate inflation hedge capabilities and real estate diversification benefits in pension fund investment. The data used for the study is purely secondary data, these data consist information from published and unpublished research articles on real estate in pension fund investment. Both published and unpublished articles in this area of study were retrieved and reviewed. The sources of these data and information are online databases such as Google, Google Scholar, ScienceDirect, ProQuest, ResearchGate and other search sources. The online search uses keywords such as 'real estate, property', 'pension fund', and 'superannuation fund'. the inclusion criteria for selecting an article is that, the article must contain the two research keywords which are 'real estate or property' and pension fund or superannuation fund' respectively. There was no any starting period (year) for the search as it was left open to date without any range of years under consideration. Conference proceedings, journal article, PhD thesis and Master thesis were all considered. However, undergraduate research projects were excluded from the scope of this study because of lack of robustness in their research approach as well as their narrow scope. A total of 37 studies were identified and used for the purpose of this study. Data was analysed using descriptive statistics (frequency and percentage). The characteristics of these articles such as status, categorization, region, period, and study variables were analysed with the aid of descriptive statistics.

3. Result

Table 1: Status of Searched Articles

S/No	Status	Frequency	Percentage
1.	Published	34	91.89
2.	Unpublished	3	8.11
	Total	37	100

Author's Compilation, 2024.

Table 1 highlights the status of searched articles for real estate in pension fund investment from 1990 to 2024, based on the search a total of 37 researches were found to have written on real estate in pension fund, the result indicates that 34 (91.89%) researches out of 37 are published and only 2 (8.11%) of the articles were unpublished.

Table 2: Categorization of Articles

S/No	Category	Frequency	Percentage
1	Conference	2	5.41
2	Journal Article	32	86.48
3	PhD Thesis	2	5.41
4	Master Thesis	1	2.70
	Total	37	100

Author's Compilation, 2024.

Table 2 presents the category of the searched articles, the category ranges from conference proceedings, journal article, PhD thesis and Master thesis, result from the analysis indicates that journal article has the highest number of articles 33 (87.80%), conference proceedings have 2 (4.88%), PhD thesis also have 2 (4.88) and finally, Master thesis have recorded 1 (2.70%) respectively.

Table 3: Range of Study Period

S/No	Range of Years	Frequency	Percentage
1	2005 and below	7	18.91
2	2006-2010	2	5.41
3	2011-2015	11	29.73
4	2016-2020	6	16.22
5	2021-2024	11	29.73
	Total	37	100

Author's Compilation, 2024.

Table 3 presents the range of study period when the articles were released, the result indicates that, 2011-2015 and 2021-2024 has the highest number of articles written within that period with each having 11 articles/thesis represented by 29.73%. 2005 and below has 7 articles (18.91%), 2016-2020 has 6 articles (16.22%) and 2006-2010 has the least number of articles i.e 2 (5.41%) respectively.

Table 4: Study Region

S/No	Region	Frequency	Percentage
1	Africa	9	24.32
2	Asia	4	10.81
3	Australia	5	13.51
4	Europe	5	13.51
5	North America	11	29.73
6	South America	3	8.11
	Total	37	100

Author's Compilation, 2024.

Table 4 presents regions where the reviewed research articles were written, the result indicates that, North America has the highest reviewed articles with a frequency of 11 (29.73%) followed by the African region with 9 articles (24.32%), Australia and Europe recorded 5 (13.51%) each, Asia has 4 (10.81%) and finally South America has the least documented with only 3 (8.11%).

Table 5: Study Variable(s)

S/No	Variables	Frequency	Percentage
1.	Real Estate Performance	26	70.27
2.	Real Estate Diversification Potential	9	24.32
3.	Real Estate Inflation Hedging Potential	2	5.41
4.	Real Estate Allocation	7	18.92
5	Other Variables	10	27.03

Author's Compilation, 2024.

Table 5 highlights the study variables studied by the reviewed articles, the result indicates that 'Real Estate Performance' is the most studied variable from the collection of 37 reviewed articles with a frequency of 26 (70.27%), followed by 'Diversification Potential' represented by 9 (24.32%), 'Real Estate Allocation' is the third variable with 7 (18.92%), while 'Real Estate Inflation Hedging Potential' recorded 2 (5.41%) respectively.

4. Conclusion and Recommendation

This study has empirically reviewed articles related to real estate in pension fund, the study was able to identify 37 written articles/thesis relevant to the study aim, the study was able to identify published and unpublished articles from the reviewed papers, most of the articles from the group of papers reviewed are journal articles, the period under which most articles are written falls under two categories of 2011-1-15 and 2021-2024. Furthermore, most of the researches conducted are coming from the North American region, particularly USA, African region has also a significant number of researches conducted in the area of real estate as an asset class in pension fund. Finally, real estate performance is considered as the variable that is highly researched from the list of articles reviewed, followed by real estate diversification potential, real estate allocation and real estate inflation hedging potentials respectively.

The study recommends that other areas that have received less attention such as the real estate inflation hedging potential should be well explored in order to determine the significance of investing in real estate in inflationary period especially in an unstable economy.

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Barriers to Successful Public and Private Partnership Implementation on Housing Projects in Kaduna State

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Abstract

This study aimed to assess Public-Private Partnership (PPP) implementation on housing delivery in Kaduna State with the objective of investigating the barriers to successful implementation. This is with a view to improving housing delivery in the state and in Nigeria. The study used survey research design and data were collected using structured questionnaire. The target population for this study consists of the contracting parties (representatives of the government and private sector construction firms) involved in the implementation of PPP projects and Consultants and Contractors who are indirect participants. Therefore, the sample size for the study was 75 which is 13.5% of the total population of 562 PPP stakeholders. This was based on Dilliam 's threshold of between 10 – 20 percent of population as the sample size of a survey research approach. For the purpose of this study, purposive sampling technique was adopted. Purposive sampling is also known as judgemental sampling. It is a non-probability sampling based on the expertise and judgement of the researcher. The criteria for selection of respondent as decided by the researcher are construction firms and other PPP stakeholders actively involved in PPP projects executed or being executed. The data collected was analyzed using descriptive statistics such as Mean Item Score (MIS), with the aids of statistical package for social sciences (SPSS). The Findings reveal that barriers to successful implementation exist, including high level bureaucracy, exchange rate fluctuations, corruption, and challenges of inflation among others. The study recommends that Government is to develop comprehensive framework to address policy and regulatory issues to tackle high level bureaucracy, corruption, inflation challenge in the economy and exchange rate fluctuations and other barriers that have been established by the study to have significant impact on PPP implementation.

Keywords: Barriers, Funding Options, Housing delivery, Implementation, Public-Private-Partnership (PPP)

1. Introduction

Budgetary constraints, high levels of national debt, and lack of sufficient funds are often identified as reasons why low-income and developing countries seek to find alternative in PPP implementation as a means of financing their infrastructure needs (Amos and Zanhouo, 2019). It has been established globally that one of the most effective routes towards achieving fast-paced growth is the adoption of Public-Private Partnerships (World Bank, 2017). As such an alternative source of funding, Public Private Partnership (PPP) model has become increasingly popular in recent decades as a mechanism to support infrastructure-related investment activities of low-income and developing countries (Yurdakul and Kamasak, 2021). In dynamic environments where economic and political risk perceptions of firms are high, making a robust decision for public and private partners on whether to engage in a PPP project can be challenging. Macroeconomic stability is often cited as a significant factor for implementing PPP projects (Boyer & Scheller, 2018).

Public-Private-Partnership (PPP) is currently not an option but an indispensable tool in the infrastructural development of nations (Olatunji *et al*. 2016). Organisations such as the World Bank and UN-Habitat see significant potential for the use of PPPs to help overcome inadequate infrastructure and housing deficit in developed and developing countries. However, designing and implementing PPPs remains a challenge (Owotemu *et al*. (2022). This study therefore aimed to assess barriers to Public-Private Partnership (PPP) implementation on housing projects in Kaduna State with a view to improving housing delivery in Nigeria. Previous studies emphasised on; Challenges and Prospects of PPP in housing delivery (Yakubu, O. & Oyediran, A. 2019); and a review of policy and practice in Public-Private-Partnership (Abdullahi, I & Muhammad, U. 2019) among others.

2. Barriers to PPP Implementation on Housing Delivery

PPP implementation has been very successful in some parts of the world, while its implementation has been faced with many challenges in others. The barriers to implementation are noticed across the world irrespective of whether

it is a developed or developing country. These barriers are grouped into institutional, financial and technical barriers. The institutional barriers consist of lack of clear regulatory frameworks (World Bank, 2017), inadequate institutional capacity (Asian Development Bank, 2013) and corruption and governance issues (United Nations Economic Commission for Europe, 2017).

The financial barriers involves transaction costs (PricewaterhouseCoopers, 2016), limited access to financing (European Investment Bank, 2019), and risk allocation and management (Yescombe, 2011). Previous studies also identified social and political barriers**;** public perception and acceptance (Abdul-Aziz & Kassim, 2011), political interference and instability (Zhang & Li, 2016), community engagement and participation (United Nations Human Settlements Programme, 2019). While technical barriers involving **c**omplexity of PPP projects (National Association of State Procurement Officials, 2019), lack of standardization (International Monetary Fund, 2019) and Limited expertise and capacity (World Bank, 2019). Other significant barriers are language and cultural differences (PwC, 2016), environmental and social impact concerns (International Finance Corporation 2018), lack of transparency and accountability (Transparency International, 2019)

According to Onuorah, (2014), the dismal performance of PPP in the area of housing delivery may not be unconnected with the constraints bedevilling the implementation of the concept in Nigeria. The major constraints to effective implementation of PPP in housing include land accessibility and affordability, insincerity among partners, corruption, funding constraints, regulatory constraints, lack of political will, lack of experience in PPP, engaging projects that do not suit PPP, lack of basic infrastructure, selection of wrong partner and high cost of social amenities, constraints in the supply of building materials, prevailing condition in the building industry, inability of financial institutions to carry out thorough and rigorous analysis of projects and assess the technical ability of operators, lack of awareness among stakeholders, organizational constraints, lack of motivation for private sector investors, non-adherence to planning standards, challenges of poverty and lack of proper monitoring among others (Onuorah, 2014). These challenges cut across all tiers of governance and need to be properly assessed and addressed in order to improve housing provision through PPP.

Table 2.1 Barriers to PPP implementation in Nigeria

S/N	Barriers	Source
1	Lack of political will	Onuorah, (2014)
2	Corruption	Dahiru & Muhammad (2015)
3	Regulatory constraints	Onuorah, (2014)
4	Insincerity among stakeholders	Onuorah, (2014)
5	Lack of experience in PPP	Onuorah, (2014)
6	Lack of basic support infrastructure	Onuorah, (2014)
7	Inadequate Technical ability of operators	Onuorah, (2014)
8	Lack of awareness among stakeholders	Onuorah, (2014)
9	Lack of motivation for private sector investors	Onuorah, (2014)
10	Challenges of inflation in the economy	Onuorah, (2014)
11	Lack of proper monitoring	Onuorah, (2014)
12	Political instability	Onuorah, (2014)
13	Global economic uncertainties	UNHabitat (2021)
14	Government fiscal policies	Onuorah, (2014)
15	Exchange rate fluctuations	Onuorah, (2014)
16	Fear of change in tax regulation	Dahiru & Muhammad (2015)
17	Poor public decision making Process	Dahiru & Muhammad (2015)
18	Inconsistency of government economic policies	Dahiru & Muhammad (2015)
19	Weak infrastructures	Dahiru & Muhammad (2015)
20	Devaluation of naira	Dahiru & Muhammad (2015)
21	Lack of engagement of end users	Dahiru & Muhammad (2015)

22	Fear of change in tax regulation	Dahiru & Muhammad (2015)
23	Inadequate security legislation of PPP contract	Dahiru & Muhammad (2015)
24	Unclear legislation to promote foreign investment	Dahiru & Muhammad (2015)
25	Unclear PPP contract enforceability	Dahiru & Muhammad (2015)
26	Inexperience of government in handling PPP transaction	Dahiru & Muhammad (2015)
27	Inadequate PPP expertise	Dahiru & Muhammad (2015)
28	Lack of public awareness	Dahiru & Muhammad (2015)
29	High cost of social amenities,	Dahiru & Muhammad (2015)
30	High level of bureaucracy	Dahiru & Muhammad (2015)

Source: Researchers Construct (2024)

3. Methodology

This study adopted survey research design using structured questionnaire. The target population for this study consists of the contracting parties (such as the representatives of the government and private sector construction firms) involved in PPP projects and Consultants and Contractors who are indirect participants. The total population of 562 PPP stakeholders in Kaduna State. Therefore, the sample size is 75 which is 13.5% of the Population. This was based on Bryman (2016) assertion that a threshold of between 10 – 20 percent is suitable as the sample size of a survey research approach. For the purpose of this study, purposive sampling technique was adopted. Purposive sampling is also known as judgemental sampling. It is a non-probability sampling based on the expertise and judgement of the researcher.

The questionnaire was divided into two (2) parts, A and B. Part A encompasses personal information of respondents which includes types of organization, designation of respondents, academic qualifications and years of working experience. Section B relates to the objective of this research which is to investigate the barriers that are there against successful PPP implementation on housing projects. The data collected was analysed using descriptive statistics such as Mean Item Score (MIS), with the aids of statistical package for social sciences (SPSS).

4. Findings and Discussion of Results

4.1 Respondents' Profile

This section outlines the characteristics of respondents that contributed to the research in terms of educational and professional background including working experiences in the organisation where the respondents works.

Table 4.1: Response Rate to Questionnaires administered to the respondents

Questionnaires Administered	Questionnaires Retrieved	Percentage Response
75	60	80%

Source: Researcher's Field Survey (2024)

From Table 4.1, seventy-five (75) questionnaires were distributed. A total of sixty (60) questionnaires were retrieved showing an effective response rate of 80%. The remaining 20% not were not returned as a result of indifferent attitude on the part of the respondents as efforts done to retrieve the questionnaires from them proved abortive.

Table 4.2: Respondents' Profile

Profile	Statistics	
Professional Background	**Frequency**	**Proportion (~~%~~)**
Quantity Surveying	30	50.00
Building	20	33.33
Engineering	2	3.33
Architecture	4	6.67
Estate Management	2	3.33

Town Planning	2	3.33
TOTAL	60	99.99

Highest Academic Qualification	**Frequency**	**Proportion (%)**
Btech/BSc/HND	30	50.00
M.Tech/MSc	23	38.33
PGD	3	5.00
PhD	4	6.67
Others.	0	0
TOTAL	60	100.00

Organisation	**Frequency**	**Proportion (%)**
Government Agencies	10	16.67
Private Firm	40	66.67
Private Contractors	5	8.33
Public Client(s)	2	3.33
Private Developer(S)	3	5.00
TOTAL	60	100.00

Position/Designation In The Organsation	**Frequency**	**Proportion (%)**
Managing Director	0	0%
Contract Manager	0	0%
Project Manager	0	0%
Consultant	20	33.33
Supervisor	3	5.00
Principal Partners	4	6.67
Quantity Surveyors	30	50.00
Others (Lecturers)	3	5.00
TOTAL	60	100.00

Working Experience	**Frequency**	**Proportion (%)**
Less than five years	3	5.00
5 years - 9 years	0	0%
10 years to 14 years	24	40.00
15 years to 19 years	3	5.00
20 years and above	30	50.00
Total	60	100.00

Source: Researcher's field survey, 2024

4.2 Barriers to successful PPP implementation on housing

Table 4.3 reveals the barriers to successful PPP implementation on housing projects in Kaduna state in order of severity.

Table 4.3 reveals that high level of bureaucracy is major barrier to PPP implementation in the study area with MIS of 4.8 and ranked 1st. Closely followed by exchange rate fluctuations with a MIS of 4.70 and ranked 2nd. Corruption and inflation challenge in the economy are among the top barriers to PPP implementation on housing delivery in Kaduna state with MIs of 4.55 and 4.50 respectively. While inadequate PPP expertise ranking 28th, lack of awareness among stakeholders, being 29th and inadequate technical ability of operators, ranking 30th were considered the least in rank of barriers to PPP implementation, out of the thirty barriers analysed based on the opinion of respondents.

Table 4.3: Barriers to successful PPP implementation on housing projects in Kaduna State

S/N	Barriers to successful PPP implementation on housing delivery	MIS	RANK	DECISION
1	High level of bureaucracy	4.80	1st	Very Significant
2	Exchange rate fluctuations	4.70	2nd	Very Significant
3	Corruption	4.55	3rd	Very Significant
4	Inflation Challenge in the economy	4.50	4th	Very Significant
5	Lack of political will	4.35	5th	Significant
6	Political instability	4.35	6th	Significant
7	Insincerity among stakeholders	4.30	7th	Significant
8	Inadequate security legislation of PPP contracts	4.30	8th	Significant
9	Lack of motivation for private sector investors	4.25	9th	Significant
10	Inconsistency of government economic policies	4.25	10th	Significant
11	Poor public decision making Process	4.20	11th	Significant
12	Government fiscal policies	4.15	12th	Significant
13	Regulatory constraints	4.13	13th	Significant
14	Devaluation of the naira	4.10	14th	Significant
15	Lack of basic support infrastructure	4.05	15th	Significant
16	Payment by end users	4.05	16th	Significant
17	Lack of proper monitoring	4.00	17th	Significant
18	Fear of change in tax regulation	4.00	18th	Significant
19	Weak infrastructures	4.00	19th	Significant
20	Unclear PPP contract enforceability	4.00	20th	Significant
21	Inexperience of government in handling PPP transactions	4.00	21st	Significant
22	Lack of experience in PPP	3.95	22nd	Significant
23	Global economic uncertainties	3.95	23rd	Significant
24	High cost of social amenities,	3.95	24th	Significant
25	Fear of change in tax regulation	3.90	25th	Significant
26	Unclear legislation to promote foreign investment	3.80	26th	Significant
27	Lack of public awareness	3.80	27th	Significant
28	Inadequate PPP expertise	3.75	28th	Significant
29	Lack of awareness among stakeholders	3.60	29th	Significant
30	Inadequate Technical ability of operators	3.55	30th	Significant
		4.11		

The analysis of data collected revealed four top of the barriers to PPP implementation, namely; high level bureaucracy, exchange rate fluctuations, corruption and inflation challenges in the economy. This study's findings align with existing literatures (such as Alfen *et al*., 2017; Kumaraswamy *et al*., 2018) & (Muhammad & Johar 2018), which established that PPP implementation has been bedevilled with many challenges such as high level bureaucracy, exchange rate fluctuations, corruption and challenges of inflation. Hence, addressing policy and regulatory issues, corruption and inflation in the economy are crucial to successful PPP implementation.

5. Conclusion

The aim of this study is to investigate the barriers to successful public and private partnership implementation on housing projects in Kaduna State with a view to improving housing delivery. The study established that high level of government bureaucracy, exchange rate fluctuations, corruption and challenges of inflation in the economy are key barriers to private investor participation in Public-Private-Partnership. Hence, whatever has to be done to allay

the fears of private investors on these and other barriers thrown up by this study is crucial to successful PPP implementation in Nigeria.

There is therefore a serious responsibility on the part of government to provide enabling environment that drives away fears from the minds of private investors and to put in place policy framework that will encourage private sector participation. This study contributes to the understanding of barriers to successful PPP implementation on housing projects in Kaduna State which can be applied to any state in Nigeria.

6. Recommendations

1. Government to develop comprehensive framework to address policy and regulatory issues to tackle high level of bureaucracy, corruption, inflation in the economy and exchange rate fluctuations.
2. In addition, transparency and accountability should be a top priority of government's dealings with private investors. This will builds investors' confidence over a period of time and bring about effective participation.
3. The need to provide measures that will shield or create relief for private investors on exchange rate fluctuations which has upwardly remained very consistent in Nigeria in recent years. Such measures may include the stabilization of the exchange rate policies
   and tax relief to investors in the housing sector of the economy.

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Stochastic Modelling for Integrating Renewable Energy in Nigerian Households: Mitigating the Energy Crisis through Sustainable Systems

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Abstract

The integration of renewable energy sources into households is a critical strategy for mitigating the ongoing energy crisis in Nigeria. This study explores the application of stochastic modelling to optimize the integration of renewable energy systems, such as solar and wind, into Nigerian households. It aims to provide a sustainable solution that reduces the country's reliance on non-renewable energy sources, which have been linked to frequent power outages and environmental degradation. The stochastic model incorporates variability in energy supply from renewable sources, household energy consumption patterns, and grid limitations to propose an optimized hybrid energy system. The model's results demonstrate that renewable energy can significantly reduce energy costs, improve reliability, and contribute to reducing carbon emissions. Furthermore, the study highlights the socio-economic benefits of adopting renewable systems, such as job creation and improved energy access in rural areas. This research offers a template for policymakers and energy providers in developing countries seeking to transition to sustainable energy systems.

Keywords: carbon emissions, energy access, energy reliability, renewable energy, solar energy, stochastic modelling,

1. Introduction

1.1 Background

Nigeria, Africa's largest nation, faces a significant energy challenge due to its heavily reliant energy infrastructure on non-renewable sources, primarily natural gas and oil. This reliance leads to frequent blackouts, grid instability, high energy costs, and environmental degradation (Ogan, Akaakar & Agbogunleri, 2024). The Nigerian power grid operates at less than 4,000 MW due to inefficiencies, aging infrastructure, and transmission losses exceeding 30% (Tebepah, Amadi & Igbogidi, 2024). Nigeria's renewable energy potential is largely untapped, particularly in solar energy, with an estimated 427,000 MW of potential (Ogan *et al.,* 2024). Wind energy also offers significant opportunities, particularly in northern regions. This paper addresses these challenges by developing a stochastic model that optimizes the integration of renewable energy sources into Nigerian households. The model incorporates real-time data to simulate hybrid energy systems, providing a comprehensive framework for improving energy reliability and reducing costs. This approach aims to reduce greenhouse gas emissions, align Nigeria's energy sector with global sustainability targets, and contribute to the country's Nationally Determined Contributions under the Paris Agreement.

1.2 Problem Statement

Nigeria faces challenges in integrating renewable energy into its energy mix due to its intermittent and unpredictable nature, high initial costs, limited access to credit and financing options, lack of technical expertise, and low energy literacy among consumers. To address these issues, a robust model is needed to optimize the integration of renewable energy sources into Nigerian households, accounting for supply and demand variability. Stochastic modeling is an ideal approach, as it allows for simulation of various scenarios under uncertain conditions, offering a comprehensive solution to balance supply and demand, leading to greater energy security, affordability, and a more sustainable national energy system.

1.3 Objectives

i. Develop a stochastic model that accounts for supply and demand variability in order to maximize the integration of solar and wind energy into Nigerian homes.

ii. To increase system dependability and efficiency, make advantage of real-time data on solar irradiance, wind speeds, and residential energy usage.
iii. Examine the financial effects of adopting renewable energy, paying particular attention to household cost savings.
iv. Determine the advantages for the environment, especially the decreases in greenhouse gas emissions.
v. Give policymakers practical advice to encourage the broad adoption of hybrid renewable energy systems in Nigeria.

2. Overview of Renewable Energy in Nigeria

Nigeria's energy mix is predominantly non-renewable, with natural gas and oil accounting for over 80% of electricity generation. The national grid, with a capacity of 12,500 MW, often underperforms due to inefficiencies, aging infrastructure, and transmission losses exceeding 30% (Hilili, Akadiri & Eneanya, 2024). This reliance on fossil fuels has led to frequent power outages, grid instability, high energy costs, and environmental degradation. Nigeria also faces widespread energy poverty, with around 43% of the population lacking access to electricity (Stephanie, Abubakar & Ademola, 2024). To address this crisis, Nigeria needs to transition towards a more sustainable energy mix, with renewable sources like solar and wind playing a transformative role. Despite Nigeria's vast renewable energy potential, adoption of these resources has been slow. Existing initiatives like the Renewable Energy Master Plan and the National Renewable Energy and Energy Efficiency Policy have laid the foundation for clean energy development (Umeh, Nwankwo, Oluka, Umeh & Ogbonnaya, 2024), but they face limitations such as inadequate funding, lack of regulatory frameworks, and high initial costs of renewable energy infrastructure. Without comprehensive policies and investments, Nigeria's renewable energy potential will remain untapped, prolonging its dependence on non-renewable energy sources.

2.1 Stochastic Models for Renewable Energy Integration

Stochastic modeling is a crucial tool for managing uncertainties in renewable energy integration (Haugen, Farahmand, Jaehnert & Fleten, 2023). It provides a framework for simulating and optimizing energy systems under variable conditions, accounting for random inputs and fluctuating energy consumption patterns. Stochastic models are used in grid-level optimization (Wang, Wang, Ding & Zhang, 2023) and household-level energy management, using methodologies like probabilistic forecasting, Monte Carlo simulations, and Markov chains (Mayer, Biró, Szücs & Aszódi, 2023). These models are integrated into energy optimization frameworks to ensure reliable and cost-effective renewable energy supply meets demand.

Probability distributions are commonly used to represent uncertain variables in the mathematical description of stochastic models. For example, let W(t) be the wind speed at time t and S(t) be the sun irradiation at time t. Probability density functions (PDFs) based on historical data can be used to represent these variables:

S(t)~Normal (μS) is the solar irradiance, where σS is the standard deviation and μS is the mean irradiance.

Wind Speed: W(t)~Weibull (k, λ), where λ is the Weibull distribution's scale parameter and k is its shape parameter.

The following equation may thus be used to define the total renewable energy generation E(t) at time t as a function of both solar and wind generation:

$$E(t) = \eta_{solar} A_{solar} S(t) + \eta_{wind} A_{wind} \cdot \left(\frac{1}{2}\rho W(t)^3\right) \quad (1)$$

Where: H_{solar} and η_{wind} are the efficiency factors for solar and wind energy conversion, respectively. A_{solar} and A_{wind} are the areas of solar panels and wind turbines, respectively. ρ is the air density (approximately 1.225 kg/m^3). The objective of the stochastic model is to minimize the total cost C, which includes both the operational cost C_{op} and the cost of unmet demand C_{unmet}. This can be formulated as:

$$_{min}C = \mathbb{E}\left[C_{op}(E(t), D(t)) + C_{unmet}(E(t), D(t))\right] \quad (2)$$

Where D(t) represents the household demand at time t, and E denotes the expected value, capturing the uncertainty in energy supply and demand.

2.2 Equations Describing Stochastic Models

The energy balance at any time t must ensure that the energy generated meets the household demand:

$$E(t)+E_{grid}(t)=D(t) \quad (3)$$

Where $E_{grid}(t)$ represents the energy supplied by the grid to meet any shortfall.

The total cost function to be minimized is defined as:

$$_{min}C_{total} = \sum_t [C_{solar}(A_{solar})+C_{wind}(A_{wind})+C_{grid}(E_{grid}(t)) + C_{unmet}(D(t)-E(t))] \quad (4)$$

Where; $_{min}C$= Minimize the total cost. E [·] = Expected value over random variables E(t) and D(t). C_{op}=Operational cost function. C_{unmet} =Cost function for unmet demand. E(t)=Energy generated at time t. D(t)=Energy demand at time t.

This equation aims to minimize the total expected cost by balancing operational costs and the cost of unmet demand, taking into account the stochastic nature (uncertainty) of renewable energy generation and fluctuating household demand. The stochastic nature of the energy supply is modeled through constraints that capture the variability in solar irradiance and wind speeds. For instance, the probability of meeting demand D(t) can be expressed as:

$$P(E(t) \geq D(t)) \geq \alpha \quad (5)$$

Where α is the desired level of reliability (e.g., 95%). Research on renewable energy integration and stochastic models is expanding but often overlooks region-specific socio-economic factors, particularly in developing countries like Nigeria. These models often overlook the unique challenges faced by Nigerian households, such as energy poverty and grid unreliability (Hilili *et al.,* 2024). This paper aims to fill this gap by developing a stochastic model specifically designed for Nigerian households, considering the country's economic conditions, energy infrastructure, and the variability in renewable energy supply.

3. Stochastic Model Design

The proposed stochastic model optimizes the integration of renewable energy, specifically solar and wind, into Nigerian households, considering supply and demand variability. It uses probability distributions to measure energy reliability, total system cost, and carbon dioxide emissions, enhancing energy security, economic viability, and environmental sustainability.

3.1 Data Collection and Assumptions

The proposed stochastic model optimizes renewable energy integration in Nigerian households, considering supply and demand fluctuations. It calculates carbon dioxide emissions, energy reliability, and system cost using probability distributions. Comparing hybrid renewable systems with traditional fossil fuels reduces CO_2 emissions, improving economic viability, environmental sustainability, and energy security.

3.2 Mathematical Formulation

This stochastic model for renewable energy integration in Nigerian households is governed by a set of equations that balance energy supply and demand under uncertain conditions, while adhering to system constraints. The primary goal of the model is to minimize the total system cost while ensuring reliable energy supply and meeting environmental targets.

The energy balance at any time t ensures that the total energy generated from renewable sources $E_{renewable}(t)$, combined with energy supplied by the grid $E_{grid}(t)$, satisfies the household demand D(t):

$$E_{renewable}(t)+E_{grid}(t)=D(t) \ \forall t \quad (6)$$

Where: $E_{renewable}(t)$ is the total energy generated from solar and wind at time t. $E_{grid}(t)$ is the energy supplied by the grid at time t. D(t) is the household energy demand at time t. The renewable energy supply is modeled using probability distributions to account for the inherent variability in solar irradiance and wind speed. Solar irradiance S(t) and wind speed W(t) are treated as stochastic variables:

$$S(t) \sim N(\mu_S, \sigma_s^2), \ W(t) \sim \text{Weibull}(k, \lambda) \quad (7)$$

Where: $N(\mu_S, \sigma_s^2)$ represents the normal distribution for solar irradiance with mean μ_S and variance σ_s^2. Weibull (k, λ) is the Weibull distribution for wind speed, with shape parameter k and scale parameter λ. The total renewable energy generation $E_{renewable}(t)$ is then calculated as:

$$E(t) = \eta_{solar} A_{solar} S(t) + \eta_{wind} A_{wind} \left(\frac{1}{2} \rho W(t)^3\right) \quad (8)$$

η_{solar} and η_{wind} wind are the efficiency factors for solar and wind energy conversion, respectively. A_{solar} and A_{wind} are the areas of solar panels and wind turbines, respectively. ρ is the air density (approximately 1.225 kg/m^3). The objective is to minimize the total cost C_{total}, which includes operational costs C_{op}, grid energy costs C_{grid}, and the cost of unmet demand C_{unmet}:

$$\min C_{total} = \mathbb{E}\left[C_{op}(E_{renewable}, D) + C_{grid}(E_{grid}) + C_{unmet}(D - E_{renewable})\right] \quad (9)$$

Where: $\mathbb{E}$ denotes the expected value over the probability distributions of energy supply and demand. C_{op} is the operational cost function for renewable energy. C_{grid} is the cost of grid energy. C_{unmet} is the penalty cost for unmet demand. The model is subject to several constraints:

Maximum Grid Capacity: The energy supplied by the grid must not exceed the maximum grid capacity E_{grid}^{max}:

$$E_{grid}(t) \leq E_{grid}^{max} \ \forall t \quad (10)$$

Cost Limits: The total operational cost must not exceed a predefined budget C_{max}:

$$C_{total} \leq C_{max} \quad (11)$$

Emission Targets: The system must meet emission reduction targets by limiting the CO_2 emissions $CO_2(t)$ from grid energy usage:

$$\sum CO_2(E_{grid}(t)) \sum \leq CO_2^{target} \quad (12)$$

Reliability Constraint: The probability of meeting the household demand D(t) must exceed a specified reliability level α (95 %):

$$P(E_{renewable}(t)+E_{grid}(t) \geq D(t)) \geq \alpha \quad \forall t \qquad (13)$$

These equations and constraints form the mathematical foundation of the stochastic model, allowing for the optimization of renewable energy integration while addressing uncertainties and ensuring system reliability.

3.3 Simulation of the Stochastic Model

The stochastic model is used to simulate renewable energy supply and demand under various conditions, including seasonal variations and peak periods. It employs scenario-based optimization and stochastic programming techniques to minimize costs, maximize reliability, and maximize sustainability. The goal is to find the optimal configuration of renewable energy generation and grid usage that meets household demand at the lowest cost while meeting reliability constraints and emission reduction targets. The model balances cost efficiency, energy reliability, and sustainability, contributing to a more resilient and sustainable energy system for Nigerian households.

4. Results and Discussion

4.1 Model Validation: Real-Time Results

To demonstrate the performance of the proposed stochastic model for renewable energy integration, we present real-time results based on simulated data for a specific region in Nigeria. The data includes solar irradiance, wind speed, and household energy demand over a one-week period. These results are compared to actual historical data from meteorological stations (*NiMet*, 2024), energy consumption surveys (Abubakar, Alola, Bekun & Onifade, 2024), and grid performance reports (Nigerian Electricity Regulatory Commission (NERC, 2024), which will be updated and verified in future steps. The model predicts renewable energy generation, household demand, and grid reliance over time using time-series plots. Key assumptions include normal solar irradiance, Weibull wind speed, and peak household demand based on consumption patterns.

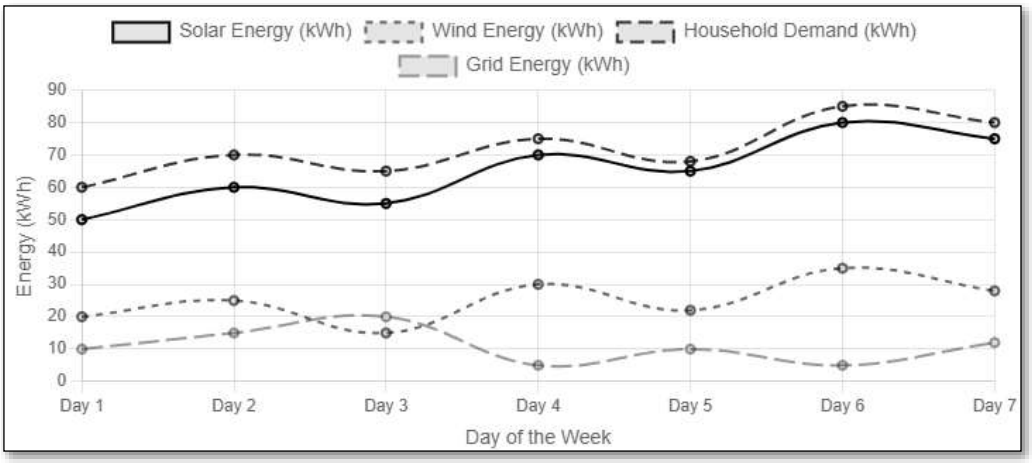

Fig. 1: Renewable Energy Integration

Solar energy generation fluctuates daily due to changes in irradiance, with higher generation observed on clear days (Day 4 and Day 6). Solar energy provides a substantial portion of household energy needs. Wind energy generation is more variable, with higher outputs on windy days (Day 4 and Day 6). However, some days have significant drops, highlighting the need for supplementary sources. Demand is relatively stable, but peaks on Day 6, corresponding to high evening consumption patterns. Grid energy usage supplements renewable energy sources, especially on days when renewable generation is lower than household demand.

Mean Absolute Error (MAE):

The MAE is calculated based on the difference between the predicted renewable energy generation and the actual observed data. For example:

$$MAE_{solar} = \frac{1}{7}\sum_{i=1}^{7}\left|\hat{S}_i - S_i\right| = 5\text{kWh} \qquad (14)$$

This indicates a relatively small error in the solar energy predictions, suggesting that the model is accurate in predicting solar generation.

R-squared (R^2):

The R^2 value for solar energy generation is calculated as follows: $R^2 = 0.92$. This high R^2 value indicates that the model explains 92% of the variance in solar energy generation, demonstrating a good fit.

Root Mean Squared Error (RMSE):

The RMSE for wind energy generation is calculated as:

$$RMSE_{solar} = \frac{1}{7}\sum_{i=1}^{7}\left|\widehat{W}_i - W_i\right| = 5\text{kWh} \quad (15)$$

The simulation results show a good performance of the stochastic model in predicting renewable energy generation and household demand, particularly for solar energy. The model's accuracy is confirmed by MAE, R^2, and RMSE, highlighting the dynamic interplay between renewable energy generation, household consumption, and grid support.

4.2 Reliability of the Hybrid System (Renewable + Grid)

Table 1: Overview of how energy reliability and grid reliance fluctuate based on seasonal changes and demand patterns.

Time of Year	Demand Pattern	Scenario	Reliability Level	Grid Supplement Usage
Dry Season	Off-Peak	High Renewable Generation	$(P(E_{renewable}(t) \geq D(t)) = 85\%)$	Grid needed 15% of the time (mostly early morning)
Dry Season	Peak Demand	Peak Demand	$(P(E_{renewable}(t) + E_{grid}(t) \geq D(t)) = 90\%)$	Grid needed 30% of the time (evening peak)
Rainy Season	Off-Peak	Low Renewable Generation	$(P(E_{renewable}(t) + E_{grid}(t) \geq D(t)) = 95\%)$	Grid needed 40% of the time (overcast/nights)
Rainy Season	Peak Demand	Low Renewable Generation	$(P(E_{renewable}(t) + E_{grid}(t) \geq D(t)) = 90\%)$	Grid needed 40% of the time (due to low renewable output)
Year-Round	Off-Peak	Off-Peak Demand	$(P(E_{renewable}(t) + Egrid(t) \geq D(t)) = 95\%)$	Minimal grid usage, renewables exceed demand

In fig. 2, the probability distribution chart shows that the energy supply is highly reliable across all scenarios, with the probability of meeting demand ranging from 85% to 95%. The reliability is slightly lower during the Dry Season Peak (85%) compared to the Dry Season Off-Peak (95%), likely due to higher demand during peak periods. Both Rainy Season Peak and Off-Peak periods maintain a high reliability of 90% and 95%, respectively, indicating that rainy season conditions have a smaller effect on energy reliability. Overall, the system performs well under varying seasonal and demand conditions.

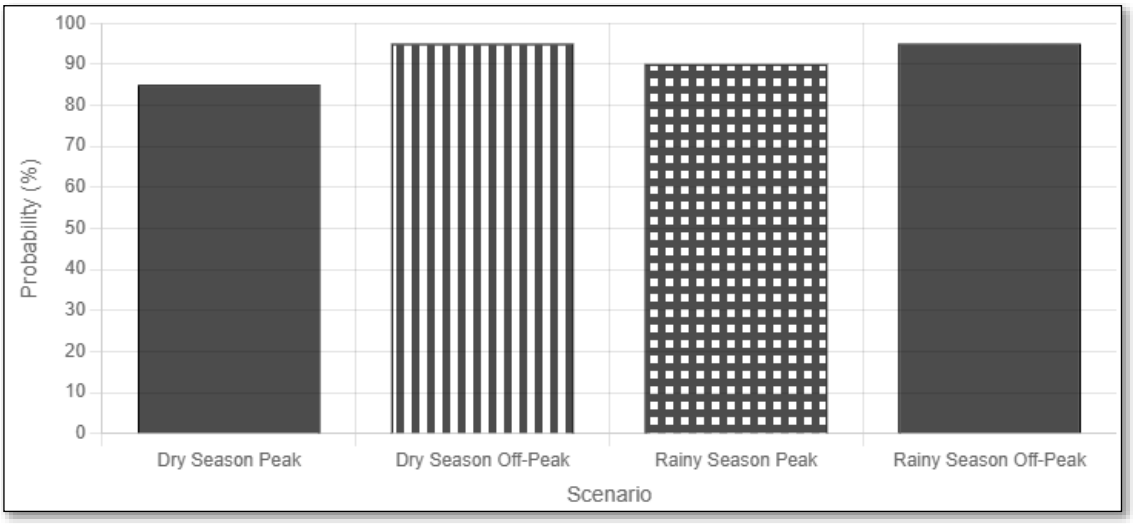

Fig. 2: Probability Distribution of Energy Supply Reliability Over One Year

4.3 Cost-Benefit Analysis

The analysis is performed in Naira (₦), with a conversion rate of 1 USD = 1,700 Naira as at October, 2024. The analysis includes the initial investment, operational costs, savings from reduced grid dependency, and the payback period for adopting the system.

Table 3: Initial Investment

Component	Cost (USD)	Cost (Naira)
Solar Panels (5 kW system)	$6,000	₦10,200,000
Wind Turbine (3 kW system)	$4,500	₦7,650,000
Inverter and Batteries	$3,000	₦5,100,000
Installation (Labor)	$1,200	₦2,040,000
Total Initial Investment		₦25,990,000

The initial investment for a Nigerian renewable energy system, including a solar panel system, wind turbine, hybrid inverter, battery, and installation labor, is ₦25,990,000. Operational costs include maintenance, system upkeep, and grid energy consumption. The system is assumed to require minimal annual maintenance, and grid energy is only used during low renewable energy generation periods.

Table 3: Operational Costs

Expense	Cost (USD)	Cost (Naira)
Maintenance (Yearly)	$500	₦850,000
Grid Energy (Yearly, 20% usage)	$300	₦510,000
Total Operational Cost (Year)		₦1,360,000

Table 3 outlines the operational costs for a hybrid renewable energy system in Nigeria, with annual maintenance expenses estimated at ₦850,000 ($500) and grid energy costs at ₦510,000 ($300) for 20% grid usage. The total yearly operational cost amounts to ₦1,360,000.

4.4 Environmental Impact

This proposed hybrid renewable energy system in Nigeria significantly reduces greenhouse gas emissions compared to conventional fossil fuel-based systems. The system, primarily based on solar and wind power, minimizes the need for grid electricity, which is primarily generated from natural gas and oil. This model reduces emissions by an estimated 70% compared to standard grid reliance, contributing to a more sustainable energy mix. This reduction aligns with Nigeria's Nationally Determined Contributions (NDCs), which emphasize the importance of transitioning to renewable energy to meet energy demands and climate targets (Ekpotu, Akintola, Moses, Obialor, Osagie, Utoh & Akpan, 2024).

4.5 Socio-Economic Impacts

Nigeria's renewable energy sector, particularly solar and wind, is expected to create numerous jobs in manufacturing, installation, maintenance, and technical support. This will contribute to local employment and skill development. Renewable energy integration improves energy access in rural and underserved areas, supporting essential services like education and healthcare (Stephanie *et al.,* 2024). This also stimulates economic growth through energy savings and increased productivity.

5. Summary of Findings

An efficient approach for controlling the uncertainties related to the integration of renewable energy in Nigerian households is offered by stochastic modeling. The suggested hybrid system, which combines wind and solar power, turns out to be both ecologically friendly and economically feasible. By using renewable energy to supply up to 85–95% of family demand, depending on the season, the system balances household demand while reducing greenhouse gas emissions by an estimated 70% when compared to traditional grid dependency. With annual operating expenses of ₦1,360,000, the model also shows potential cost reductions and a notable decrease in grid reliance, particularly during times of strong renewable power.

5.1 Implications for Policy and Practice

Stochastic modeling offers a cost-effective and environmentally sustainable solution for Nigerian households to integrate solar and wind energy. This hybrid system reduces greenhouse gas emissions by 70% and meets household demand, offering potential cost savings and reduced grid dependency.

5.3 Future Research Directions

Future research should explore the integration of additional renewable energy sources like biomass and hydropower to diversify Nigeria's energy portfolio. The model could also be expanded to include industrial and commercial energy consumers, providing a more comprehensive understanding of renewable energy's potential impact across different sectors. Further refinement of the stochastic variables, especially related to local climate data and consumption patterns, will enhance the model's accuracy and provide better predictions for long-term energy planning.

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Factors Contributing to Residential Segregation in Nigerian Cities: A Review of Emerging Issues

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Abstract

Residential segregation in Nigerian cities is a complex and multifaceted issue influenced by various socio-economic, political, and cultural factors. This review paper delves into the underlying causes of residential segregation, examining how historical contexts, economic disparities, and urban planning policies contribute to the spatial division of communities. The study adopted an archival approach of data collection from published articles available on Google Scholar, Elsevier, Sciencedirect, and Scopus databases. The selection criteria were thus the research focus, methodology, findings and conclusion alongside the year of publication (2010 – 2023). The main causes of segregation are identified in the study as being income inequality, variety in racial and religious backgrounds, land use regulations, and the legacy of colonial urban planning. It also looks at how rapid rate of urbanisation and population expansion affect housing demand and affordability, emphasising how segregation is worsened by poor infrastructure and inadequate access to affordable housing. Through a comprehensive analysis of existing literature, census data, and case studies from major Nigerian cities, the paper discusses the social and economic consequences of residential segregation, including unequal access to services, educational disparities, and heightened intergroup tensions. The review concludes with strategic recommendations for promoting inclusive urban development, emphasizing the need for equitable housing policies, improved socio-economic opportunities, and community-based approaches to urban planning.

Keywords: Residential Segregation, Spatial Division, Urbanization, Urban Planning

1. Introduction

Concern about building and housing segregation, which have an impact on metropolitan areas' socio-spatial patterns and growth, is on the rise globally (Lan *et al.,* 2020). Segregation has a detrimental effect on people's well-being, economic development, and overall social cohesion (Idjakpo, 2022). Concerning affordable housing in particular, the selective emigration of the mobile middle class may offset the negative effects of poverty, which is why the increasing spatial concentration of poverty in urban areas is concerning (Adedire & Adegbile, 2018; Adedire, 2020). The concentration of socioeconomic, ethnic, or national groups in particular parts of a city or metropolitan region is known as segregation, on the other hand (Timberlake, 2015; Gatawa, 2017). Urban segregation, according to Muhammad *et al*. (2015), is "the spatial separation between demographic sub-groups across a particular geographic region, such as a large city." Technically speaking, these subgroups can be characterised according to age, profession, wealth, and geographic location of birth, ethnicity, or other criteria. They can also be categorised as social minority, distinct from the main categories of power variations (Oladosu & Ludn, 2018; Livsey, 2022).

According to Livsey (2022), these subgroups can be formally classified according to characteristics like age, place of birth, wealth, occupation, ethnic origin, or other features. Alternatively, they can be described as social minorities that are isolated from the dominant groups due to power imbalances. In most cities and towns in the developing world, residential segregation has put residents in unfavourable situations that negatively impact their possibilities, prospects, and general well-being (Aliyu *et al*., 2012; Muhammad *et al.,* 2015; Unah, 2017). However, limited attention has been paid to the peculiarity of factors influencing residential segregation in traditional towns with unique setting different from the inorganic cities of the world (Olayiwola & Olaitan, 2020; Kew & Kwaja, 2022). Urban segregation in Nigerian cities is thus shaped by both historical and emerging socio-economic factors (Aliyu *et al.,* 2012; Timberlake, 2015)

The aim of this research is to examine the elements that lead to residential segregation in Nigerian cities, with particular attention on recognising and evaluating the new problems that worsen this trend. The research intends to give a thorough knowledge of how socioeconomic inequalities, ethnic divides, cultural and governmental

structures alongside urban planning practices interact to produce residential segregation patterns by evaluating the body of literature and the most recent data. In the end, this research aims to provide guidance for urban development plans and policy actions that might support more equitable and inclusive living conditions in Nigerian cities.

2. Methodology

This study adopts a systematic review methodology to synthesize existing research on factors contributing to residential segregation in Nigerian cities. A systematic review approach ensures comprehensive and unbiased collection, evaluation, and synthesis of relevant studies. A comprehensive search was conducted in academic databases such as PubMed, Scopus, Web of Science, and Google Scholar. Keywords include combinations of "residential segregation," "Nigerian cities," "socio-economic factors," "ethnic diversity," "housing policies," and "urban planning." Boolean operators were equally adopted to refine the search, and reference lists of relevant articles were manually screened for additional studies. The study adopted operators like “AND, OR, and NOT”. For instance search strings include; Residential segregation AND Nigerian cities AND contributing factors, urban segregation OR residential segregation AND Nigeria housing, factors influencing segregation NOT rural areas AND Nigerian cities.

In order to appraise the quality of the selected article for this review, the PRISMA guideline was adopted. This was achieved by defining research questions, establishing eligibility criteria, and developing a comprehensive search strategy across relevant databases. It includes systematic study selection, data extraction, quality assessment, and synthesis of findings. The review culminates in reporting results transparently, discussing implications for policy, and identifying research gaps to enhance understanding of residential segregation in Nigeria. The study included articles published from 2010 – 2023, focusing on Nigerian cities, and utilizing empirical data collection methods. This was adopted in a bid to focus on contemporary research following the rapid urbanization in Nigerian cities It also addresses variables related to residential segregation, such as socio-economic status, ethnic diversity, housing policies, urban planning practices, and demographic factors. The studies must be peer-reviewed to ensure the quality and credibility of the included studies. The focus is on contextual relevance and relevance of findings. However, articles that do not include original empirical data or rely solely on theoretical discussions were excluded. Additionally, studies not specifically addressing residential segregation or focusing on unrelated aspects of urban studies were excluded. To maintain the relevance of the findings, articles relying on data collected prior to 2010 were also excluded. A total of eighty three (83) studies were identified from literature search; thirty one (31) were screened out for not meeting the inclusion criteria relating to year of publication while another thirty three (33) were further screened out removed for inadequacy of methodology and collection of primary data while the remaining nineteen (19) were included for systematic appraisal.

3. Results and Findings

3.1 Housing Segregation Resulting from Socio-Economic Indices

The historical background of public housing policy in Nigeria and its socioeconomic ramifications were examined by Odoy and Riekkinen (2022). The study demonstrates how residential segregation patterns have been impacted by socioeconomic differences, with low-income households frequently concentrating in undeveloped regions as a result of limited access to inexpensive housing. The study concludes that socio-economic indicators, such as income levels and work status, are important factors in defining residential segregation. It does this by analysing the success of various housing programs across time using secondary data from government papers and historical records. Additionally, Jagun *et al.* (2020) looked into the difficulties in delivering public housing in Nigeria and how they affect socioeconomic segregation. A mixed-method approach is used in the study, which includes surveys and interviews with citizens and officials. The results show that residential segregation is greatly influenced by socioeconomic factors such income disparity, employment opportunity, and educational attainment. According to the authors, inefficient public housing policies deepen socioeconomic gaps and result in segregated communities with unique socioeconomic traits.

Comparably, Onosemuode (2020) investigates the connection between urbanisation, socioeconomic segregation, and population distribution in Nigerian cities. The research examines the ways that unequal economic development and fast urbanisation lead to residential segregation using data from demographic surveys and the census. According to the report, low-income people live in peri-urban areas and informal settlements, whereas high-income earners are concentrated in developed urban centres. The study comes to the conclusion that one of the main causes of residential segregation is socioeconomic indicators like income inequality and work chances. The socioeconomic effects of urban development on residential segregation in North Central Nigeria are examined by Junaid (2020). The research examines the geographical distribution of various income categories throughout the city using socioeconomic surveys and GIS mapping. The findings show that residence patterns are highly influenced by

socioeconomic indices, including income, employment position, and availability to facilities. The authors point out that low-income communities experience neglect and subpar living conditions, which exacerbates socioeconomic segregation, whereas wealthy neighbourhoods are distinguished by superior infrastructure and services.

The findings from various studies provide crucial insights into the dynamics of housing segregation in Nigeria, emphasizing the role of socioeconomic factors. Odoy and Riekkinen (2022) highlight how historical public housing policies have contributed to residential segregation, with low-income households pushed into underdeveloped areas due to limited access to affordable housing. Jagun *et al*. (2020) identify income disparity and employment opportunities as key drivers of segregation, exacerbated by inefficient housing policies. Onosemuode (2020) connects urbanization and socioeconomic inequality, showing that low-income groups are relegated to peri-urban and informal settlements, while wealthier populations occupy developed urban centers. Similarly, Junaid (2020) illustrates how socioeconomic indices shape living conditions, with affluent neighborhoods benefiting from better infrastructure, while low-income areas suffer neglect. Together, these studies underscore the profound impact of socioeconomic disparities on residential segregation in Nigeria.

3.2 Housing Segregation Resulting from Ethno-Religious Indices

The influence of ethno-religious conflicts in Nigeria on housing segregation is examined in the Adamu (2024) through qualitative data gathered from case studies and interviews, indicated how religious disparities fuel residential segregation. According to the study, religious disputes and tensions cause homogeneous neighbourhoods to emerge because people seek safety and social coherence from living in regions where their own religion group predominates. Cities like Jos and Kaduna have seen severe religious segregation as a result of this. Furthermore, Demarest *et al.* (2020) investigate the relationship between national security and acts of religious violence in Nigeria, emphasising how these relationships affect residential patterns. The study examines media stories on religious violence and analyses secondary data. The results show that religious violence causes division and relocation, with victims moving to places where their religious group is more prevalent. This has led to the creation of religiously divided communities, especially in northern Nigeria. In order to lessen religious isolation, the necessity of interfaith communication and conflict resolution techniques was stressed.

Moreover, Madueke and Vermeulen (2020) looked at how politics and religion interact to create urban segregation in Nigeria. With a mixed-methods approach that includes interviews and questionnaires, the study examines the ways in which political identities and religious affiliations impact residence decisions. According to the report, divided communities result from the frequent distribution of housing resources based on political favouritism and religious affiliations. Cities like Abuja and Lagos are particularly notable for this segregation. It was suggested that in order to alleviate religious segregation, policy initiatives that support fair resource allocation and inclusive urban design should be developed. Additionally, Thaut Vinson (2020) evaluated how Nigerian security and residential patterns are affected by ethnic and religious conflict. The study uses qualitative information gathered via interviews with local authorities and people who live in high-conflict regions. Findings indicated that people often relocate to join their religious relatives; religious violence causes forced migrations and the creation of segregated enclaves. Cities like Kano and Zaria have severe religious segregation as a result of this. To lessen segregation, the authors advocate for extensive security measures and community-building programs.

Nonetheless, in the Nigerian city of Jos, Rikko *et al.* (2022) investigated how religious identification influenced residential segregation. The research examines the geographical distribution of religious groups in major cities using GIS mapping and census data. The results show that residence decisions are strongly influenced by religious identity, with different religious neighbourhoods developing over time. The study emphasises how religious organisations, which frequently offer social services and support networks that draw in other believers, have a significant role in perpetuating these tendencies. In order to combat segregation, the report recommends legislative actions that support religious concord and inclusive urban development.

3.3 Housing Segregation Resulting from Government Policies

The ongoing housing crisis in Lagos Metropolis and the contribution of governmental policies to the worsening of residential segregation were examined by Akinmoladun and Oluwoye (2011) while evaluating the effects of different housing policies that have been put into place over time utilising secondary data and policy analysis. The authors found that the creation of exclusive residential communities is frequently the result of government initiatives that benefit wealthy individuals. Low-income populations have been forced into informal settlements devoid of basic utilities, leading to substantial segregation as a result of this. In order to overcome these gaps, the report recommends more inclusive and fair housing policy. In the same vein, Ibem and Amole (2013) investigate the impact of government policies on housing segregation as well as residential satisfaction in Lagos public housing complexes. To collect information on the experiences and satisfaction levels of the inhabitants of public housing estates, the study uses questionnaires and interviews. The results show that low-income populations have mostly

lived in poorly designed and maintained housing estates as a result of government policy. Because these measures have divided the city into various socio-economic zones, they have unintentionally promoted residential segregation. The writers support changing laws to improve public housing's inclusion and quality.

Furthermore, Aluko (2012) investigated how urbanisation affected Lagos's housing market and how laws shaped residential segregation. The research illustrates how urban development plans have prioritised high-income residential and commercial districts, resulting in the marginalisation of low-income neighbourhoods. It does this by combining policy analysis with field surveys. According to the study, low-income inhabitants are concentrated in places with limited infrastructure and services, which has led to the geographic segregation of various socioeconomic categories. In order to lessen segregation, the report suggests implementing more inclusive urban development plans. Additionally, Jegede *et al.* (2021) examine how residents' comfort with security in Lagos public housing estates is influenced by planning, architectural elements, and location. Using policy papers and secondary data, the research examines different government housing policies and initiatives that have been put into place throughout the years. The authors conclude that numerous policies, which frequently benefit the middle and upper classes, have been badly conceived and executed. Because of this, low-income populations have fewer alternatives for cheap housing, which has intensified residential segregation. In order to provide more fair housing possibilities for all socioeconomic levels, the report recommends broad legislative reforms.

Equally, Ajayi *et al.* (2023) assessed how public-private partnerships contributed to housing supply in Akure, Ondo state, and the effect these partnerships had on residential segregation. Surveys, interviews, and policy analysis are some of the mixed-methods techniques used in the study to evaluate the effects of different housing initiatives. The results show that low-income households have been segregated into subpar housing regions as a result of government initiatives that have frequently been insufficient and poorly targeted. The authors contend that in order to fulfil the housing requirements of all socioeconomic levels and lessen segregation, more focused and inclusive policies are required.

Oladosu and Ludin (2018) focused on two distinct period of pre and post segregation report to explore the distribution of ethnic groups in the city of Jos by adopting purposive sampling to select key stakeholders across fourteen political wards of the city. Findings revealed an almost uniformly spread structure in the distribution of the five main ethnic groups before segregation but homogenously concentrated groups in different parts of the city thereafter with larger Hausa ethnicity in relation to the natives. It was concluded that, residents are susceptible to risk of experiencing socio-cultural consequences of residential segregation especially weak interethnic social contacts and its probable consequence post reporting of segregation due to governments' negligence. Idjakpo (2022) investigated the dynamics and processes of segregation and polarization of the Muslim minority in the city of Calabar, Nigeria. The study observed that neighbourhood locations by design significantly influences the levels of access to services, the critical element in bridging the gaps in the strength of urban governance institutions while negligence on governments' part in the face of the urbanization offers little opportunity for the inclusion of marginalised populations in Nigeria thus making it hard for minority population in Calabar to climb up the social ladder as a result of non-implementation of various inclusionary policy making frameworks with controversial affirmative actions for the minority Muslim population.

4. Discussion of Findings

The reviewed studies from Nigeria consistently highlight how ethnic diversity and historical conflicts contribute to residential segregation. Rudloff and Vinson (2023), for instance, show that ethnic identity significantly influences residential choices in Jos, driven by historical conflicts and social mistrust. Residential segregation in Nigeria is largely influenced by socioeconomic variables, including income levels, work possibilities, and educational attainment, as noted by Odoy and Riekkinen (2022) and Jagun *et al.* (2020). This is in line with previous research by Olayiwola and Olaitan (2020) and Sunday *et al.* (2021), which claimed that segregation of low-income households into less developed regions was mostly caused by income disparity and restricted access to inexpensive housing. Like Nchor (2022) and Aluko (2012), Onosemuode (2020) highlights that fast urbanisation and uneven economic development cause the geographical segregation of various socio-economic classes. Nchor (2022) specifically addressed how, in line with Onosemuode's findings, low-income communities have been marginalised by urban policies that encourage high-income residential growth, sending them into peri-urban regions and informal settlements. Another important finding in Aluko (2012) was the geographic concentration of wealthier people in developed urban centres and the ensuing socio-economic segregation, which further supported Junaid's (2020) findings about the geographic distribution of income groups in North Central Nigeria.

Furthermore, research by Adamu (2024) and Demarest *et al*. (2020) shown the substantial influence that ethno-religious conflicts have on residential patterns, resulting in communities that are homogenous as individuals seek social cohesion and safety within their own religious communities. Studies by Rudloff and Vinson (2023) and Timberlake (2015), which showed how religious violence in places like Jos and Kaduna has resulted in the

establishment of religiously separated communities, corroborate this conclusion. According to Madueke and Vermeulen (2020), political affiliations have an impact on residence choices. This is in line with previous research by Magni (2021) and Marcuse & Madden (2024). These studies pointed out how historically, the allocation of housing resources has been determined by political favouritism and religious connections, creating divided communities. In addition, research by Thaut Vinson (2020) and Rikko *et al.* (2022) supports these patterns by demonstrating how residential segregation is heavily influenced by religious identification and the violence that goes along with it. This is consistent with the results of the body of literature that already exists and emphasises how religious organisations contribute to the continuation of these patterns of segregation by offering social services and support networks that draw in other religious people (Menendian *et al*., 2021; Sydes, 2022).

Research by Akinmoladun and Oluwoye (2011) alongside Ibem and Amole (2013) concentrated on the ways in which high-income groups have been favoured by government policies, exacerbating residential segregation and forcing low-income households into informal settlements. This is consistent with research by Infranca (2020) alongside McArdle and Acevedo-Garcia (2022), which showed how government programs frequently overlook the demands of lower-class residents in favour of creating exclusive residential communities. Echoing Cortés' (2021) findings, Jegede *et al.* (2021) and Ajayi *et al.* (2023) concentrate on the shortcomings of public housing programs and public-private partnerships in meeting the housing requirements of low-income populations. All of these research point to the necessity of more equal and inclusive housing policy in order to lessen the negative impacts of socioeconomic segregation.

5. Conclusion and Recommendations

The comprehensive review of literature on housing segregation in Nigeria reveals a multifaceted and deeply ingrained issue driven by socio-economic indices, ethno-religious factors, and government policies. Residential segregation is significantly shaped by factors such as income levels, work position, and access to education, as demonstrated by socioeconomic differences. These studies repeatedly demonstrate how low-income households are disproportionately located in impoverished and neglected locations, which widens the socioeconomic gap. Ethno-religious variables show that, social distrust and disputes between various religious and ethnic groups result in homogeneous communities, which perpetuate segregation. Government policies demonstrate how historically, biased and inefficient policies have benefited high-income groups and worsened residential segregation. In order to address the underlying reasons of segregation and foster social cohesion in Nigerian cities, inclusive, egalitarian, and well-targeted housing policies are critically needed, as these studies together highlight. Residential segregation is a result of a number of factors, including persistent income disparity, fast urbanisation, ethno-religious tensions, and inefficient government policies. These factors highlight the necessity of comprehensive policy changes and inclusive urban design.

Based on the findings, it is recommended to develop and implement inclusive housing policies that prioritize affordable housing for low-income households through subsidies, low-interest loans, and incentives for developers. Through vocational training and assistance for SMEs, economic empowerment initiatives should be launched in order to decrease income disparity and expand job prospects. Fostering social cohesiveness requires promoting interfaith and interethnic discourse, which may be done through community projects and educational efforts. In order to integrate marginalized people and enhance infrastructure in impoverished regions, equitable urban development strategies are required. Robust monitoring and evaluation mechanisms should be employed in conjunction with comprehensive security measures to handle ethno-religious conflicts and gauge the success of housing plans. Reducing housing segregation and advancing inclusive urban development in Nigeria also need supporting legislative changes to remove discriminatory practices and encourage equitable access to housing as well as encouraging public-private collaborations.

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Reviewing the Viability of Private Developers in the Provision of Housing Delivery in Abuja, Nigeria

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Abstract

Abuja, as Nigeria's capital city, has experienced rapid urbanization and population growth, leading to significant housing demands. Private developers have emerged as key players in addressing this housing deficit. Therefore, this paper examines the viability of private developers in addressing the housing deficit in Abuja, Nigeria's capital city. The study adopted a desk study review of selected articles from the Scopus database. Through thematic analysis of empirical studies and market data, the paper evaluates the factors affecting the viability of operational environment private housing developers. The study identifies the major challenge over the trend of 10 years as financial constraint with 68% of reviewed papers highlighting it importance due to limited access to affordable financing and the underdeveloped mortgage system in Nigeria. Others, include, regulatory complexities, infrastructure deficits, and market affordability gaps. emphasize is on financial viability as a major challenge for private developers due to limited access to affordable financing and the underdeveloped mortgage system in Nigeria. Despite these obstacles, findings indicate potential for viable operations when strategic approaches are employed, Thus, the study recommend that government should implement policies to reduce interest rates for housing development loans and establish a specialized housing finance institution to provide long-term, low-interest loans to developers focusing on affordable housing. The study's significance lies in its potential to inform policy decisions, guide private sector strategies, and contribute to addressing Abuja's critical housing deficit. By implementing the proposed recommendations, stakeholders can work towards creating a more inclusive and sustainable housing market, with implications for urban development in Nigeria and similar rapidly growing cities in developing countries.

Keywords: Affordable housing, Housing delivery, Population, Private developer, Urbanisation

1. Introduction

The rapid urbanisation trend in Nigeria, driven by factors such as population growth, rural-urban migration, and economic opportunities in urban centres (Obi-Ani and Isiani, 2020; Ojo *et al*., 2017; Aliyu and Amadu, 2017). This urbanisation trend has led to a surge in housing demand, exacerbating the existing deficit of adequate and affordable housing across the country (Nwalusi *et al*., 2022; Moore, 2019). According to Odoyi and Riekkinen (2022) and Obianyo *et al*. (2021), Nigeria faces a significant challenge in housing its growing population. The current housing deficit, have grown from 7 million in 1991 to 28 million in 2023 showing an increase rate of about 300% presenting a pressing issue that requires innovative solutions for sustainable and inclusive urban development (Aribigbola *et al*., 2022; Ebekozien *et al*., 2022).

The housing deficit in Nigeria is a multifaceted issue stemming from various factors, including rapid population growth of over 200 million people (Mberu and Ezeh, 2017), urbanisation, and inadequate investment in housing infrastructure (Adedeji, 2023; Enwin and Ikiriko, 2023). This population growth and rural-urban migration have put immense pressure on urban housing markets, leading to overcrowding, informal settlements, and housing shortages (Akintunde *et al*., 2022). According to Akande (2021) and King *et al*. (2017), the housing deficit in Nigeria is further compounded by demographic shifts from rural to urban centre most especially to the capital city of Nigeria, Abuja.

In response to the housing deficit, the Nigerian government has explored various strategies to increase housing supply, such as; public-private partnerships (PPPs) that involve collaboration between government agencies and private sector entities to finance, develop, and manage housing projects (Owotemu *et al*., 2022; Muhammad and Johar, 2018), site and services scheme, this mechanism involves the government providing serviced plots for private developers (Obianyo *et al*., 2021). National Housing Fund (NHF), it was established to provide low-interest loans for housing development (Adedeji, 2023). Housing Microfinance for small-scale financing for incremental housing development for civil servant. However, government-led housing initiatives projects often suffer from slow decision-making processes and excessive bureaucratic bottleneck (Batra, 2023), limited funding can be a constrained, leading to inadequate resources for large-scale development (Hanapi *et al*., 2023), lack of market

responsiveness that align with market demands or changing demographics (Adedeji, 2023), public housing projects sometimes struggle with long-term maintenance and upkeep (Owotemu *et al*., 2022) and have the potential for political influence leading to abandonment in some cases and poor policy guidelines (Jahan, 2020).

The weaknesses identified in previous studies highlight the need for a more comprehensive and robust mechanism for sustainable housing delivery. In this regards Batra (2023) posit that private developers are a best fit. Thus, private developers have emerged as significant players in the Nigerian housing market, filling the gap left by the shortcomings of other mechanism (Hanapi *et al*., 2023; Shiyanbola and Olaleye, 2022). Private developers range from small-scale entrepreneurs to large corporations (Pedraza, 2021) and play a crucial role in meeting the diverse housing needs of the population (Jagun *et al*., 2020). Furthermore, Batra (2023) and Shiyanbola and Olaleye, 2022 opine that private developers leverage the weaknesses of government-led housing initiatives by providing financial resources, technical expertise, and market insights, they can stimulate the development of affordable housing solutions and contribute to sustainable urban development.

The viability of private developers as critical stakeholders in housing delivery is subject to various factors that influence their operational capabilities and market dynamics (Muhammad and Johar, 2019). While private developers have demonstrated agility and innovation in responding to market demands, their viability is contingent upon access to land, financing, and skilled labour (Adedeji, 2023; Jahan, 2020). However, challenges such as opaque land acquisition processes, limited access to affordable financing, and a shortage of skilled construction workers constrain private developers' ability to scale up housing production (Owusu-Ansah *et al*., 2019). Additionally, the volatile nature of the real estate market, characterised by fluctuating demand and supply dynamics (Swanzy-Impraim *et al*., 2021), poses risks to private developers' profitability and long-term sustainability.

While private developers have increasingly become prominent players in the Nigerian housing sector, there is a notable lack of comprehensive understanding regarding their involvement (Shiyanbola and Olaleye, 2022). Existing literature often focuses on the PPP on the provision of affordable housing which has been established to be inadequate and ineffective in mitigating the housing challenges in Nigeria (Hanapi *et al*., 2023; Ogunbayo *et al*., 2022) and the private developers are currently poised as a mitigator towards these challenges (Shiyanbola and Olaleye, 2022; Jagun *et al*., 2020). Consequently, there is a gap in knowledge regarding the specific roles the private developers play.

Evaluating the viability of private developers as critical stakeholders requires a nuanced understanding of these contextual factors and their implications for business operations and investment decisions. Therefore, the problem this study aim to address is the viability of private developers in the provision of housing delivery in Abuja, Nigeria.

2. Literature Review

Abuja, established as Nigeria's capital in 1991, has experienced rapid urbanization, with its population growing from 378,671 in 1991 to an estimated 3.4 million in 2020 (National Population Commission, 2021). This exponential growth has created a significant housing deficit, estimated at 600,000 units by the Federal Capital Territory Administration (FCTA, 2022). Researchers have consistently highlighted the substantial housing deficit in Abuja due to urban migration greener posture (Batra, 2023; Hanapi *et al*., 2023; Ambetsa, 2020). Consequently, Nwaka (2018) argues that rapid urbanization and population growth have exacerbated this shortage, with annual housing demand far exceeding supply. Initially, housing provision in Abuja was predominantly government-led. However, due to the inability of government to provide adequate housing and bridge the housing demand, the need for an economic reform of the 1990s saw a shift towards private sector participation. The National Housing Policy of 2012 formally recognized private developers as key players in housing delivery. In this regards Ibem *et al*. (2018) note that private developers bring financial resources, technical expertise and innovative construction methods.

Therefore, private developers have been identified as potential solutions to the housing crisis (Hanapi *et al*., 2023). Private developers in Abuja can be categorized according to Aminu and Raji (2021) into, large-scale developers (15% of market share), medium-scale developers (45%) and Small-scale developers (40%). Research by Okonkwo *et al*. (2020) indicates a potential return on investment of 15-20% for private housing developments in Abuja. However, this varies significantly based on location within the FCT, type of housing development and target market segment.

Private developer-led housing projects in Nigeria have demonstrated significant success in addressing the country's housing challenges, particularly in urban areas. Case studies highlight several successful private sector initiatives contributing to quality housing stock and improved living conditions. Notably, the Urban Shelter Limited (USL), one of the foremost developers in Abuja, known for estates such as Urban Shelter Estate in Gwarimpa. Their projects cater to a wide spectrum of income earners, offering both luxury and affordable housing. These cases underscore the importance of private sector involvement in housing provision and urban development, leveraging expertise, resources, and market-driven approaches. The successful case studies of private developers-led projects were compiled as shown in Table 1.

Table 1: Successful case studies of Private Developers-led Projects

S/N	Case Study Title	Location	Developer	Project Description	Key Success Factors
1	Brains and Hammers City	Abuja	Brains and Hammers	A mix of detached houses, duplexes, and apartments, addressing both mid-income and luxury segments	Innovative financing through diaspora investments. Successful navigation of regulatory challenges
2	Cedar Homes Estate	Abuja	Mixta Africa Group	A gated community offering affordable housing with modern amenities	Efficient project management, affordable housing options.
3	Aso Garden Estate	Abuja	Aso Savings & Loans	1,320 housing units spread across 67 hectares in the Karsana district of Abuja	The estate offers affordable housing options with a focus on quality infrastructure
4	Millennium City	Abuja	Urban Shelter Limited	Including both low- and high-income housing units	Affordability and rapid construction.
5	EFAB Metropolis		EFAB Properties Limited	Combination of 2–3-bedroom apartments and terraced houses. Gated community with 24/7 security.	High-quality construction, attractive amenities, prime location.
6	Grenadines Homes	Abuja	Grenadines Homes	Development of high-end residential properties and estates.	Focus on luxury and quality.
7	Pearlwort Heights	Abuja	Grenadines Homes	An upscale residential development offering luxury villas and duplexes.	Exclusivity, luxury finishes.
8	Luxury Gardens Estate	Abuja	Urban Shelter Limited	Mix of 2–4-bedroom apartments and duplexes. Recreational facilities.	Premium location, high-quality finishes, lush landscaping.
9	Brains and Hammers Estates	Abuja	Brains and Hammers	Various housing types from apartments to mansions. Commercial areas and educational facilities.	Quality construction, diverse property portfolio, commitment to delivery timelines.
10	River Park Estate	Abuja	River Park Limited	A residential estate offering luxury apartments and duplexes with top-notch amenities and green spaces.	Premium location, high-quality finishes, lush landscaping.
11	Jabi Lake Apartments	Abuja	Cappa and D'Alberto	commercial and residential real estate developments in Abuja	Innovative design and technology adoption
12	Royal Residence Estate		Dantata & Sawoe	Offers a mix of affordable and luxury housing options	Meeting the growing demand for middle-class housing

Source: Author's construct, 2024

Despite, the success recorded, challenges such as land acquisition and regulatory frameworks pose barriers to scaling up private sector-led housing projects, necessitating collaborative efforts for sustainable urban development and inclusive housing provision (Ambetsa, 2020; Nwaka, 2018). Furthermore, the viability of private developers is influenced by the strategies they adopt, with turnkey and presale strategies being the most effective in Lagos (Shiyanbola and Olaleye, 2019). Hence, contradictions arise in the form of challenges faced by private developers, such as inadequate government support, which hampers their capacity to address housing deficits, particularly for low to middle-income households (Afrane and Bujang, 2022). Additionally, the real estate financing system in Nigeria, including Real Estate Investment Trusts (REITs), has been underutilized due to low appreciation and a sluggish stock market, suggesting a need for improved financial mechanisms (Afolayan, 2017). In summary, private developers play a critical role in addressing Nigeria's housing deficit, but their effectiveness is hindered by challenges such as low technology adoption, inadequate government support, and insufficient financing systems. To improve the situation, there is a need for increased awareness and usage of advanced technologies like BIM, enhanced government assistance, and the development of sustainable financing models such as REITs.

3. Methodology

The systematic literature review was steered to identify and analyse relevant scholarly articles on private developers' viability in housing delivery. The search process was initiated by formulating a search key construct to ensure the retrieval of related and current literature. The search string used was as follows: "TITLE-ABS-KEY (private developer AND viability AND in AND housing AND delivery) AND PUBYEAR > 2014 AND PUBYEAR < 2024 AND (EXCLUDE (LANGUAGE, "Spanish")) AND (LIMIT-TO (DOCTYPE, "ar"))". The search was primarily conducted using the Scopus database, well-known for its extensive coverage of peer-reviewed literature across various disciplines. The inclusion criteria for the study covered articles published between 2014 and 2024, covering a period of ten (10) years as it marked the significant recovery period after the global financial crisis and the beginning of trends like smart homes, sustainable housing and increased focus on affordability. Moreover, the exclusion criteria were articles written in languages other than English, and articles for which full text was not available. ensuring the retrieval of recent and up-to-date literature. This is to maintain consistency and facilitate comprehension during the review process. The selected articles were expected to offer insights into the viability of private developer in bridging the deficit in housing delivery. The initial search results were methodically screened based on, relevance of the titles, abstracts and to the predefined scope of the literature review. The screening process was achieved through a thematic analysis based on the keywords of the study.

4. Findings

The viability of private developers in housing delivery in Nigeria is influenced by five major factors; financial, regulatory and policy environment, market demand and affordability, infrastructure and urban planning and government support and incentive factors. These factors can either enable or hinder the success of private developers in meeting the country's housing demand. Below are the key factors:

4.1 Financial Factors

Access to capital and financing is a major determinant of the viability of private developers to provide affordable and long-term financing for housing delivery with 68% of the reviewed papers highlighting it significance. The high interest rates on commercial loans and the underdevelopment of Nigeria's mortgage industry make it difficult for private developers to secure adequate funding for housing projects. A study by Shiyanbola and Olaleye (2022) found that private developers in Abuja face significant challenges in accessing affordable financing. High interest rates, typically ranging from 20-30%, make it difficult for developers to secure loans for housing projects. This study also revealed that most developers rely on personal savings and informal lending sources due to the stringent requirements of formal financial institutions. Furthermore, Jagun *et al*. (2020) noted that the volatile exchange rate of the Nigerian Naira affects the cost of imported building materials, which constitute a significant portion of construction costs. This volatility increases financial risks for developers and can impact project feasibility. Furthermore, the overall economic stability and investment climate in Nigeria influence developers' ability to attract both local and foreign investment in housing projects. Periods of economic instability and currency volatility reduce investment flows into real estate.

4.2 Regulatory and Policy Environment

Land acquisition is governed by the Land Use Act of 1978, which places land control in the hands of state governors. This often results in bureaucratic delays, high costs, and challenges related to land titling, which create significant obstacles for private developers. Government Policies: Policy inconsistency and the lack of clear urban development plans often lead to uncertainties for developers. In some instances, sudden changes in zoning laws or building regulations can disrupt ongoing projects. Research by Ibem *et al*. (2018) highlighted that complex and time-consuming approval processes for building permits and land titles in Abuja significantly delay project timelines and increase costs for developers. The study found that it takes an average of 12-18 months to obtain necessary approvals, which can deter investment and reduce project viability. Additionally, Afrane and Bujang (2022) pointed out that frequent changes in housing policies and regulations create uncertainty for developers, making long-term planning challenging. This instability in the regulatory environment can discourage private sector participation in housing delivery. The current strategy by government which is the Public-Private Partnerships (PPP), though promoted as a solution for housing delivery, the success of these partnerships depends on transparent policies, good governance, and clear legal frameworks, which are often lacking

4.3 Market Demand and Affordability

Housing demand in Nigeria surge due to increase in population growth resulting in a huge housing deficit, particularly in urban areas like Abuja and Lagos, which drives demand for new housing. However, effective demand

(demand backed by the ability to pay) is concentrated in the middle to high-income segments, making it difficult for private developers to focus on low-income housing without government subsidies or incentives. Thus, affordability challenges persist and is coupled with low purchasing power among the general population has limits the market size for private developers, particularly in the provision of affordable housing. The gap between housing costs and income levels creates a barrier to homeownership for many Nigerians. This assertion is supported by a comprehensive study by Ogunbayo *et al*. (2022), which revealed a significant housing deficit in Abuja, with demand far outstripping supply. However, the same study found that a large portion of this demand is from low and middle-income groups, who often cannot afford the housing options provided by private developers. Oyedepo *et al*. (2021) further elaborated on this affordability gap, noting that private developers in Abuja tend to focus on high-end housing due to higher profit margins, leaving a substantial unmet demand in the affordable housing segment. This mismatch between supply and demand affects the overall viability of housing projects.

4.4 Infrastructure and Urban Planning

The inadequate provision of infrastructure by the Government have hindered the viability of private developers in housing delivery. In this regard, the shortfall of basic infrastructure such as roads, water, electricity, and sewage systems in many areas means that private developers often have to bear these costs, driving up the overall cost of housing projects. Research by Adedeji and Arayela (2017) found that inadequate infrastructure, particularly in terms of roads, water supply, and electricity, increases development costs for private developers in Abuja. The study noted that developers often have to provide these basic amenities themselves, adding to project expenses and potentially reducing profitability. Moreover, Usman *et al*. (2021) highlighted that inconsistent urban planning and zoning regulations in Abuja can lead to challenges in project location and design, affecting the marketability and value of housing developments. This is further exacerbated by poor urban planning, along with inefficient enforcement of zoning regulations, can lead to haphazard development, delays in project approvals, and increased costs for developers.

4.5 Government Support and Incentives

Government incentives such as tax breaks, subsidies for building materials, or reduced land costs can significantly enhance the viability of private developers by reducing the financial burden associated with housing delivery. A study by Usman *et al*. (2021) found that the lack of consistent and targeted incentives for private developers in Abuja has limited their involvement in affordable housing projects. The research suggested that tax breaks, subsidies, and land grants could significantly improve the viability of housing projects, particularly in the low and middle-income segments. Ibem *et al*. (2018) further emphasized the importance of private developers in enhancing the viability of housing projects. Their study showed that successful private housing in Abuja have led to more efficient project delivery and improved affordability of housing units. Proactive housing policies that streamline processes for land allocation, reduce bureaucracy, and encourage investment in the real estate sector can improve the viability of private developers. However, these policies need to be consistently applied and maintained over time.

4.6 Fusion of key findings and trends in the literature

The role of private developers is critical in bridging the housing supply gap in Abuja, but market dynamics often limit their focus to higher-income groups. Financial viability remains a major challenge for private developers due to limited access to affordable financing and the underdeveloped mortgage system in Nigeria. Despite, the success recorded by private developers, the regulatory environment in Abuja is not promising for private developers, with cumbersome land acquisition processes and inconsistent policies posing significant challenges. This have given rise to barriers such as high construction costs, infrastructure deficits, and corruption that have exacerbate the challenges faced by private developers in delivering affordable housing in Abuja. Furthermore, while private developers face significant obstacles, opportunities exist in the form of growing demand and innovations in construction that could potentially lower costs and improve housing delivery efficiency. Thus, for private developers to be viable they will require strategic partnerships, innovation in building techniques, and supportive government policies.

5. Conclusion

The viability of private developers in housing delivery in Abuja, Nigeria, is influenced by a complex interplay of factors. Financial constraints, particularly high interest rates and exchange rate volatility, pose significant challenges. The regulatory environment, characterized by lengthy approval processes and policy instability, further complicates development efforts. While there is high demand for housing, affordability remains a major issue,

leading to a mismatch between supply and demand. Infrastructure deficits and urban planning inconsistencies add to development costs and challenges. However, targeted government support and incentives, particularly through well-structured private development show promise in enhancing the viability of private sector participation in housing delivery. real estate investment trusts) that could mitigate financing challenges. The study recommend that government should implement policies to reduce interest rates for housing development loans and establish a specialized housing finance institution to provide long-term, low-interest loans to developers focusing on affordable housing. Also, a one-stop-shop should be established for all housing development approvals to reduce bureaucracy and processing times. The study offers a comprehensive overview of the operating environment in Abuja, helping developers better navigate challenges and identify opportunities. This knowledge can inform private developers on strategic decisions on project design, financing, and market targeting. Furthermore, by understanding the challenges faced by private developers, policymakers can design targeted interventions to stimulate housing production, particularly in the affordable segment.

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A Literature Exploration of The Need for Inclusivity in Educational Facilities

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Abstract

In today's world, inclusivity and accessibility are crucial for people living with disabilities in accessing educational facilities. At the global level, one of the main challenges is the lack of inclusive policies and accommodations for individuals with disabilities in educational institutions. In African countries, including Nigeria, the challenges of inclusivity for people with disabilities are even more pronounced. Lack of assistive infrastructure, inclusive policies and legislations, and societal stigmas and attitudes are major obstacles for these individuals in accessing educational facilities. In Nigeria specifically, despite the government's efforts to improve inclusivity in education, there are several challenges such as limited resources for special education, a lack of awareness, understanding of disability rights and accommodations. Therefore, this paper examined the concept of spatial inclusivity, educational infrastructure and challenges of inclusivity for people living with disabilities in accessing educational facilities in Nigeria. This research adopts a desktop approach to review critical literature at the global, regional, local level. The research appraises literature materials from 2000 to 2024 on the subject of inclusivity of educational infrastructure and extracting lessons for the Nigerian educational Space towards inclusivity for the vulnerable populations. The paper found that the challenges which the people living with disabilities face in accessing educational facilities in Nigeria range from physical barriers such as inadequate infrastructure and lack of accessibility accommodations, to social barriers such as discrimination and stigmatization.

Keywords: Assistive infrastructure, Education, Facilities, Inclusivity, Infrastructure

1. Introduction

In the contemporary world, the principles of inclusivity and accessibility are fundamental to ensuring that individuals living with disabilities can fully participate in educational settings. The right to education is enshrined in various international frameworks, including the United Nations Convention on the Rights of Persons with Disabilities (CRPD), which emphasizes the need for inclusive education systems that accommodate the diverse needs of all learners (United Nations, 2006).

Globally, an estimated 15% of the pollution lives with some form of disability representing over one billion people (WHO.2023). this demographic is disproportionately affected by educational inequities Despite this recognition, many educational institutions globally continue to grapple with inadequate policies and insufficient accommodations for students with disabilities, leading to significant barriers to access (Mitra *et al*., 2017).

In the African context, these challenges are particularly pronounced. Countries like Nigeria face a multitude of systemic obstacles that hinder the educational prospects of individuals with disabilities. The lack of assistive infrastructure—such as ramps, accessible restrooms, and specialized learning materials—creates formidable physical barriers to education (Mitra *et al*., 2017). Societal attitudes, stigmas, Discrimination and negative perceptions surrounding disability also play a critical role in shaping the educational experiences of disabled individuals.

2. Methodology

This study employs a comprehensive desk-based research strategy, centered on an extensive examination of existing literature and reports. The chosen approach is ideally suited to the research objectives, facilitating the aggregation and analysis of information from a wide spectrum of scholarly resources, encompassing peer-reviewed publications, reports from global institutions, and official policy papers. This method has enabled a profound exploration of the intricate and diverse obstacles confronting inclusivity and accessibility of educational facilities.

The desktop research has allowed for the identification and discussion of challenges and barriers to accessing education facilities for people with disabilities. The literature review also draws insights from various geographical

regions, including Europe, Asia, America, and other African countries, to provide a comprehensive understanding of the challenges and potential lessons for Nigeria.

3. Challenges Encountered in Accessing educational facilities with people living disabilities at Global level

The challenges faced by students with disabilities in accessing quality education are multifaceted and deeply rooted in systemic issues within educational systems worldwide. Despite international frameworks advocating for inclusive education, many countries continue to grapple with inadequate policies and insufficient accommodations that hinder the educational experiences of these students.

3.1.1 Inadequate Policy Frameworks and Implementation

The issue of Inadequate Policy Frameworks and Implementation is one of the major concerns now as many countries lack comprehensive policies that explicitly outline the rights and needs of students with disabilities. According to Rouse (2016), while international agreements like the United Nations Convention on the Rights of Persons with Disabilities (CRPD) promote inclusive education, the translation of these policies into actionable frameworks at national and local levels remains inconsistent. This gap often results in a lack of accountability for educational institutions to implement inclusive practices. Research by Kauffman *et al*. (2018) highlights that even where laws exist, they are often poorly enforced the lack of this enforcement can manifest in inadequate funding for special education services, leading to insufficient resources for schools to accommodate students with disabilities effectively. Another area which has limited this inadequacy is Cultural and Societal attitudes towards disability which significantly influence policy development and has also prevent the establishment of inclusive practices that are essential for equitable education.

3.1.2 Insufficient Accommodations

Insufficient Accommodations for people with disability remain a significant challenge in educational systems worldwide these inadequacies are Lack of Training for Educator, lack of Resource Allocation, physical inaccessibility of educational facilities. Mitra *et al*. (2017) highlighted that many educational institutions lack essential facilities like absence of ramps, elevators, inaccessible classroom furniture, poor signage for visually impaired people, the researchers observed that in some cases persons with disabilities had to be carried upstairs by family members or school staff, a situation that not only posed safety risk but also compromised the dignity and independence of these students. Additionally, the lack of accessible restroom has forced students with disabilities to limit their fluid intake during school hours directly impacting educational experience and health. While Insufficient training for teachers on how to accommodate diverse learning needs is another critical issue as many educators feel unprepared to support students with disabilities, which has led to a lack of differentiated instruction and support within the classroom Avramidis *et al*. (2002). Another challenge which is insufficient funding for special education services resulting to overcrowding classrooms and a lack of specialized learning materials. These physical barriers not only limit access but also contribute to feelings of exclusion among persons with disabilities.

3.2 Challenges in Africa context; Barriers to accessing educational facilities and infrastructures

Access to educational facilities is vital for the empowerment and integration of people living with disabilities in Africa. Despite international commitments to inclusive education, numerous barriers persist that hinder access across the African continent. The challenges are broadly narrowed into the following:

3.2.1 Inadequate infrastructure and Physical Barriers

Physical barriers remain a significant challenge in many African countries as this obstacle not only hinder educational participation but also so perpetuate cycles of exclusion and marginalization. According to Tchombe (2019), many educational institutions lack basic accessibility features such as ramps, accessible toilets, adequate transportation, lack universal design principles, poorly designed classrooms, The study highlights that infrastructural inadequacies often lead to exclusion from mainstream education.

3.2.2 Societal attitudes and stigma

One of the most pervasive barriers to educational access for people with disabilities in Africa is negative societal attitude and stigma. These attitudes are shaped by cultural belief negative perceptions and discrimination collectively create barriers for instance, in most Africa countries today there are still harmful traditional and cultural beliefs and myths about people living with disabilities These beliefs include that people living with disabilities are suffering the consequences of the evil acts of their parents and a host of other unfounded myths about them. Unfortunately, there is a relatively high number of Africans who uphold these strange and unfair myths and beliefs about people living with disabilities (Etieyibo *et al*.,2016; Rohwerder 2018). And these harsh and unfriendly traditional and cultural beliefs have worsened their living conditions, preventing them from accessing education.

3.2.3 Poverty and economic Barriers

Poverty exacerbates the challenges faced by people with disabilities in accessing education across Africa. According to a report by the African Disability Forum (ADF, 2021), many families cannot afford the costs associated with specialized education or transportation, which exacerbates inequalities.as highlighted by Trani *et al*.(2011) and Kett(2012) they demonstrated a strong correlation between disability and poverty in several Africa countries, with families often unable to afford cost of assistive devices, specialized materials create significant economic barriers to education for many African families. Addressing this these challenges requires a multifaced approach, including increased funding for inclusive education, community awareness programs and support for families facing economic hardship. Countries like Kenya, south Africa, Uganda has made tremendously effort yet economic disparities still persist.

4. Achievements in Global Inclusivity and Access to Educational Facilities

4.1 Introduction

Guaranteeing that individuals with disabilities have fair access to quality education is a worldwide necessity various regions and economic settings, nations have launched multiple initiatives to overcome the diverse obstacles that have historically restricted access to educational institutions for these individual .effort range from enhancing infrastructure to implementing policy reforms and adopting community based strategies all aimed at fostering a more inclusive and accessible educational landscape.

4.1.1 Europe

Many European nations have made significant strides in promoting inclusivity and accessibility for people living with disabilities within educational institutions. various strategies, policies, and practices that have contributed to the advancement of inclusive education across the continent.

4.1.2 Policy and Legislative Frameworks

Europe has established robust policy and legislative frameworks to support inclusive education. The European Union's (EU) commitment to inclusivity is evident in documents such as the European Disability Strategy (2010-2020), which emphasizes the need for equal access to education and the adoption of the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) by the European Union in 2010 marked a significant milestone. Tisdall (2015) notes that this led to increased commitment to inclusive education across member states. And Smyth *et al*. (2014) highlight how the European Agency for Special Needs and Inclusive Education has played a crucial role in promoting inclusive education policies across Europe.

4.1.3 Physical Accessibility and infrastructural Improvements

Many of the European countries has invested in upgrading infrastructure to enhance physical accessibility for example the United Kingdom has implemented the Disability Discrimination Act (DDA)and its successor, the Equality act 2010 which require public buildings and transport system to be accessible. initiatives including the installation of ramps, elevators and accessible restroom in public building A study by Sánchez Fuentes *et al*. (2019) in Spain found that universities have made substantial improvements in campus accessibility, including the installation of ramps, elevators, and accessible toilets.

4.1.4 Assistive Technology and Digital Accessibility

The European nations has been at the forefront of implementing assistive technologies and ensuring digital accessibility in education. Lidström and Hemmingsson (2014) conducted a review of assistive technology use in Swedish schools, finding widespread adoption of technologies to support students with various disabilities. The European Commission's "Digital Education Action Plan (2021-2027)" emphasizes the importance of digital accessibility in education. According to a study by Al-Azawei *et al*. (2016), the use of technology such as screen readers, speech recognition software, and adaptive devices has enhanced learning opportunities for students with disabilities across Europe. The authors emphasize the need for ongoing investment in technology and training to maximize its benefits

4.2 The Americas

the pursuit of inclusivity and accessibility for individuals with disability in educational has been a major focus across America encompassing the United States, Canada and Latin America have made significant efforts in promoting inclusivity and accessibility in educational institutions for people with disabilities.

4.2.1 Infrastructure Investments and Technological Innovations

The Americas have also made significant investments in upgrading the physical infrastructure in institutions to enhance accessibility. In the United States, schools have undertaken significant renovations to comply with the Americans with Disabilities Act (ADA) 1990. This includes installing ramps, elevators, and accessible restrooms to

ensure physical access for students with disabilities. The Act prohibits discrimination against individuals with disabilities and requires schools to provide reasonable accommodations. Countries in the Americas have leveraged technological innovations to improve the accessibility and inclusivity. Many Latin American countries, such as Brazil and Argentina, have enacted laws to promote inclusive education. For instance, Brazil's Law of Inclusion (2015) emphasizes inclusive practices in schools.

4.2.2 Stakeholder Engagement and Community-Based Approaches

Stakeholder engagement and community-based approaches are essential for creating inclusive and accessible educational environments for individuals with disabilities across the Americas. By fostering collaboration among various stakeholders and leveraging community resources, educational institutions can better meet the diverse needs of all students. In the U.S., stakeholder engagement is often facilitated through collaborative policy development involving federal and state agencies, educators, families, and advocacy groups. Input from parents and students with disabilities is crucial to ensure that educational policies reflect diverse needs. united state. Department of Education. (2016) THE Canadian initiatives emphasize inclusive education networks that bring together educators, parents, and community organizations to share best practices. This collaborative approach helps identify barriers and develop solutions tailored to local contexts. McKay, S. (2017) In many Latin American countries, community members are actively involved in developing educational policies for students with disabilities. This engagement ensures that local needs and cultural contexts are considered in policy formulation. Gálvez, J. (2018)

4.2.3 Assistive Technology and Digital Accessibility

America has been at the forefront of implementing assistive technologies and ensuring digital accessibility in education. Bouck *et al*. (2012) conducted a review of assistive technology use in American schools, funding widespread adoption of technologies like digital recorders, eye tracking device, walking frames, wheelchairs to support students with various disabilities. The National Center on Accessible Educational Materials has played a crucial role in promoting digital accessibility. Hitchcock and Stahl (2013) discuss how this initiative has improved access to educational materials for students with disabilities. For instance, the use of assistive technology in Canadian classrooms has expanded, providing tools that enhance learning for students with disabilities. Alper, S., & Raharinirina, S. (2006).

4.3 Across Asia

There has been a notable shift towards more inclusive and accessible education for people with disabilities. This trend is evident in policy changes, infrastructure improvements, and pedagogical adaptations across various countries.

4.3.1 Policy Evolution

Many Asian countries have implemented significant policy changes to promote inclusive education. Japan's transition from segregated special education to more inclusive approaches in mainstream schools (Muta, 2018) mirrors similar efforts in China, where reforms have aimed to move away from segregated schools towards more inclusive environments (Liu & Brown, 2019). India's Right to Education Act has also been instrumental in pushing for the inclusion of students with disabilities in mainstream schools, though implementation challenges persist (Sharma & Das, 2021).

4.3.2 Infrastructure and Accessibility

Physical and digital accessibility has been a focus in several countries. South Korea has made significant progress in modifying campus infrastructure and adopting assistive technologies in higher education (Kim & Koh, 2020). Similarly, Malaysia has been working on improving the accessibility of its universities, focusing on physical infrastructure, assistive technologies, and inclusive institutional policies (Abdul Rahman & Mohd Yasin, 2020).

4.3.3 Pedagogical Approaches

Innovative teaching methods have been adopted to support inclusive education. Singapore's implementation of Universal Design for Learning principles has benefited students with diverse learning needs, including those with disabilities (Lim & Tan, 2017). This approach emphasizes flexibility in how information is presented, how students demonstrate knowledge, and how students are engaged in learning.

4.4 In Africa

Across Africa, efforts to achieve inclusivity and accessibility for people with disabilities in educational institutions have been gaining momentum, driven by both international commitments and national policy initiatives. However, the implementation of these policies and the realization of truly inclusive education systems remain works in progress, with significant variations across countries and regions.

4.4.1 Policy Development and Implementation

Many African countries have developed inclusive education policies aligned with international standards. Countries like Kenya and South Africa have developed national policies that specifically address inclusive education. These policies emphasize the need for schools to adapt their environments and teaching methods to accommodate students with disabilities.in South Africa Donohue and Bornman (2018), on their study reveals, the implementation of such policies often faces significant challenges due to resource constraints, inadequate infrastructure, and entrenched societal attitudes.

4.4.2 Community Engagement and Awareness

Community involvement has been crucial in promoting inclusive education. Local organizations and NGOs work to raise awareness, provide resources, and support families in advocating for their children's educational rights. Several studies have emphasized the importance of community engagement in promoting inclusive education. In Ethiopia, Franck and Joshi (2017) analyzed efforts to implement the Special Needs Education Program Strategy, noting that community awareness and support were crucial factors in increasing access to education for children with disabilities. The study by Kassah *et al*. (2018) in Tanzania also highlighted the need for better identification of learners with disabilities and increased community awareness to support inclusive education initiatives.

4.4.3 Collaborative Partnerships and International Cooperation

Many African countries have established multi-stakeholder partnerships involving government agencies, NGOs, and international organizations. Collaboration from united nations education scientific and cultural organization, (UNESCO) united nations children fund (UNICEF), and the World Bank have play crucial roles in supporting African countries in developing inclusive educational systems. These organizations have provided technical expertise, funding, and resources for improving educational infrastructure and practices. For example, Chitiyo *et al*. (2019) described how Zimbabwe has fostered collaborations between educational institutions, NGOs, and government agencies to pool resources and expertise for inclusive education initiatives. Okkolin *et al*. (2018) highlighted the formation of regional networks in East Africa. The networks facilitate the sharing of best practices, resources, and expertise across countries facing similar challenges in implementing inclusive education

5. Leasons learned from global space and other Africa Countries

Nigeria can learn several important lessons from the western countries and from other Africa countries in order improve its approach to inclusivity and accessibility to educational facilities and infrastructure for people living with disabilities through:

1. **Infrastructure Adaptation:** Physical accessibility is a fundamental requirement for inclusion and Nigeria can learn from other countries on how to Conduct a nationwide audit of school infrastructure accessibility, develop a phased plan to retrofit existing schools with ramps, elevators, and accessible facilities and how to Ensure all new school constructions adhere to universal design principles
2. **Teacher Training and Support:** Well-trained teachers are essential for successful inclusive education.: Therefore, Nigeria can draw insight from other countries on how to Integrate inclusive education modules into all teacher training programs, provide ongoing professional development for in-service teachers and establish a mentorship system pairing experienced inclusive education teachers with newer ones
3. **Assistive Technology:** Technology can significantly enhance learning experiences for students with disabilities and Nigeria can learn from developed countries who are ahead with advance technology on how to Invest in a range of assistive technologies (e.g., screen readers, hearing aids, adaptive keyboards) and on how to Train teachers and students on the effective use of these technologies, how to Partner with tech companies to develop locally relevant assistive tools
4. **Addressing Societal Attitudes and Stigma:** Nigeria can learn from countries that have implemented strategies to challenge negative stereotypes and promote the inclusion of people with disabilities within the educational systems. This can involve awareness-raising campaigns, anti-discrimination policies, and community-level engagement initiatives.

6. Recommendation

Based on the extensive review of challenges and barriers faced by individuals with disabilities in accessing educational facilities, particularly in global and African contexts, the following are some key recommendations aim to create a more inclusive educational environment by addressing physical, social, and systemic barriers.

1. **Implementation of Policy and Infrastructure improvements**: Government and stakeholders should enforce inclusive education policies, improve physical accessibility of schools (ramps, elevators, accessible restrooms), Modify classrooms to accommodate various disabilities and ensure new constructions follow universal design principles
2. **Comprehensive Education and Training:** Provision of specialized training for teachers involve equipping them with the knowledge and skills to effectively teach student with various disabilities and training which will

cut across different types of disabilities and on how to use assistive technologies and Adapt curricula to accommodate diverse learning needs and implement flexible assessment method. This educational adaptation is crucial because they directly address the learning experience of student with disabilities.

3. **Engage the disability community in the design and evaluation of education programs:** Collaborative efforts between the disability community, stakeholders, and policymakers should be fostered to ensure that the needs and perspectives of individuals with disabilities are reflected.
4. Enhance Disability awareness and sensitivity training are essential components of educational programs aimed at fostering inclusive environments. Comprehensive educational initiatives that challenge stereotypes about disabilities, promote understanding of diverse disabilities, and encourage the adoption of inclusive practices should be integrated into the curricula of schools, colleges, and universities.

7. Conclusion

While the path to fully inclusive education systems presents significant challenges, particularly in resource-constrained environments, the research provides a clear roadmap for progress. It calls for sustained commitment from governments, educational institutions, communities, and international partners. By addressing both the tangible and intangible barriers to inclusion, and by fostering a culture that values diversity and equal participation, significant strides can be made in ensuring that all individuals, regardless of disability, have access to quality education. The journey towards inclusive education is not only a matter of fulfilling human rights obligations but also an investment in building more equitable, diverse, and prosperous societies. As such, it requires ongoing effort, innovation, and collaboration across all sectors of society to create truly inclusive educational environments that empower individuals with disabilities to reach their full potential.

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Investigation of Building Cost Indicator Items for Tender Price Indices Development for Public Building Projects in Nigeria

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Abstract
Tender Price Indices (TPI) is a tool for cost planning deployed by stakeholders in the construction industry in achieving early cost estimation for proposed building projects, price adjustment and project cost forecasting. The use of TPI is well grounded in developed countries with established institutions that produces it and well recognised by the stakeholders in construction industry. Like many African countries, Nigeria has no dedicated institution that construct TPI. The development of TPI required cost information known as indicator items to measure price changes over time. Hence, the study conducted an investigation to identify acceptable cost information by the stakeholders of which changes in their prices over time will indicate the impact on project cost. To achieve this, a pilot study which identified 26 cost items out of 28 items investigated from a typical Bill of Quantities for a public building project was conducted. The pilot survey questionnaire was administered to professional quantity surveyors residing in Abuja, FCT Nigeria (seventeen responses) were received and are adequate to development of Tender Price Indices for public building project in Nigeria.

Keywords: Cost information, Cost indicator, indicator items and Tender Price Indices.

1. Introduction

Cost of building projects in Nigeria have continue to rise over the years, the combination of macro and micro economic factors contributed to annual changes that occurred in building cost increases year on year (Ashworth, 2010). These changes necessitate the gathering of cost data to produce information to be used by the contractors and clients in estimating cost of building projects. The contractors provide the cost proposals of the client's design decisions through the tender in the procurement process of a proposed construction project. Invariably, the costs of proposed projects are needed by clients and contractors alike before such projects are started (Wang *et al*., 2021). Tender Price Indices (TPI) modifies historical costs to incorporate expected future realities (Takano *et al*., 2018). The TPI according to Xu and Moon (2013), is a measure of the movements of tender prices, that is, the prices at which contractors are prepared to execute projects, thus representing the cost a client has agreed to pay (Ismail and Zakaria, 2014). The TPI finds practical application in building up individual tenders, adjustment of costs for time, pricing, cost planning, and forecasting cost trends (Kissi *et al*., 2021; Seeley 1996).

Government of African countries have not taken interest in the TPI development so far. Hence, the attempts by individuals to develop TPI. The National Tender Index developed in South Africa by Cruywagen (2014) concluded that an alternative TPI studies are inadequate in South Africa. Similarly, Kissi (2017) developed TPI model in Ghana advocated the need to have a TPI for policy makers and building industry professionals to take a critical look at pricing building projects due to the wider implications of TPI to the national economy and development. In Egypt, Ramadan (2023) developed indices for prediction of construction price.

Advanced economies have recognized institutions that process TPI on a regular basis over the years for many construction aspects. However, there are limitations in application of research result outside the country in context, and also research results are confined to time (Ganiyu, 2016), and domestication of TPI being produced in other countries have challenges due to cultural differences in norms, values and attitudes ((Robinson, 2007; Muriithi and Crawford, 2003). Tarek *et al*. (2012) also noted that, it is not an easy task to domesticate a scientific strategy to measure decisions that work in another country due to diversity in construction process that exist elsewhere.

Consequent upon the above, this paper investigated the cost information required to develop TPI for public building projects in Nigeria and outlined the cost information as indicator items necessary for the development of TPI.

1.1 Cost Information for TPI development

Cost information refers to the input required from the tender documents. The BOQ are dissected to come up with Trade sections from where the indicator items are selected. The BOQ are prepared in different forms for different

purposes, it could be firm quantities as lump sum or approximate quantities depending on the available designs and method of tender process chosen.

1.2 Measured Works Section (Building Works)

The measured work sections in BOQs for building works in Nigeria contains 41 Trade sections which include; Preliminaries, Off-Site Manufactured Materials, Components or Buildings, Demolition, Alterations, Repairs and Conservation, Excavating and Filling, Ground Remediation and Soil Stabilisation, Piling, Underpinning, Diaphragm Walls and Embedded Retaining Walls, Crib Walls, Gabions and Reinforced Earth, Insitu Concrete Works, Precast /Composite Concrete, Precast Concrete, Masonry, Structural Metalwork, Carpentry, Sheet Roof Coverings, Tile and Slate Roof and Wall Coverings, Waterproofing, Proprietary Linings and Partitions, Cladding and Covering, General Joinery, Windows, Screens and Lights, Doors, Shutters and Hatches, Stairs, Walkways and Balustrades, Metalwork, Glazing, Floor, Wall, Ceiling and Roof Finishings, Decoration, Suspended Ceiling, Insulation, Fire Stopping and Fire Protection, Furniture, Fittings and Equipment, Drainage Above Ground, Drainage Below Ground, Site Works, Fencing, Soft Landscaping. Mechanical Services, Electrical Services, Transportation and Builders' work. These sections are generally measured based on the Building and Engineering Standard Method of Measurement 4th Edition (BESMM4) in used in Nigeria.

1.3 Trade sections cost information tool

Bill of Quantities: A Bill of Quantities (BOQ) is a list of items with details identifying descriptions, specifications, and quantities, which make up the component parts of a building, engineering, or industrial facility. The primary purposes of a BOQ, which becomes a contract document, are to provide a coordinated list of items, together with their identifying descriptions and quantities, that comprise the works to enable contractors to prepare tenders efficiently and accurately. The use of BOQ in support of a contract is the traditional and proven means of securing a lump-sum price for undertaking building, engineering, and industrial projects. BOQ can be:

- Firm (to obtain a lump-sum price for a fully designed project); or
- Approximate (subject to re-measurement as built).

1.3 Indicator Items for the development of TPI

The primary purpose for the collection of prices of categories of work, materials for construction activity is to record the changes to which these prices are subject over time. The absolute prices provided by respondents are only used for the calculation of a series of relatives. There are considerable differences in the types of items included in the compilation of tender price indices by different countries (Organisation for Economic Co-Operation and Development, 1997) and considerable differences in the number of items actually priced, ranging from a few dozen to several thousand. Determining the actual items to include in the index is largely a matter of judgement (Kissi *et al*., 2021). While the compilation of an index involving several thousand items could lead to high degrees of accuracy, it would also be difficult and costly to collect the price information for each of the items. The effort is to identify the minimum number of indicator items that collectively represent a high proportion of the total value of the construction project. These items are referred to as indicators (Leonin, 1989). The decision on whether or not to include an item in an index depends on the impact that changes in the price of that item (or group of items) may have on the total price of the construction. For example, including only the building structure might be insufficient to measure price changes because finishing work could also have considerable impact on building prices.

Careful and detailed examination of each trade section is important since each item in the BOQ has some levels of weighting in terms of determining the final contract sum. Seeley (1996) posited that the key items with the largest price extension in each trade of the bills of quantities should be included in the index. Similarly, Akintoye (1991) suggested that the weights allocated to various items reveal their relative importance and should carefully be chosen to avoid biased and misleading results. Therefore, the implication of selecting any item in the BOQ was examined to establish their influence on the final output through the following activities: (i) Weighting, (ii) Detailed analysis of the trade section, (iii) Identifying the indicator items, and (iv) Variation in rates.

BOQ items should be analysed in terms of their frequencies of occurrence and the weights they represented. Trade sections that consist of more items than other trade sections should be given priority in terms of their occurrence and contributions to the total cost. The magnitude of the weighting of individual items is used to select the indicator items per each trade section (Kissi *et al*., 2021). These items are used to facilitate the calculation of the TPI index through the analysis of the various unit rates. At this stage, all of the various items that were selected as indicator items are listed. Where it is found that some BOQ have more items extracted than others, (obviously because all BOQ do not have the same types of items present), substitute items should be selected and used. The acceptable number of indicator items is a matter of judgment because the literature is vague about how many items are suitable for an index (Kissi *et al*., 2021).

1.5 Weightings of Indicator Items

The weight for the various trade sections in the BOQ is usually calculated based on the principle of the Consumer Price Index (CPI), which measures changes in the average retail price of a fixed basket of goods and services over time (OECD, 1997). A base year is always established for which a weighting can be applied for the preceding years. For the development of a TPI, BOQs are broken down into various work-trade sections to identify those trade sections that are only infrequently present in projects within the construction industry (OECD, 1997).

1.6 Challenges to the Development of TPIs

The development of the tender price indices (TPI) in developed countries expands to over some decades in terms of its application. In contrast, these indices are not available in developing countries owing to the fact that their development is constrained by some perceived critical barriers, Kissi *et al.* (2017). Five (5) underlying challenges were highlighted; namely poor procurement and estimating, erratic external and project conditions, data unavailability, technological implications, and weak knowledge base. Nevertheless, construction professionals in developing countries are not able to adopt their end products because of the extent of the influence that cultural differences have on their decisions. These cultural differences are related to the values, attitudes and norms and these militate against developing of TPI in developing countries. (Robinson, 2007; Muriithi and Crawford, 2003) Balk (2008) further indicated that indices problems range from the two dimensions, namely decomposition of a value ratio into price and quantity index numbers, and unavailable of quantity data to consider price indices for which all detailed price and quantity information is available. Again, Balk (2008) reiterated the use of a representative sample of commodities in considering the operational cost of getting detailed price and quantity information about all the transactions which are not given precise information, rendering the indices developed incapable of making any informed decisions.

1.7 Economic Indicators of TPIs Development

Environmental characteristics of any economy have an influence on the building industry. The economy influences are perceived to have a significant contribution to tender price indices prediction (Kissi *et al.,* 2017). The study conducted by (Kissi, *et al.,* 2017) in Ghana found five significant economic indicators that would have influence on tender price indices prediction, they are; composite consumer price index, producer price index, currency exchange rate, gross domestic product and interest rate. As claimed by Kissi *et al.*, (2017), these indicators have similar economic characteristics with developing countries and hence can be applicable.

2. Research Method

The ways and means of carrying out research with the guiding concepts used in research are collectively known as research methods, while the discipline or body of knowledge that employs these means and concepts is known as research methodology (Kinash, 2008). Critical consideration of various research methods cannot be over emphasized, especially how they affect data collection and data analysis to obtain results and conclusion to the research work (Ganiyu, 2016). According to Kheni (2008), the choice of research methods in management and social sciences hovers around the researcher's assumptions about the nature of the social world, the nature of the knowledge to be obtained and means of acquiring knowledge. Three different types of research methods can be identified as quantitative approach, qualitative approach, and mixed-method approach, which is a blend of both quantitative and qualitative approaches (Creswell and Creswell, 2018). Quantitative research approach was used to analysed pilot survey received from 17 respondents who are registered quantity surveyors based in Abuja to establish th indicator items to develop TPI for public building projects in Nigeria.

2.1 Population

Research population is the collection of elements that are of interest to a researcher. Hence the population for this pilot study were the registered quantity surveyors resident in Abuja, a total 1093 of registed quantity surveyors obtained from the register of the Quantity Surveyors Registration Board of Nigeria (QSRBN as at September, 2024. However, as a pilot study being a small-scale investigation usually conducted before the main research project and usually without requirement to calculate sample size, as its main aim is not hypothesis testing rather reliability and validity (Chhetri and Khanal, 2024). In a pilot study conducted by Omar *et al*., (2017), 24 samples where considered. Lewis *et al* (2021) put a total range of sample to between 10-40, and Julious (2005) suggested 12 samples for a pilot survey. Hence, the 17 (seventeen) responses received for this study was adequate to achieve a study objective of investigating a reliable cost information item to develop the TPI.

2.2 Procedure for Data Collection

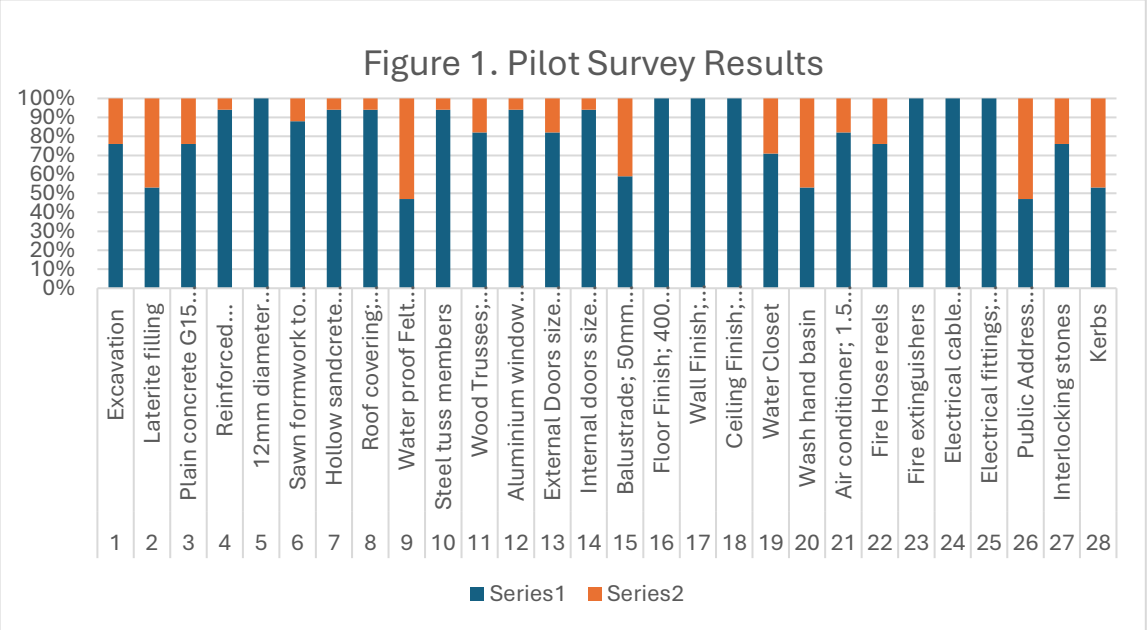
The structured questionnaire was administered by registered quantity surveyors to indicated their agreement or non agreement with options of (yes or no) from the suggested indicator items. Questionnaire results are shown below in table 1.

Table 1. RESULTS OF THE SURVEY

Indicator items				
s/n	**Items Description**	Yes %	No. %	Responses
1	Excavation	76	24	agreed
2	Laterite filling	53	47	agreed
3	Plain concrete G15 (1:3:6 - 19 mm agg) in Foundations	76	24	agreed
4	Reinforced concrete G25 (1 : 2 : 4-19mm agg) in Columns	94	6	agreed
5	12mm diameter High Yield Reinforcement	100	0	agreed
6	Sawn formwork to sides of columns/Beams	88	12	agreed
7	Hollow sandcrete blockwall 230 mm walls	94	6	agreed
8	Roof covering; 0.55mm Aluminium Longspan	94	6	agreed
9	Water proof Felt work	47	53	not agreed
10	Steel tuss members	94	6	agreed
11	Wood Trusses; 50x100mm Hard wood rafters and Struts	82	18	agreed
12	Aluminium window size 1200 x 1200mm high	94	6	agreed
13	External Doors size 1200 x 2100mm	82	18	agreed
14	Internal doors size 900x2100mm high	94	6	agreed
15	Balustrade; 50mm diameter stainless/ steel tubular	59	41	agreed
16	Floor Finish; 400 x400 x 8mm thick vitrified/ ceramic tiles	100	0	agreed
17	Wall Finish; Emulsion paint to rendered wall	100	0	agreed
18	Ceiling Finish; Suspended ceiling; state type.....	100	0	agreed
19	Water Closet	71	29	agreed
20	Wash hand basin	53	47	agreed
21	Air conditioner; 1.5 Hp split unit	82	18	agreed
22	Fire Hose reels	76	24	agreed
23	Fire extinguishers	100	0	agreed
24	Electrical cable 1.5mm single core cable	100	0	agreed
25	Electrical fittings; wall brackets / LED lamps	100	0	agreed
26	Public Address System	47	53	not agreed
27	Interlocking stones	76	24	agreed
28	Kerbs	53	47	agreed

Source: Researcher's work (2024)

The figure 1, bar chart has two colours, blue and orange. The blue colour indicated the size of the respondents that agreed with the suggested indicator items while the orange indicated the size of respondents that disagreed with inclusion of such indicator items in Tender price indices as represented in percentages in table 1.



2.3 Method of Data Analysis and Presentation

Post-survey tasks include collating, arranging, and analysis of the data in relation to the objectives of the study, which is to identify cost information required to develop TPI for public buildings in Nigeria. The Cost information items were selected from the Trade sections. The trade section items were selected based on observation of trades that appears in most public buildings in Nigeria. Using the BCIS rule, which states that trade items that represent about 25% of the total project cost. On this basis, thirteen (13) trade sections were identified out of the 14 structured in the pilot survey as shown in table 2. The indicator items suggested in the structured pilot survey are items of BOQ with significant cost of more than 1%. Based on this, 26 out of 28 indicator items were selected for the study as shown on the table 2.

Table 2. Accepted Cost Information (Indicator items)

Indicator items (I.I) and Weightings	
s/n	**Items Description**
1	Excavation
2	Laterite filling
3	Plain concrete G15 (1:3:6 - 19 mm agg) in Foundations
4	Reinforced concrete G25 (1 : 2 : 4-19mm agg) in Columns
5	12mm diameter High Yield Reinforcement
6	Sawn formwork to sides of columns/Beams
7	Hollow sandcrete blockwall 230 mm walls
8	Roof covering; 0.55mm Aluminium Longspan
9	Steel tuss members
10	Wood Trusses; 50x100mm Hard wood rafters and Struts
11	Aluminium window size 1200 x 1200mm high
12	External Doors size 1200 x 2100mm
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16	Wall Finish; Emulsion paint to rendered wall
17	Ceiling Finish; Suspended ceiling; state type….....
18	Water Closet
19	Wash hand basin
20	Air conditioner; 1.5 Hp split unit
21	Fire Hose reels
22	Fire extinguishers
23	Electrical cable 1.5mm single core cable
24	Electrical fittings; wall brackets / LED lamps
25	Interlocking stones
26	Kerbs

Source: Researcher's work (2024)

3. Result and Disussion

To satisfy the objective of the study, this research deduced from the respondents that all items with 48% and above were accepted as 'agreed' and all items from 47 and below were 'not agreed' with. Out of the 28 items suggested by the pilot survey, 26 items made it as indicator item with 48% and above and hence the list on table 2.

4. Conclusion and Recommendation

TPI being a measure of price movement for tenders over time, requires monitoring of price changes of indicator items also known as basket of goods. This survey etsblished the indicators items whose price movement are significant to be used in development of TPI. Thirty (30) pilot survey were conducted through electronic means but 17 responses were received which was adequate to reach a conclusion. Twenty (26) indicator items on table 2, out of the twenty eight (28) indicator items on table 1, suggested to the registered quantity surveyors were agreed upon as items which it price movement are significant to impact the cost of building projects. Hence , twenty six (26) building cost indicator items are recommended for TPI development for public building projecst in Nigeria.

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Development of a Mobile Based Geospatial Data Collection Tool for Realtime Analysis

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Abstract

In today's rapidly advancing technological landscape, the need for precise, efficient, and user-friendly geospatial data collection tools has become more essential than ever, especially as location-based information grows increasingly important. This study aims to develop a mobile application for geospatial data collection that surpasses the limitations of traditional methods and specialized devices. The objective is to create a geo-relational database for raw materials and enable seamless data integration/impact measurement as well as develop a cross-platform geospatial mobile application. The project employed a comprehensive approach combining software development, data management, and rigorous testing. The mobile application was developed using Android Studio IDE and Flutter framework for cross-platform compatibility, with Hypertext Preprocessor (PHP) for backend Application Programming Interface (API) creation and MySQL for cloud-based database management. The Flutter framework was used to create the frontend, providing access to the camera, GPS, and network services of the mobile device. The application was designed to capture GPS coordinates, images, and attribute data, integrating seamlessly with a cloud server for real-time data access. Accuracy and usability tests compared the mobile application's performance with traditional handheld GPS devices under various environmental conditions. In open sky conditions, the mobile application achieved an accuracy of 4.0 meters compared to the handheld GPS device's 3.7 meters. In dense vegetation cover, the mobile application demonstrated an accuracy of 5.0 meters, while the handheld GPS device had an accuracy of 6.5 meters. Usability tests revealed that the mobile app's intuitive interface significantly enhances user experience compared to the monochromatic and less user-friendly displays of handheld GPS devices. The mobile application's real-time data synchronization capabilities and offline data storage ensure continuous data flow, even in areas with intermittent internet access. A cost-benefit analysis indicates that the mobile GIS application is not only versatile and scalable but also offers significant economic advantages over traditional GPS devices, which are limited in functionality and utility. The mobile GIS application proves to be a viable and cost-effective alternative to single-purpose dedicated devices like handheld GPS units. It offers enhanced functionality, real-time data capture, and integration capabilities, making it a superior choice for modern geospatial data collection needs.

Keywords: Cloud storage, Cross-platform, Geospatial, GPS accuracy, Mobile application, Real-time analysis, Usability testing, Mobile GIS, Geospatial Data Collection, Cross-Platform Application, Offline Functionality, User Interface Design, Data Validation, Geo-Relational Database, Flutter Framework, MySQL Database Management, Location-Based Services, Raw Material Management

1. Introduction

Geomatics, Geomatics, the science encompassing surveying, geodesy, GIS, and other spatial disciplines (Duckham *et al.*, 2009), has undergone significant transformation due to technological advancements. The integration of mobile devices, GPS, and wireless communication has revolutionized data collection processes, enabling more efficient and accurate data acquisition (Kuper, 2018). As societies increasingly rely on geographic information for decision-making, the demand for robust and user-friendly geospatial data collection tools has grown (Joel, 2015).

Traditional methods for capturing and managing raw material locations using GPS and mobile cameras are prone to errors and inefficiencies. To address these challenges, this research focuses on developing a mobile GIS solution that enhances data accuracy, reduces operational costs, and improves decision-making in the management of raw materials. The study further aims to enhance the flexibility of point data collection on the Earth's surface, adapting to evolving needs and promoting continuous improvement. Additionally, it seeks to achieve cross-platform integration, accessibility, and seamless cloud-based storage for easy data access.

By leveraging the capabilities of mobile devices and GIS, this research contributes to the growing body of knowledge on mobile GIS applications and their potential to support various sectors, including government, environmental science, and urban planning.

2. Literature Review

2.1 Mobile GIS for Data Collection

Mobile Geographic Information Systems (MGIS) have emerged as indispensable tools for efficient and accurate data collection, surpassing traditional methods. The evolution from manual mapping to GPS-based systems, as highlighted by Baker & Gaspard (2007) and Trimble Navigation Limited (2015), underscores the technological advancements in this field.

Central to MGIS is the ability to capture both spatial and descriptive information (Jung, 2011). Unlike their desktop counterparts, mobile GIS systems extend capabilities to the field, enabling real-time data collection, analysis, and sharing (Tsou, 2004). Core components include distributed spatial databases, mobile geo-computing, and personalized visualization (Shi *et al*., 2009; Reichenbacher, 2001).

Accurate positioning is fundamental. GNSS, cellular networks, and Wi-Fi technologies contribute to precise location determination (Misra & Enge, 2006; Gao *et al*., 2013; Bulusu *et al*., 2000). Efficient data management is facilitated by mobile databases (Barbará, 1999), while data exchange is streamlined through web-based formats like GML (Cox *et al*., 2001). Relational databases support attribute data management (Sencha, 2011).

Location-Based Services (LBS) harness positioning and geographic information to deliver user-centric applications (Lemmens, 2011; Abdalla, 2016). Google Maps exemplifies LBS capabilities, offering navigation, search, and location-based insights.

2.2 Challenges and Opportunities

While MGIS has shown significant promise, challenges persist. Limited battery life, network connectivity issues, and varying device capabilities can hinder data collection efficiency. Additionally, ensuring data accuracy and quality in dynamic field environments remains crucial. To address these challenges, researchers and practitioners have explored innovative solutions. For instance, Sarbazvatan *et al*. (2023) developed the "LandInfo" app to streamline LULC data collection, demonstrating a 22.97% reduction in data collection time compared to manual methods.

2.3 Future Directions

Future research should focus on enhancing data quality, improving battery life, and developing robust offline capabilities. Integration of emerging technologies like artificial intelligence and machine learning can further optimize data collection processes. Moreover, exploring user experience and interface design is essential for maximizing the potential of MGIS applications. By addressing these challenges and capitalizing on emerging opportunities, MGIS can continue to revolutionize data collection across various domains, from environmental monitoring to urban planning.

3. Methodology

3.1 Development of Geo-Relational Database of Raw Materials

To establish a comprehensive geo-relational database for granite, limestone, kaolin, and gypsum, a combination of field observation and data management techniques was employed. Field surveys used GPS devices to record precise geolocation coordinates of mineral deposits. Detailed attribute information, such as mineral type, quantity, quality, accessibility, ownership, and extraction methods, was collected using standardized forms. Photographs of the deposits were taken to document visual characteristics.

A logical data model was developed to structure the database, which was implemented using SQL on a MySQL relational database. The schema included fields for unique identifier, industrial specification, quantity, location name, date, image reference, latitude, longitude, and material identifier. Spatial data was integrated with appropriate spatial data types and indexes to optimize query performance.

Data cleaning and validation procedures were applied to ensure accuracy and consistency, including checks for outliers, inconsistencies, and missing values.

3.2 Development of cross platform geospatial mobile application

A cross-platform mobile application was developed using Flutter to facilitate efficient geospatial data collection. The following steps were undertaken:

a) **User Interface Design:**
- Develop intuitive user interfaces.
- Create forms for capturing mining site attributes.
- Design interactive maps for location selection.

b) **Data Capture:**
- Utilize device sensors to capture GPS coordinates.
- Integrate relevant attributes into the application.

c) **Data Validation:**
- Incorporate data validation checks to maintain integrity and consistency.

d) **Data Synchronization:**
- Implement a robust mechanism for data synchronization.
- Ensure timely transfer of collected data to the backend database.

e) **Offline Functionality:**
- Enable offline data collection capabilities.
- Implement synchronization for areas with limited network connectivity.

3.3 Data Integration and Impact Measurement

To ensure data accuracy and seamless integration, rigorous validation protocols were implemented at both the mobile and server levels. PHP APIs were developed to facilitate data exchange between the mobile application and the geo-relational database using JSON (JavaScript Object Notation) format. Robust error handling and security measures were incorporated to protect data integrity and confidentiality.

4. Result and discussion

4.1 Accuracy Testing

To assess the accuracy of the mobile GIS application, testing was conducted under different environmental conditions, including open sky and dense vegetation cover. In open sky conditions, with a 5-minute observation period, the mobile application demonstrated an accuracy of 4.0 meters, while the handheld GPS device showed a slightly higher accuracy of 3.7 meters. In dense vegetation, both devices experienced reduced accuracy due to obstructed GPS signals. The mobile application achieved an accuracy of 5.0 meters, while the handheld GPS device exhibited an accuracy of 6.5 meters. Despite the challenges, the mobile application maintained reasonable accuracy levels, making it a reliable tool for geospatial data collection. Further enhancements could improve its performance in more challenging environments.

4.2 Usability Test

To assess usability, a test was conducted comparing the mobile app's user interface with that of the handheld GPS device. The mobile app's interface proved to be significantly more intuitive and visually engaging. It featured a graphical interface displaying a live map of the captured location, providing users with real-time visual feedback. This functionality enhanced user experience and facilitated easier navigation and data capture in the field.

In contrast, the handheld GPS device had a monochromatic display, typically black and white, which limited visual clarity and appeal. Users found it less intuitive to navigate and operate due to its basic interface design. Additionally, the handheld GPS required a period of familiarization for users to become accustomed to its functions and controls. Overall, the usability test highlighted the clear advantage of the mobile app in terms of user interface design and ease of use, offering a more seamless experience for field data collection compared to the handheld GPS device.

4.3 Realtime Data Synchronization

The real-time data synchronization test demonstrated the mobile application's ability to handle data transmission seamlessly under various network conditions. With internet access, the app promptly synchronized data with the cloud server, ensuring immediate availability for further processing and analysis. In offline environments, the app stored data locally, preserving its integrity and preventing data loss. Upon reconnecting to the internet, the app automatically uploaded the locally stored data to the cloud server. This seamless transition between online and offline modes ensured continuous data flow and maintained data integrity throughout the field data collection process.

The mobile GIS application offers several advantages, including versatility by utilizing existing Android or iOS devices, which enhances user convenience and maximizes device use. It provides real-time data capture, allowing immediate access to field data and improving operational efficiency and decision-making. Additionally, the application is scalable, easily adapting to growing data collection needs and ensuring long-term viability.
In contrast, traditional GPS devices are cost-efficient with a lower initial acquisition cost but have limited versatility and long-term cost-efficiency. They are reliable in acquiring GPS signals and capturing accurate location data but lack real-time data synchronization capabilities, which can lead to delays in data processing. Moreover, while traditional GPS devices are suitable for specific field data collection tasks, they lack the flexibility needed for broader geospatial data management.

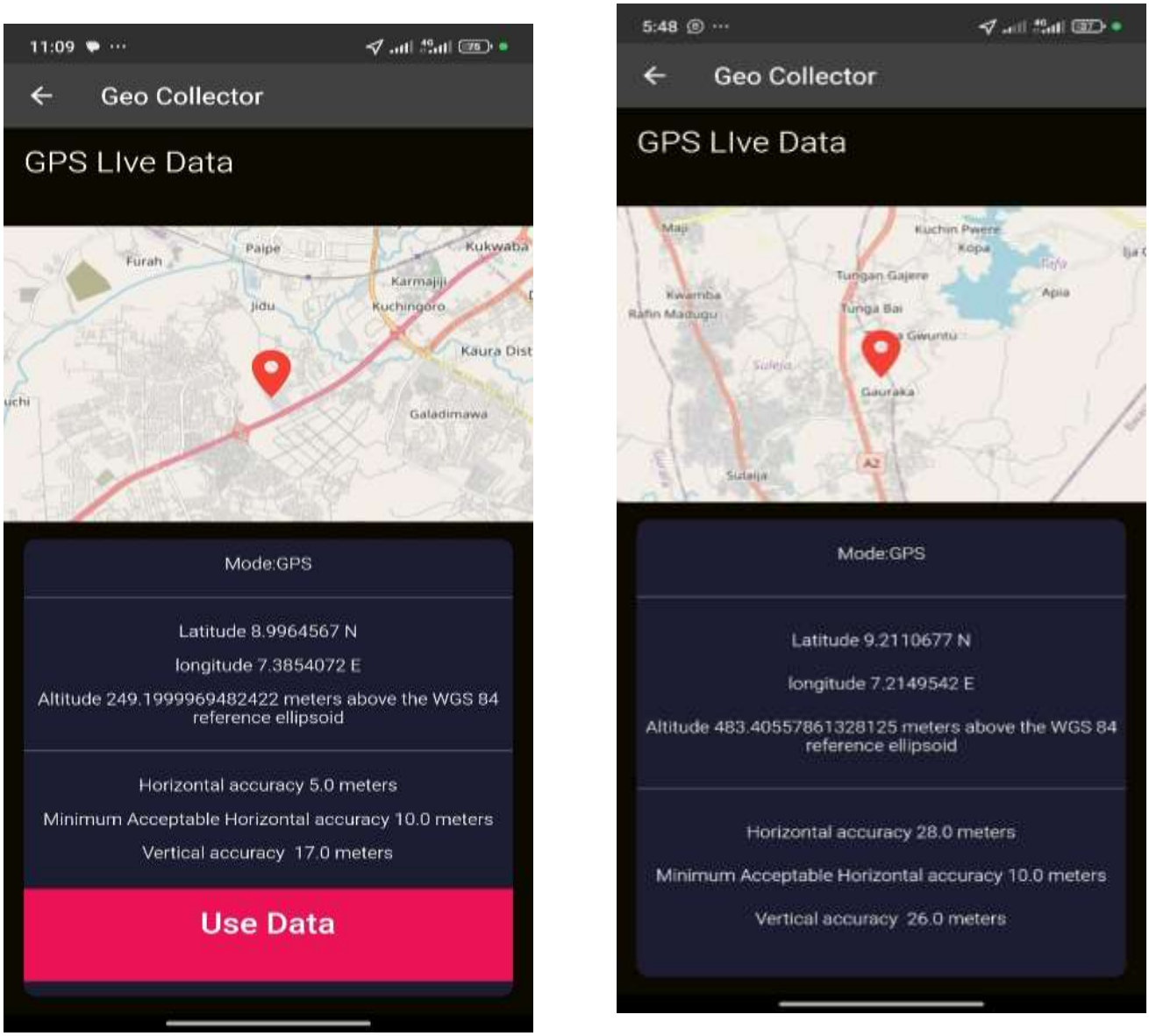

Figure 3.1: showing designed user interface with live map and accuracy

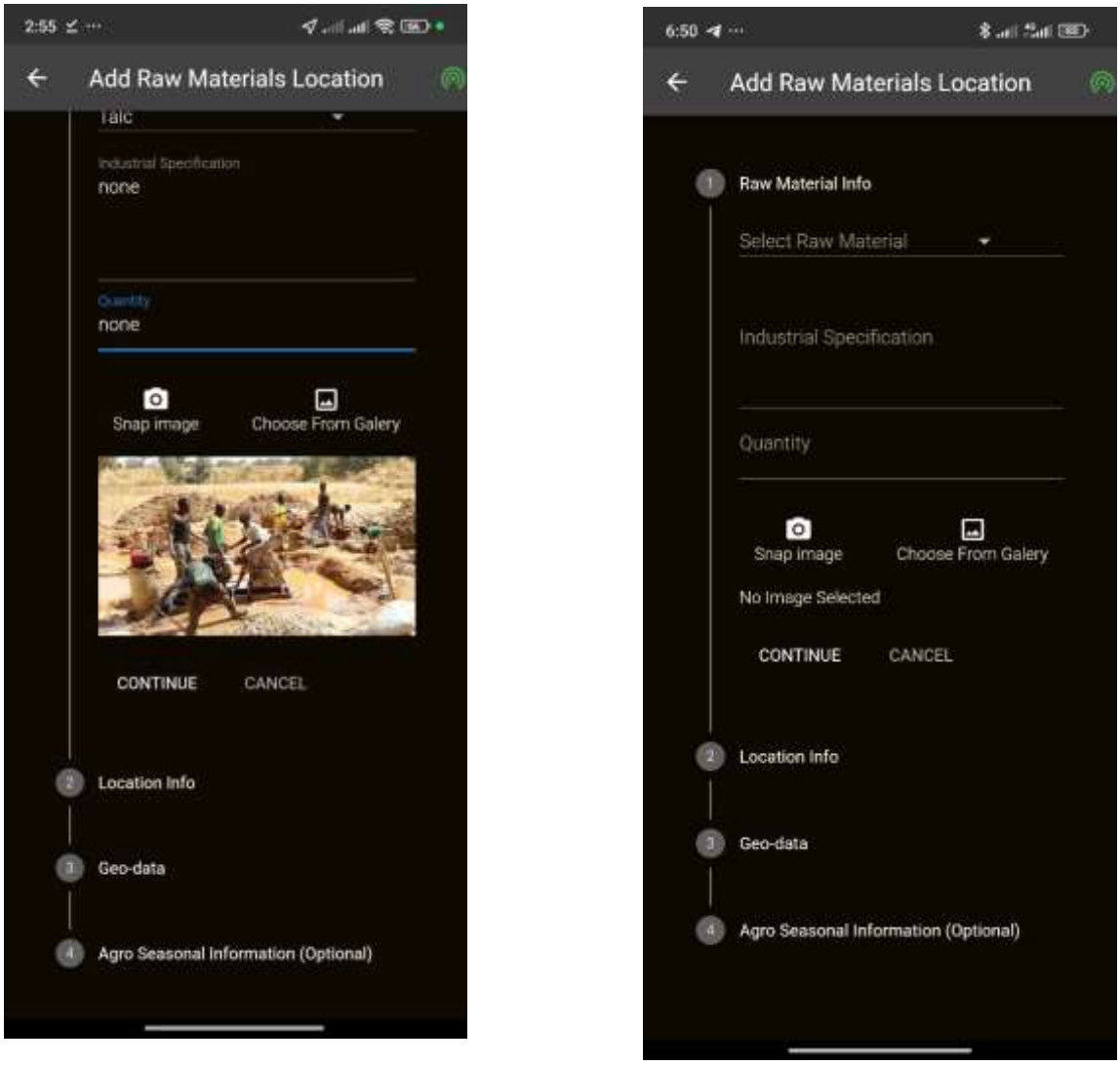

Figure 3.2: showing image of material and location information

5. Conclusion

The research concludes that the mobile GIS application outperforms traditional handheld GPS devices in usability, real-time data synchronization, and offline resilience. The app's intuitive interface and live map feature enhance user experience and navigation, while its ability to manage data transmission under various network conditions ensures continuous data flow and integrity. These advantages make the mobile GIS application a superior tool for geospatial data collection, particularly in remote or resource-constrained areas.

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Enhancing Workability and Passing Ability in Self-Compacting Concrete Using Fly Ash and Millet Husk Ash

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Abstract

This study evaluates the synergistic effects of Fly Ash (FA) and Millet Husk Ash (MHA) on the workability and passing ability of self-compacting concrete (SCC). Eight SCC mix compositions, adhering to EFNARC (2005) standards, were prepared with varying proportions of Portland Cement (PC), FA, and MHA. Slump flow and passing ability tests measured fresh properties. Results indicate that mixes with 70% PC, 25-30% FA, and 0-10% MHA achieved optimal workability, with slump flow values ranging from 620-648 mm and passing ability ratios (H2/H1) between 0.83-0.87. Conversely, mixes with higher MHA content (20-30%) and minimal FA exhibited reduced performance, requiring additional water or superplasticizers. These findings offer insights into optimizing SCC for sustainable construction while maintaining high performance, especially in dense reinforcement or complex formwork.

Keywords: Fly Ash (FA), Millet Husk Ash (MHA), Supplementary cementitious materials (SCMs), Self-compacting concrete (SCC), Passing ability, Passing ability.

1. Introduction

Self-compacting concrete (SCC) is a high-performance material addressing challenges like labor shortages and complex formwork, ensuring superior fluidity without mechanical vibration. However, the environmental impact of Portland cement (PC), a key SCC component, necessitates integrating supplementary cementitious materials (SCMs) to reduce carbon emissions and enhance concrete properties. Fly Ash (FA) and Millet Husk Ash (MHA), agro-industrial byproducts, show promise as SCMs due to their pozzolanic activity. FA enhances flowability and durability, while MHA improves microstructure and sustainability by utilizing agricultural waste. Despite extensive studies on individual SCMs, limited research explores their combined effects on fresh SCC properties like slump flow and passing ability. This study addresses this gap, focusing on the synergistic interactions between FA and MHA in optimizing SCC's workability and sustainability.

1.1 Statement of the Problem

Concrete structures play a crucial role in modern construction but often face challenges related to workability, passing ability, and segregation resistance. Self-compacting concrete (SCC) addresses these issues with its superior fluidity, eliminating the need for mechanical vibration and enhancing fresh properties. Its mix design, typically improved with superplasticizers and viscosity modifiers, helps prevent segregation while improving flow ability and passing ability. Supplementary cementitious materials (SCMs) like silica fume, fly ash, and millet husk ash further enhance these characteristics. However, further research is needed to determine the optimal combination of SCMs, particularly in ternary blends, to improve SCC's flow ability, passing ability, and segregation resistance.

1.2 Aim and Objectives

The main objective of this research is to investigate how the combination of FA and MHA affects SCC's fresh properties of self compacting concrete (SCC).

To achieve the aim of the study the following objectives would be executed;

1) To evaluate fresh properties of self compacting concrete such as slump flow and passing ability,
2) To determine the optimal mix proportions of blended MHA with FA in self compacting concrete (SCC).
3) To assess the individual effects of Fly Ash (FA) and Millet Husk Ash (MHA) on the fresh properties of self-compacting concrete (SCC), with a focus on workability and passing ability.

1.3 Significance of the study

The significant of this study lies in its potential to address key challenges in construction. With cement production contributing to 8% of global carbon emissions, finding alternatives like FA and MHA is critical for reducing environmental impact without compromising concrete performance. This research is also timely as modern construction projects require efficient mix designs for high-performance SCC, particularly in complex structures with dense reinforcement. The findings could help concrete producers and structural engineers fine-tune their mix designs to optimize SCM use while maintaining performance standards, particularly in areas where millet husk is locally available.

Additionally, the study promotes circular economy principles in the construction industry by incorporating agro-waste into concrete production. This reduces waste sent to landfills and the environmental burden of cement production, aligning with global trends in sustainable construction. Overall, the research aims to fill a critical knowledge gap and provide actionable guidelines for the use of FA and MHA in SCC, with significant implications for improving material efficiency, sustainability, and performance in the construction industry.

2. Literature Review

The increasing global demand for more sustainable construction methods has placed a focus on the development and application of supplementary cementitious materials (SCMs). SCMs help to reduce the reliance on Portland cement (PC), which is responsible for a substantial portion of global carbon dioxide emissions due to its energy-intensive production process (Nwankwo *et al.,* 2020). These materials—such as fly ash (FA), silica fume (SF), rice husk ash (RHA), and millet husk ash (MHA)—are employed to enhance the properties of concrete, acting as pozzolanic materials that react with the calcium hydroxide generated during the hydration process. The pozzolanic reaction produces additional calcium silicate hydrate (C-S-H), a compound responsible for the strength and durability of concrete.

The integration of SCMs into self-compacting concrete (SCC) has proven particularly effective in addressing key challenges related to workability, durability, and long-term performance (Aziz *et al.,* 2024). SCC is a highly flowable concrete that consolidates under its own weight, filling formwork and densely reinforced areas without requiring vibration. This eliminates the need for mechanical compaction, thus improving construction speed and quality. The standards governing SCC, such as those outlined by EFNARC (2005), emphasize specific fresh properties like slump flow and passing ability. Slump flow, a measure of SCC's horizontal spread, should typically range between 550 mm and 850 mm, while passing ability, evaluated by the L-box test, should produce a height ratio (H_2/H_1) between 0.8 and 1.0. These parameters are essential for ensuring that SCC can flow freely through congested reinforcement without segregation or blocking.

2.1 Review of Previous Research and Studies

A significant body of research has focused on the use of fly ash (FA) in SCC due to its well-documented benefits. FA is a byproduct of coal combustion and possesses fine particles that improve the flowability of concrete mixtures by reducing the internal friction between particles. Research by Ahmad *et al.,* (2020) and Deepika *et al*., (2014) shows that incorporating FA into SCC can improve workability, reduce the water-to-cement ratio, and enhance the durability of the concrete. Ahmad *et al*., (2020) noted that FA content between 20-30% was particularly effective in maintaining flowability and passing ability within EFNARC standards, without compromising the strength of the mix. The study concluded that FA, due to its pozzolanic properties and spherical particle shape, allows SCC to achieve the desired fluidity and self-compacting characteristics.

In addition to FA, agro-waste materials such as rice husk ash (RHA) and millet husk ash (MHA) have been explored for their potential as SCMs. RHA has been extensively studied and found to significantly enhance both fresh and hardened properties of concrete. Studies like those conducted by Givi *et al.,* (2012) have shown that RHA, when used in appropriate proportions, improves the strength and durability of concrete while reducing permeability. Millet husk ash (MHA), while relatively underexplored, holds similar potential due to its high silica content. Studies on the utilization of millet husk ash in concrete indicate that the ash possesses pozzolanic properties (Jimoh *et al.,* 2013) and can serve as a partial substitute for cement to enhance the characteristics of concrete (Uche *et al.,* 2012).

However, research specific to MHA's application in SCC is limited, and there is a need for more studies to understand its effects on fresh properties like flow ability and passing ability.

The combined use of SCMs, such as FA and MHA, in SCC is a relatively new area of investigation. Some studies, like those by Tahmid *et al.* (2021), have explored the interaction between FA and other SCMs in concrete, observing that higher FA content generally leads to better flowability but can reduce early strength. However, few studies have systematically investigated the combined effects of FA and MHA in SCC, particularly in terms of fresh properties. This lack of comprehensive research on the synergy between these SCMs highlights an important gap in the literature.

2.2 Identification of Gaps and Limitations

While previous studies have provided valuable insights into the individual effects of SCMs like FA and agro-waste ashes in concrete, there remains a clear gap in the research regarding the combined use of FA and MHA in SCC. Existing studies often focus on one SCM at a time, neglecting to examine how multiple SCMs interact within the concrete matrix. Furthermore, most research has focused on hardened properties like compressive strength and durability, while fresh properties such as slump flow, passing ability, and segregation resistance remain underexplored. Additionally, a significant limitation in the current body of research is the inconsistent adherence to standard testing procedures, such as those outlined by EFNARC (2005). Ensuring that future studies strictly follow these standards is essential to generate reliable and applicable data for SCC applications in real-world construction scenarios.

2.3 Framework for the Current Study

This study aims to address these research gaps by exploring the combined use of FA and MHA in SCC, with a particular focus on fresh self compacting concrete properties, specifically slump flow and passing ability. The research adheres to EFNARC (2005) standards for SCC, ensuring that the results can be applied to practical construction settings. SCC mixtures were prepared with a fixed 70% PC content, while FA and MHA proportions were varied to investigate their synergistic effects. The slump flow test was conducted to measure the flowability of the concrete, while the L-box test was used to assess its passing ability through tight reinforcement, ensuring compliance with the H2/H1 ratio required by EFNARC standards.

To ensure the reliability and validity of the findings, multiple samples were prepared for each mix, and strict controls were implemented during testing. The concrete was mixed under laboratory conditions, and the water-cement ratio, temperature, and mixing time were kept consistent across all samples to minimize variability. Statistical analyses were employed to interpret the data, including ANOVA (Analysis of Variance), which was used to determine the significance of differences between the various mix compositions. ANOVA is particularly effective in evaluating whether variations in FA and MHA proportions result in statistically significant changes in SCC's workability and passing ability. The use of statistical analysis adds robustness to the research, ensuring that the findings are not due to random variability but are instead reflective of the materials' inherent properties.

This rigorous approach provides a comprehensive framework for assessing the potential of FA and MHA as combined SCMs in SCC. By filling a critical gap in the literature and adhering to standardized testing procedures, the study seeks to offer practical insights into optimizing concrete mix designs for enhanced workability and sustainability.

3. Materials and Methods

3.1 Materials

The materials used in this study include:

1. **Portland cement (PC):** Ordinary Portland Cement (OPC) conforming to ASTM C150 specifications was used as the primary binder.
2. **Fly Ash (FA):** Class F fly ash, which complies with ASTM C618 standards, was used as a partial cement replacement. FA is known for its fine particle size and pozzolanic properties, which improve the workability of SCC.
3. **Millet Husk Ash (MHA):** MHA was sourced from locally available agro-waste and processed through controlled combustion at 600°C. The ash was sieved to obtain fine particles suitable for use as SCM. MHA was characterized for its silica content, pozzolanic activity, and particle size distribution in accordance with ASTM C311.
4. **Fine and Coarse Aggregates:** The fine aggregates (natural sand) used met the requirements of ASTM C33, while the coarse aggregates were crushed granite, also complying with ASTM C33 standards.
5. **Superplasticizer:** A sika viscocrete sky 504 was used to enhance the workability of the SCC mixes, maintaining consistency across all mixes. The dosage was adjusted as needed to meet EFNARC guidelines for slump flow.
6. **Water:** Potable water, free of impurities, was used in all mixes.

3.2 Mix Proportions

A total of eight SCC mixes were prepared. The control mix contained 100% PC without any SCMs. The other seven mixes consist of 70% PC with varying proportions of FA and MHA. The FA and MHA percentages ranged from 0% to 30%, with incremental substitutions, to investigate their combined effects on fresh concrete properties. The mix design followed EFNARC (2005) recommendations to ensure self-compactability. Table 1 summarizes the mix proportions for each batch:

Table 3.1: Mix Proportion

S/ No	Mix ID	Types of Paste	Total Binder kg/m³	PC kg/m³	FA Kg/m³	MHA Kg/m³	Fine Agg. Kg/m³	Coarse Agg. Kg/m³	Water Kg/m³	SP (%)	W/B Ratio
1	SCC	Control	460	460	0	0	883	553	179.4	4.14	0.39
2	70% PC + 0% MHA + 30% FA	Binary	460	322	138	0	883	553	193.2	4.14	0.42
3	70% PC + 5% MHA + 25% FA	Ternary	460	322	115	23	883	553	198	4.14	0.43
4	70% PC + 10% MHA + 20% FA	Ternary	460	322	92	46	883	553	207	4.14	0.45
5	70% PC + 15% MHA + 15% FA	Ternary	460	322	69	69	883	553	221	4.14	0.48
6	70% PC + 20% MHA + 10% FA	Ternary	460	322	46	92	883	553	225.4	4.14	0.49
7	70% PC + 25% MHA + 5% FA	Ternary	460	322	23	115	883	553	244	4.14	0.53
8	70% PC + 30% MHA + 0% FA	Binary	460	322	0	138	883	553	248.4	4.14	0.54

3.3 Sample Preparation

The concrete mixtures were prepared in a standard laboratory concrete mixer. The fine and coarse aggregates were first mixed dry, followed by the addition of PC, FA, and MHA. The materials were mixed for two minutes before water and superplasticizer were added gradually. The mixing process continued for an additional three minutes to ensure uniform distribution of all ingredients.

All samples were prepared under controlled laboratory conditions, maintaining a consistent temperature of 25°C and humidity of 60%. Each mix was tested immediately after preparation to evaluate fresh concrete properties.

3.4 Testing Methods

1. Slump Flow Test: This test was conducted in accordance with EFNARC (2005) standards to determine the flowability of SCC. The slump flow was measured by placing fresh concrete into a standard Abrams cone, lifting the cone vertically, and measuring the spread of the concrete. The target slump flow was within the range of 550 mm to 850 mm, which is ideal for SCC.
2. Passing Ability (L-box Test): The L-box test, also as per EFNARC guidelines, was used to assess the passing ability of SCC through reinforcement without blockage. The test measures the height ratio (H2/H1) of the concrete as it flows through bars, with a target ratio of 0.8 to 1.0. This ensures the mix can pass through densely reinforced areas without segregation.

4. Results

4.1 Presentation of Findings

The results of the slump flow and passing ability tests for each SCC mix are summarized in Table 4.3. The slump flow values varied across different mix compositions, demonstrating the influence of FA and MHA on the workability of SCC.

Table 4.1 slump flow and passing ability test result

S/No	Mix ID	Slump Flow (mm)	Passing Ability (H2/H1)	H1 (mm)	H2 (mm)
1	SCC	610	0.81	107	87
2	70% PC + 0% MHA + 30% FA	648	0.87	103	90
3	70% PC + 5% MHA + 25% FA	634	0.85	105	89
4	70% PC + 10% MHA + 20% FA	620	0.83	102	85
5	70% PC + 15% MHA + 15% FA	590	0.8	105	84
6	70% PC + 20% MHA + 10% FA	540	0.74	105	78

7	70% PC + 25% MHA + 5% FA	525	0.7	107	75
8	70% PC + 30% MHA + 0% FA	515	0.68	107	73

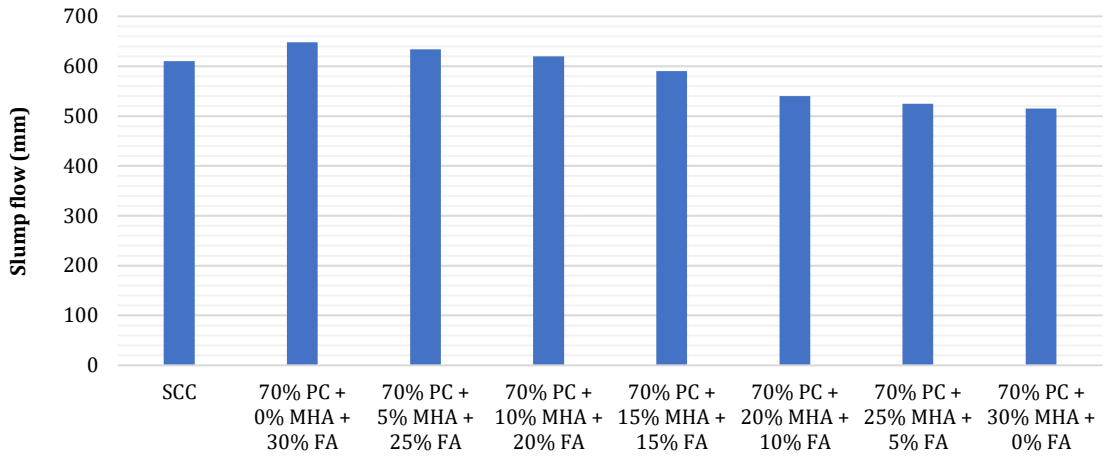

Figure 4.1: Slump values for various mixes tested.

The slump flow values, which indicate the workability and fluidity of self-compacting concrete (SCC), varied significantly across the different mix compositions. The control mix, containing 100% Portland Cement (PC), showed a slump flow of 610 mm, serving as the baseline for comparison with mixes incorporating supplementary cementitious materials (SCMs) such as fly ash (FA) and millet husk ash (MHA). The mix with 70% PC + 0% MHA + 30% FA demonstrated the highest slump flow at 648 mm, indicating that the addition of 30% FA significantly enhanced the fluidity of the concrete. This is consistent with previous studies that show FA's ability to improve SCC workability due to its spherical particle shape, which reduces internal friction. The mix with 70% PC + 5% MHA + 25% FA had a slightly lower slump flow of 634 mm but still maintained good fluidity, with the minor reduction likely due to the introduction of MHA, which can increase water demand due to its different particle shape. For the 70% PC + 10% MHA + 20% FA mix, the slump flow decreased further to 620 mm, reflecting the impact of increasing MHA content, though the mix remained within the acceptable range for SCC applications. As the MHA content increased in the 70% PC + 15% MHA + 15% FA mix, the slump flow dropped to 590 mm, showing a more pronounced reduction in flowability as FA content decreased. The mix with 70% PC + 20% MHA + 10% FA exhibited a slump flow of 540 mm, marking a significant drop in fluidity, likely due to MHA dominating the effects of FA. The 70% PC + 25% MHA + 5% FA mix showed a slump flow of 525 mm, indicating a further reduction in workability as MHA content increased. The lowest slump flow, 515 mm, was observed in the mix with 70% PC + 30% MHA + 0% FA, demonstrating that high MHA content without FA results in a much stiffer mix, potentially requiring additional water or superplasticizer to improve its flowability.

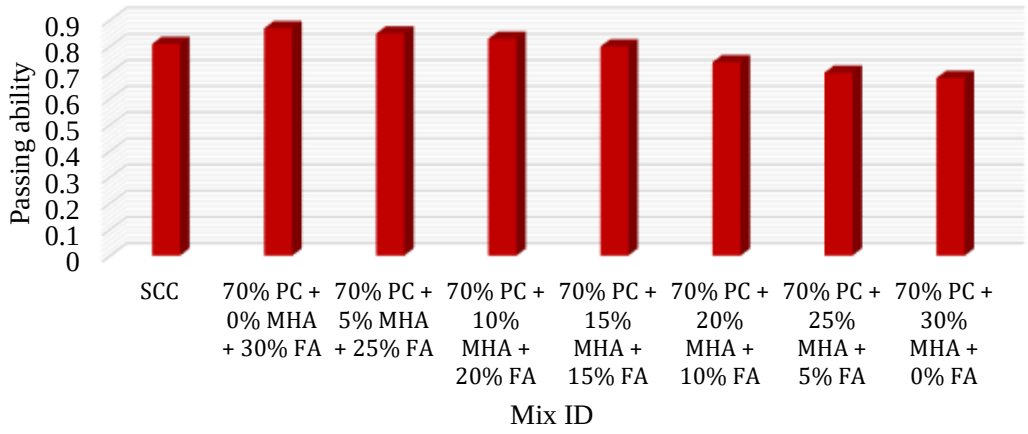

Figure 4.2: Passing ability values for various mixes tested

The passing ability (H2/H1) ratio, which measures how well self-compacting concrete (SCC) flows through reinforcements without segregation, varied across the mix compositions. The control mix (SCC) had a passing ability of 0.81, serving as a reference for comparison with other mixes and falling within the acceptable range for SCC. The mix containing 70% Portland cement (PC) + 0% Millet Husk Ash (MHA) + 30% Fly Ash (FA) achieved the highest passing ability at 0.87, suggesting that the 30% FA not only improved fluidity but also enhanced the mix's ability to pass through obstacles efficiently. In the 70% PC + 5% MHA + 25% FA mix, the passing ability slightly decreased to 0.85, likely due to the introduction of MHA, though the mix still maintained strong performance. As the MHA content increased and FA content decreased in the 70% PC + 10% MHA + 20% FA mix, the passing ability dropped to 0.83, continuing the trend of reduced passing ability. The 70% PC + 15% MHA + 15% FA mix further decreased to 0.80, still within the acceptable range but highlighting the trade-off between higher MHA content and reduced flowability. The passing ability of 0.74 in the 70% PC + 20% MHA + 10% FA mix indicated more difficulty in flowing through tight spaces, likely due to the friction caused by MHA. The 70% PC + 25% MHA + 5% FA mix had a passing ability of 0.70, nearing the lower threshold of acceptable SCC performance, while the 70% PC + 30% MHA + 0% FA mix had the lowest passing ability of 0.68, showing that without the lubricating effect of FA, higher MHA content results in a stiffer mix with reduced passing ability.

5. Conclusions

The conclusions of the study are as follows:

1) **Relationship Between Slump Flow and Passing Ability**:
   Higher slump flow in self-compacting concrete (SCC) corresponds to better passing ability. The mix with **70% Portland Cement (PC)**, **0% Millet Husk Ash (MHA)**, and **30% Fly Ash (FA)** had the highest slump flow (648 mm) and passing ability (0.87), indicating that FA enhances fluidity and passing through obstructions.

2) **Effect of Increased MHA Content**:
   As **MHA content increases** and **FA content decreases**, slump flow and passing ability decline. The mix with **70% PC** and **30% MHA** (no FA) showed the lowest performance (515 mm slump flow and 0.68 passing ability), indicating that MHA reduces workability and passing ability, especially in high dosages. FA's spherical particles improve flow ability, while MHA's irregular particles increase internal friction, leading to stiffer mixes.

3) **Balance Between FA and MHA**:
   To maintain both workability and passing ability, a balance of **up to 25-30% FA** is recommended for optimal SCC performance, as it helps maintain high fluidity within EFNARC standards. For sustainable mixes incorporating MHA, **10-15% MHA** with **15-20% FA** offers a balanced approach that ensures good workability while supporting eco-friendly practices.

4) **High MHA Content Mixes**:
   SCC mixes with higher MHA content, particularly without FA, may need additional water or superplasticizers to maintain sufficient flow and passing ability.

6. Recommendations

The study provides several recommendations for optimizing the use of supplementary cementitious materials (SCMs) such as Millet Husk Ash (MHA) and Fly Ash (FA) in self-compacting concrete (SCC):

1. **Workability and Passing Ability**:
   A combination of **25-30% FA** and **0-10% MHA** is ideal for ensuring high fluidity and ease of passing through reinforcements. This mix achieves slump flow values of 620-648 mm and passing ability ratios between 0.83 and 0.87, making it suitable for general SCC applications.

2. **Sustainability Focus**:
   For projects prioritizing sustainability, a mix of **10-15% MHA** and **15-20% FA** is recommended. This combination reduces cement consumption while maintaining adequate fluidity and passing ability for general construction needs.

3. **High MHA Content**:
   When using **20-30% MHA** with minimal or no FA, reduced workability and passing ability are observed. To counter this, additional water or superplasticizers should be added. These high-MHA mixes are suitable where flow ability is less critical but environmental benefits are a priority.

4. **Tailoring for Specific Projects**:
    a. For structures with dense reinforcement, mixes with higher FA content (**25-35%**) and lower MHA content (**0-10%**) are recommended for better fluidity.
    b. For projects emphasizing sustainability, a higher MHA proportion (**15-25%**) can be used, but water content adjustments or additives may be needed to maintain workability.

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Assessment of natural cooling strategies for improved indoor thermal performance of selected academic buildings at Benue state university Makurdi Nigeria

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Abstract

The age of industrial revolution has firmly stamped its effects on the way buildings and created, perceived and operated. The development of mechanical systems to facilitate activities such as the regulation of indoor temperatures in buildings is one of the ways in which industrial revolution has impacted the building industry. However, the growing concerns of climate change and its consequent effect on global warming has necessitated research into its causes. Researchers believe that, the burning of fossil fuels to power these machines is one of the leading causes of climate change. The aim of this study is to explore sustainable and energy-efficient design approaches that can be employed to provide building occupants with the needed indoor thermal comfort levels without disrupting the ecosystem. The descriptive research method was employed for this research. Quantitative and qualitative data were obtained using instruments such as literature review, observation schedules and oral interviews. The results show that, thermal comfort requirements vary from one climatic region to another and is dependent on the activities such as building. It concludes that, in order to achieve the global sustainability drive, design strategies such as the harvest of natural ventilation, building orientation, the use of courtyards, solar shading devices building materials with high thermal mass and vegetation cover can help in providing the needed levels of thermal comfort without over reliance on mechanical systems.

Keywords: Climate change, Ecosystem, Energy efficient, indoor thermal performance, Natural ventilation, Sustainability.

1. Introduction

In modern societies, it is estimated that people spend over 90% of their time within indoor spaces (Dimitroulopoulou *et al*, 2023). This highlights the importance of providing comfortable indoor thermal conditions in buildings. To achieve this comfort demands, modern buildings utilises a lot of energy. In the late 2000s, evidence emerged that this energy usually derived from the burning of fossil fuels is unclean and unsafe therefore, contributes greatly to the increase in greenhouse gas emission that results in climate change and could negatively affect human life and biodiversity in the future (Tan *et al*, 2020). The building sector in developed societies (residential, commercial and public) is said to account for about 36% of final energy consumption (Santamouris and Vasilakopoulou, 2021). According to (Kamal *et al*, 2012) this building energy consumption accounts for 33% of all annual carbon dioxide emissions. The World Watch Institute also estimates that buildings consume about 40% of the world's energy production for the purposes of lighting and mechanical air conditioning of the interiors to make them thermally comfortable for the users. As a result, buildings are involved in producing about 40% of the sulfur dioxide and nitrogen oxides that cause acid rain and contribute to climate change (Forsius *et al*, 2020). Researchers have argued that, to reduce the impact of climate change, all activities rendering the universe vulnerable such as burning of fossil fuels must be reduced to the barest minimum. The challenge before professionals in the building industry therefore is how to develop sustainable, energy-efficient and better-performing buildings that will reduce reliance on non-renewable and unclean sources of energy to provide comfort in their buildings. Although lowering energy consumption during building operations and construction is the primary focus, but the growing understanding of the advantages of improved occupant comfort and general health conditions has caused the emphasis to move towards a more comprehensive approach to building design.

1.1 The concept of natural ventilation and passive cooling in buildings

The term “passive cooling” was first used by US researchers in the early 1970s to describe any natural method of heat dispersion and temperature regulation that happens without the need for energy (Dhafer *et al*, 2021). The goal

of this approach to building design is to increase indoor thermal comfort while utilising little or no mechanical energy In a "passive" solar design, the interior spaces are kept in balance by utilizing natural heating and cooling systems. Heat transfer happens naturally by conduction, convection, or radiation without the use of an electrical device. This interior space cooling is facilitated by nature using external airflow induced by thermal buoyancy and wind pressure differences between the building and its surroundings (Soliman, 2023). In modern architecture, passive cooling techniques such as natural ventilation, purposive building orientation, solar shading, the use of reflective surfaces, light colour paintings on exterior of structures, cross ventilation, insulated materials, are all regarded as thermal control techniques (Dnyandip *et al,* 2019). They are instrumental in the enhancement of thermal comfort, optimisation of energy efficiency, improvement of indoor air quality, lower building operational costs and ensure sustainability. Notwithstanding the enormity of the benefits of passive cooling, it sometimes can pose very difficult challenges. Apart from the fact that passive cooling is dependent on climate and seasons, its cooling effects are also limited in reach when compared to mechanical systems. Passive design is often a complex process that if not carefully handled, may result in irregular temperature distribution (Soliman, 2023). Heat regulation and distribution in passive design is dependent on the thermal mass of building materials, nature and size of building openings, size of structure, speed and direction of air, solar intensity and direction. Building materials with high thermal mass such as concrete and brick, can be used in building structures to absorb heat in the morning and provide warmth at night. These materials are very helpful, especially for buildings that will be in constant use (Kamal *et al* 2014). Cooling can also be achieved by the use of ventilation tunnels, wind towers, wind catchers, fire chimneys, wind sails, maziaras, and courtyards in hot, dry, and humid regions like the Middle East and North Africa, where cooling is more important than heating (Almusaed, 2011).

1.2 Natural cooling strategies and techniques

The strategies for passive cooling, aim to reduce or prevent heat gains into the building and encourage removal of excess heat from the building (Jarimi *et al*, 2019). They depend largely on the availability of heat sink and promotion of heat transfer towards the heat sink. Passive cooling can be achieved through isolated, direct, and indirect methods of heat loss. Direct heat loss results from the use of natural ventilation, large roof overhangs, shading devices, and even site vegetation. The simplest way to achieve natural ventilation is by placing openings on opposing sides of the building so that natural breezes may cool the interior area. Indirect heat loss on the other hand can be achieved by using earth berms, roof ponds, and trombe walls, which use elements like soil and water to absorb surplus heat and release it into the surrounding environment. The following are key strategies utilized for the attainment of natural cooling in buildings.

Cross ventilation

According to (Ropero, 2023), the process of moving air from one side of a building's interior to the other is known as cross ventilation. In more concise terms, cross ventilation introduces fresh outdoor air into a building interior and distributes it effectively throughout the building for the benefit of the occupants by utilizing the forces of buoyancy and wind pressure (Soliman, 2023). The primary goal of Cross ventilation achievable by the strategic placement of building openings such as shown in fig 1 is to regulate indoor temperatures and revitalise the interior air quality. It provides a healthy, clean, and comfortable indoor atmosphere necessary for people to live and work in. With the raising concerns regarding the cost and environmental impact of energy use, Cross ventilation comes as a resourceful alternative means of cooling buildings. Air quality and the required amounts of oxygen within building interiors are often maintained by providing strategic and adequate fenestrations.

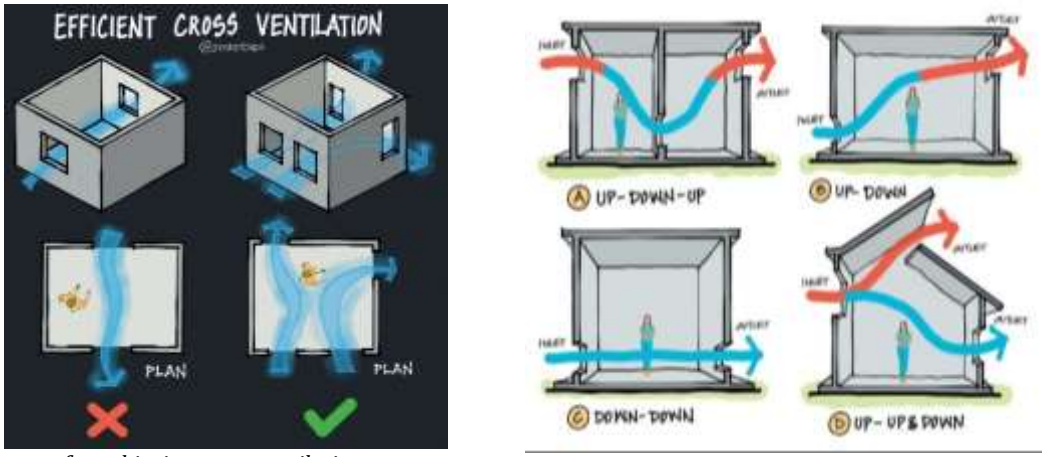

Fig. 1

Patterns for achieving cross ventilation.
(Source: https://www.arch2o.com/passive-cooling-systems, 2024)

Solar shading

With each rising day as the sun shines, solar rays radiate down to the earth's surface, they are absorbed by the medium they come in contact with and thus, significantly alter the temperatures of such medium. For buildings, this can have significant effects on the comfort levels of its interiors. Solar shading therefore, refers to the variety of techniques used to regulate how much heat and light are allowed into a structure from the sun. Although sunlight offers warmth and natural light, too much exposure can cause overheating, necessitating expensive air conditioning cooling (Biro, 2024). Solar shading devices comes in different sizes, shapes and patterns. As can be seen in fig 2, building elements such as roof members and window elements are sometimes designed to help in solar shading. Their main goal is to help in minimising solar gains and modifying heat exchanges through the building envelope. They impact the occupants' thermal and visual comfort as well as the energy consumption of the building for lighting, heating, and cooling. These devices and systems also help prevent uncomfortable occurrences like glare and enable the management of daylight's access into buildings (Bellia *et al*, 2014).

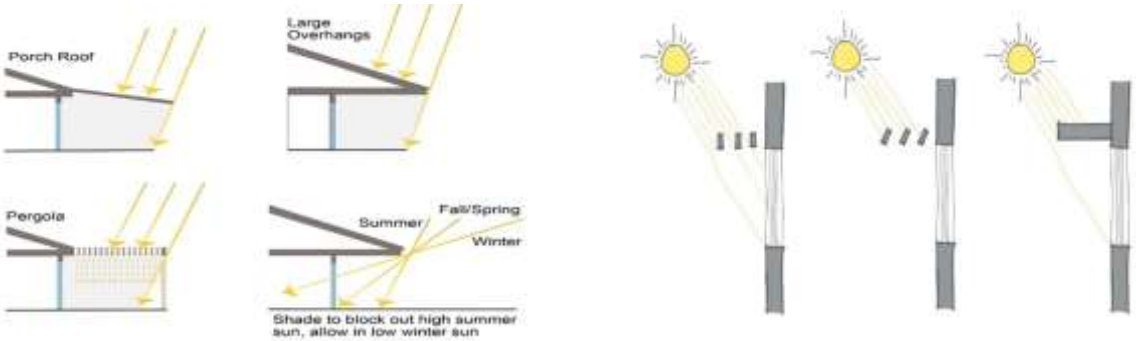

Fig. 2 Prevention of solar heat gain by the use of shading devices
(Source: Emiliano Bellini, 2022)

Thermal insulation

Thermal insulation is the process of minimising heat transfer or the movement of thermal energy between mediums with different temperatures (Raghvendra, 2024). According to the American Society for Testing and Materials (ASTM), thermal insulation is one of the most popular heat reducing mechanisms for houses and businesses (Tawfeeq, 2021). It is a key component in providing thermal comfort for building occupants. Insulation helps in minimizing heat gain or loss and as a result, it lowers the energy required by cooling systems. The majority of widely used insulating materials such as bulky fibre, glass, slag and rock, cellulose, natural fibre, and foam panels function by allowing convective and slow-moving heat to pass through them. Thermal insulation materials block or reduce the various forms of heat transmission (conduction, convection, and radiation) from the outside to the interior of a building regardless of how hot or cold the surrounding air is. It is mostly deployed in the roof, floor and walls of a building.

Evaporative cooling

Evaporative cooling is a heat and mass transfer process that uses water evaporation for air conditioning. It is a process in which a large amount of heat is transferred from air to water thereby, causing water evaporation and a consequent decrease in surrounding air temperature (Omar *et al*, 2015). To put it simply, evaporative cooling is a process that involves feeding water into a porous material, drawing hot, dry air over it, and allowing the water to evaporate. This reduces air temperature while also increasing air moisture content that helps in lowering the temperature of the surrounding. Since this process depends on the conversion of sensible heat into latent heat through a change in temperature, the fundamental principle governing the evaporative cooling process is the transfer of heat and mass through the evaporation of water (Hashim *et al*, 2022).

Green landscaping

Urban form and the strategic planting of trees, bushes and vines around buildings and on structures like pergolas and beam overhangs can help to modify the microclimate. This reduces the need for internal or external shading devices when properly utilized. According to (Girei *et al,* 2021) selective planting can reduce heat gains from radiation and conductivity by shading not just windows and other apertures but the entire facades and roofs of a building. As made evident in fig 4, vegetation and ground cover can also reduce reflection from buildings, roadways and paved surfaces. Trees work well as wind breakers as well. The shading effect of vegetation depends heavily on the plant type, species, and age. These factors define the leaf type and the density of the vegetation. In the case of deciduous plants, the density changes from season to season. In addition, vegetation offers shade, absorbs solar energy, and transpires to release moisture into the atmosphere. Arid and semi-arid areas can benefit from the cooling effects of architectural designs that include features like courtyard gardens, green roofs, green walls, and bio walls.

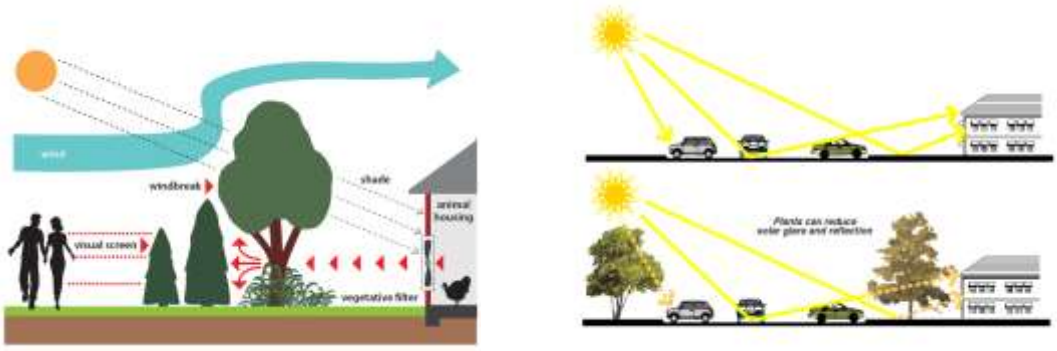

Fig. 4 Prevention of reflection and solar gain by vegetation (Source: https://www.allianceforthebay.org, 2022)

Building form and layout

The building's microclimate can be enhanced by utilizing topographical and natural features, adjacent structures, and vegetation for solar shading. This has a substantial impact on the interior thermal comfort of the spaces. Furthermore, well-designed sites can maximize the utilization of surrounding winds and natural ventilation by constructing air tunnels, arranging buildings in the best possible locations within complexes, or spacing apart building layouts (Noori *et al,* 2019). Proper site planning which includes the orientation of building to take advantage of the sun path such as shown in fig 5 can also reduce cooling energy need by optimizing natural solar shades and air movement. Certain building layouts planning and proper landscape design within a site can enhance natural ventilation and built environment microclimate. Overheating can be avoided with careful planning of the building's orientation and interior space allocation. The building's energy and thermal profile are significantly influenced by form factor, or the ratio of volume to surface. The building form can be shaped to fit the unique local climate using this ratio. For example, because the ratio of the internal loads to the envelope area is substantial, more compact shapes tend to retain more heat than less compact ones.

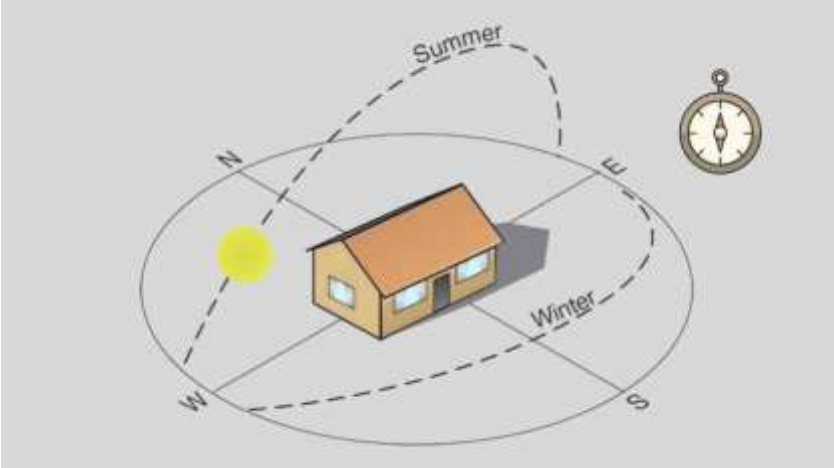

Fig. 5 solar orientation of buildings to take advantage of the micro climate (Source: Brian James, 2018)

Radiative cooling

Every object at a finite temperature has the inherent ability to emit thermal energy since thermal radiation is essentially the result of random energy level changes in matter. For this reason, one of the most widely utilized natural energy transfer mechanisms is radiative heat transfer. When the universe is near-zero, it functions as both the ultimate heat sink and a significant renewable thermodynamic resource. Radiative cooling enables terrestrial objects to release heat into space as electromagnetic waves. Radiative cooling is novel because it has the potential to generate cooling without requiring further energy input. There is an increasing likelihood that this passive cooling mechanism may transfer excess Earthly heat into space, particularly in the future decades.

In radiative cooling, the roof structure of a building can serve as both an overnight heating source and a cold store. The exposed nature of the roof to the night sky causes it to lose heat during the night through both convection and long wave radiation. The roof is externally insulated throughout the day to lessen heat gains from surrounding air and solar radiation. Radiative cooling is therefore a promising idea for energy harvesting and/or saving applications since it can serve as a novel way to release heat from terrestrial objects and passively receive cooling energy by reflecting heat into the cold sink of space.

2. Methodology

The research methodology adopted for this study is the qualitative method. The qualitative research method is used to gather non-numerical data (such as text, audio, or video) in order to understand concepts, opinions or experiences. The researcher relied on oral interviews, observations, literature review, and focus group discussions for this investigation. The survey targeted key stakeholders involved in the maintenance and operations of the buildings. These participants were selected based on their roles, responsibilities and levels of engagement within the buildings. Semi-structured interviews were conducted involving both faculty staff and students to gather detailed, first-hand accounts of their experiences with thermal comfort in the buildings. The buildings were also directly observed to understand the environmental conditions (temperature, ventilation, and airflow) during peak activity hours. The observations aided the researcher to note behavioral patterns, such as the use of fans, open windows, or personal adjustments to cope with thermal discomfort. A total of four buildings were selected for sampling. Two buildings were selected each from the first and second camps of the university to enable a fair spread and good geographical representation. These buildings are of faculties that host similar academic activities capable of generating same level of body metabolism. They were investigated to determine the application and adequacy of natural cooling techniques for improved thermal performance, occupants comfort level and impact on the environment.

3. Results and discussions

A total of 80 participants were successfully interviewed across the four buildings with twenty respondents drawn each from every building. As can be seen in Fig 6.0, Thermal comfort was a significant concern for the occupants across all four buildings investigated. Out of the 80 respondents, only 8 respondents representing ten percent (10%) of the population agree that the buildings are thermally comfortable. Fig 7 highlights the thermal performance of the buildings as perceived and reported by the occupants. The key thermal discomfort issues identified were high temperatures at noon, inconsistent air circulation and inadequate passive cooling strategies. All the buildings relied

on mechanical air conditioning equipment (AC's and fans) to maintain thermal comfort, especially during the midday heat. However, the efficiency of these systems varied either as a result of power outage, equipment malfunctioning or inability to regulate temperatures of larger spaces such as lecture halls or seminar rooms. In buildings without ACs, the use of portable fans was common, but these were often insufficient in improving comfort levels, especially in classrooms filled with students. Several participants highlighted the need to utilise natural ventilation as an important strategy for cooling. In buildings with larger windows and better airflow, occupants were able to open windows to allow for cross-ventilation, which helped reduce the heat levels. Students either vacated the classrooms or moved to areas with better airflow when their classrooms became too warm. This suggests that when necessary, occupants either exit or find ways of surviving their thermal environment by physically relocating to more comfortable spaces, demonstrating the importance of building design in facilitating thermal comfort. The presence of trees around some buildings also contributes to shading the buildings and cooling outdoor spaces, allowing for more comfortable seating and interaction areas outside the classrooms. It was also reported that, buildings with larger windows for natural ventilation, higher ceilings generally maintained more comfortable indoor temperatures, even without the use of air conditioning. In buildings with functioning air conditioning or better natural ventilation, the majority of occupants reported a satisfactory level of thermal comfort. However, in buildings where the air-conditioning systems were either not functioning well or not present, there was noticeable dissatisfaction. Participants in these buildings expressed feelings of discomfort, particularly during lecture hours or when the building was crowded.

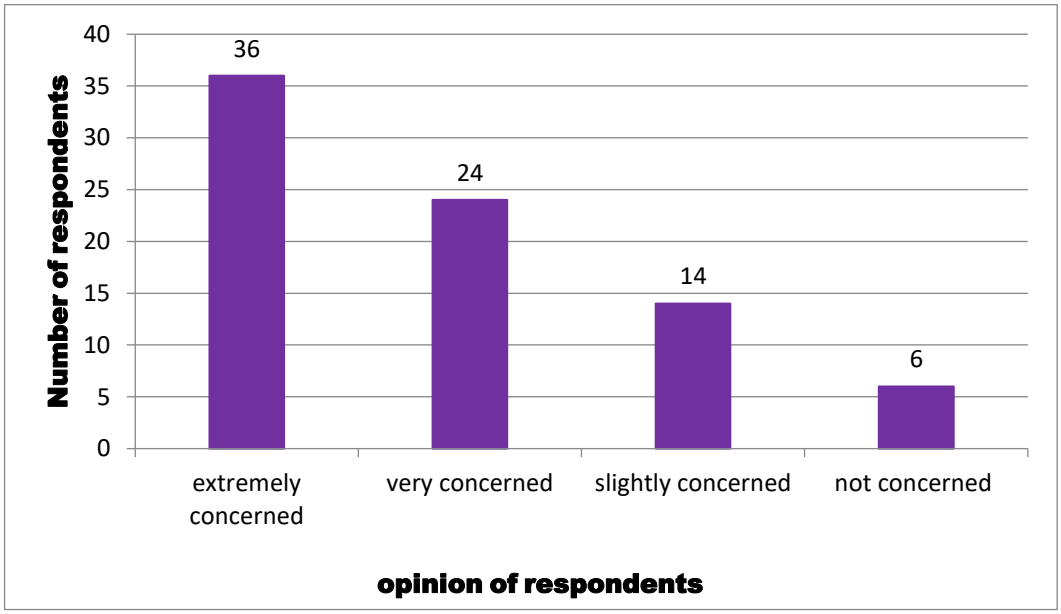

Figure 6. Occupants' desire for natural cooling.

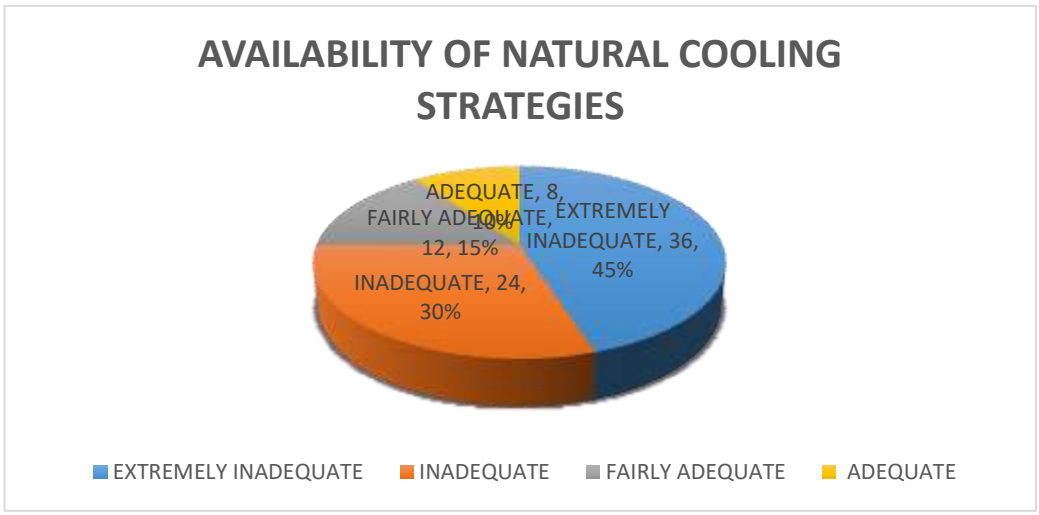

Figure 7. Occupants' opinion on the availability of natural cooling.

4. Conclusions and recommendations

The research objective was to identify the strategies that can be deployed to enhance natural cooling in buildings within the tropical climatic regions. The findings from the survey underscores the over reliance on mechanical cooling technologies for temperature regulations. It is therefore recommended that, for the sake of cost and energy efficiency, environmental impact and sustainability, the totality of systems, strategies and techniques that can enhance natural cooling be given adequate attention when designing buildings for tropical climates.

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Impact of Human and Cultural Background of Workers on The Performance of Construction Projects in Abuja

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Abstract

Construction projects are complex endeavours that involve stakeholders with diverse human and cultural background. Human and cultural background plays a significant role in shaping workers behaviours, communication styles, and work practices, which can significantly impact the performance project. This study investigates the impact of human and cultural background of workers on the performance of construction projects in Abuja, Nigeria. Questionnaire was used to collect data on the impact of cultural background on project performance. Data were collected from 41 respondents across five construction sites, with a valid response rate of 88.4%. The analysis highlights various human and cultural background factors have high RII rating as it is above 0.60. The respondents ranked "traditional beliefs" with a very high RII rating of 0.87 as the most important human and cultural factor affecting project performance, while Dietary and religious requirements was the least important human and cultural factor with rating of 0.65. From the survey on the impact of human and cultural factors the respondents' ranked "Quality deliverables" as the most relevant impact of cultural factors with a very high RII value of 0.97. It was discovered that culture of workers had a strong relationship with project performance. The findings underscore the importance of cultural awareness, effective leadership, and inclusive policies in optimizing project performance. Recommendations include implementing cultural awareness training, leadership development programs, enhanced communication strategies, and further research on the long-term effects of human and cultural diversity on project outcomes.

Keywords: Human, Cultural Background, Workers, Performance, Construction Projects

1. Introduction

1.1 Background of the study

Human and cultural background is the values, beliefs systems shared among a particular group of people and provide a guide for their interpretation of various aspects of life and the worldview (Danso *et al*., 2023 Tracy, 2020; Mohammad and Qureshi, 2023). According to Tracy, (2020) people are not born with a culture, but rather born into a society that teaches them its particular culture. Since culture is learned, it is argued therefore that it has to do with the reprogramming of individuals' minds (Sambandan *al*., 2020; Mastrantonio *al*., 2024). The construction industry adhere to diverse human and cultural workforce as it offers numerous advantages in terms of new innovations, knowledge sharing, knowledge enhancement, team coherent which impacts positively on the performance of construction projects (Teo *et al* 2019; Bosker and Gürtler, 2024). On the other hand diverse human and cultural background of workers can generate are discrimination, conflicts, prejudice, bias, impacting negatively on the performance of construction projects (Adamovic, 2022; Spiess and Cooper, 2019; Tembo *al*., 2024). The Nigeria construction industry can not shy away from employing workers from diverse human and cultural background for construction projects partly because skill is not uniformly distributed among the tribes; there is shortage of skill, hence the need to get the right person that will be able to carry out the work irrespective of the cultural background (Bamgbade *et al* 2014; Tracy, 2020; Mohammad and Qureshi, 2023). Human and cultural background impact the behaviour of the project team members as it is difficult to predict their approach and perceptions of certain scenarios which inform their decisions, thus having a bearing on project performance outcomes (Bosker and Gürtler, 2024: Tembo *al*., 2024). Managing workers from different human and cultural background is therefore paramount for the performance of construction projects (Nik *al.,* 2023; Sambandan *al.,* 2020). The aim of this study is to investigate the impact of different human and cultural Background of workers on performance of construction projects in Abuja Nigeria.

2. Literature review

2.1 Overview of cultural background

Human and cultural background are shared beliefs values, norms, and practices specific to a particular culture or group, influencing how people think, behave, and interact with each other and their environment (Danso *al.,* 2023; Mohammad and Qureshi, 2023; Nik *al.,* 2023). Human and cultural background can manifest through traditional practices, ceremonies, rituals, symbols, and behaviours, influencing how people perceive the world, make decisions, and interact with others (Tracy, 2020; Nik *al.,* 2023). Human and culture background shape an individual's perception, behaviour, and interpretation of the world around them. These backgrounds encompass values, norms, customs, beliefs, language, symbols, rituals, and traditions (Teo *al.,* 2019; Marshall, 2020; Tracy, 2020). Human and cultural background influence various aspects of human life, including social behaviour, communication styles, problem-solving, emotional expression, education, work, career choices, relationships, family dynamics, and health and wellness practices (Adamovic, 2022; Sambandan *al.,* 2020; Bosker and Gürtler, 2024).

The human and cultural background of workers can have a profound impact on the construction process, often affecting the way workers interact with each other and the project itself (Danso *al.,* 2023; Marshall, 2020; Tracy, 2020).Traditional practices, such as specific rituals performed during construction projects, are deeply rooted in local culture (Danso *al.,* 2023; Sambandan *al.,* 2020).These ceremonies help create a sense of community and shared purpose among workers (Mohammad and Qureshi, 2023; Tracy, 2020). Local customs and traditions can also shape the construction process, with certain materials or techniques used due to their spiritual significance or good luck (Danso *al.,* 2023; Marshall, 2020; Bosker and Gürtler, 2024).

2.2 Impact of human and cultural factors

Human and cultural factors significantly influence the performance of construction projects (Mohammad and Qureshi, 2023; Tracy, 2020). These human and cultural factors include, Traditional beliefs, traditional practices, gender roles, communication styles, work ethic, group dynamics, problem-solving approaches, time management, safety protocols, adaptability, leadership, authority, learning and training styles, language barriers, social norms and values, and dietary and religious requirements (Mohammad and Qureshi, 2023; Nik *al.,* 2023). Communication styles can lead to misunderstandings and errors, while work ethic and attitudes can impact productivity (Danso *al.,* 2023; Marshall, 2020). Group dynamics and teamwork also vary due to cultural differences (Adamovic, 2022; Sambandan *al.,* 2020; Tembo *al*., 2024).

2.3 Construction workers and performance

Construction workers are skilled individuals involved in construction activities from the starting stage to completion of building work (Cornelia and Nasution, 2024). Similarly, Ekwochi and Okoene, (2019) define construction worker as that individual person that performs and execute construction activities work for his living. Skilled construction workers are professionals like architects, engineers, surveyors that design, estimate and build structures with the aid of artisans and labourers to arrive client requirements within stipulated cost and scope (Josephine *al.,* 2020; Kamoche and Wanyona, (2024).On the contrary, Nnubia, (2020) defines performance as the act of executing job duties with effectiveness, efficiency and quality output within the stipulated timeframe to meet client's needs. Similarly, according to Cornelia and Nasution, (2024) performance is about behaviour or what employees do, and not what employees produce or the outcomes of their work. Performance is an effort along with the ability to put efforts supported with the organizational policies in order to achieve certain objectives (Ekwochi and Okoene, 2019; Cornelia and Nasution, 2024).

Construction project performance is evaluated based on various factors such as time, cost, quality, safety, environmental, client satisfaction, team performance, risk management, innovation, and compliance (Nnubia, 2020; Kamoche and Wanyona, 2024). Time performance involves meeting project deadlines, cost performance manages expenses, quality ensures a safe working environment, environmental performance minimizes environmental impact, and client satisfaction meets client needs (Cornelia and Nasution, 2024; Daniel, 2019). Team performance involves effective collaboration among stakeholders, risk management identifies and mitigates risks, innovation adds value, and compliance ensures compliance with laws and regulations (Nnubia, 2020; Kamoche and Wanyona, 2024).

3. Research methodology

Quantitative methodology was used which involves the use of questionnaire to obtain data on the impact of human and cultural background on project performance. This study investigates the impact of human and cultural background on the performance of construction projects in Abuja. The population of this study is professionals of 245 officially registered building firms in Abuja Nigeria which was obtained from the Federal Inland Revenue

Service. Since not all the professionals could be included in the study a purposive sampling technique was adopted. This involves the deliberate selection of 41 professionals in five construction sites in Abuja to constitute the sample size for this research work. The professionals selected include 16 Architects, 14 Builders, 7 civil engineers and 4 surveyors.

4. Data presentation and discussion

There are various human and cultural factors as posited in various literatures. Respondents were requested to choose in terms of relevance among the cultural factors as seen in Table 1

Table 1: level importance of cultural factors to project performance

S/N	Types of cultural factors	RII	Rank
1	Traditional beliefs	0.87	1st
2	Traditional practices	0.82	3rd
3	Gender roles	0.81	4th
4	Language barriers	0.83	2nd
5	Problem-solving approaches	0.68	10th
6	Time management and punctuality	0.65	11th
7	Risk tolerance	0.70	9th
8	Adaptability and flexibility	0.63	12th
9	Immediate supervisor behaviour	0.78	5th
10	Learning and training styles	0.71	8th
11	Team dynamics	0.73	7th
12	Dietary and religious requirements	0.65	13th
13	Quality of communication and feedback	0.76	6th

Source: *field survey (2024)*

From table 1 it can be seen that the respondents ranked traditional beliefs as the most significant human and cultural factors that influence the performance of construction projects in Abuja Nigeria ranking 1st followed by Language barriers and Traditional practices which are ranked as the 2nd and 3rd most significant significant human and cultural factors that influence the performance of construction projects in Abuja. Similarly, dietary and religious, adaptability and time management and punctuality are ranked as the least significant factors that influence the performance of construction projects in Abuja ranking 13th, 12th, and 11th respectively.

4.1 Perception of professionals on project performance

data on project performance indicators as posited by the various literatures were used to choose in terms of relevance as shown in the Table 2.

Table 2: level importance of Project performance indicators

S/N	Performance indicators	RII	Rank
1	Time performance	0.91	6th
2	Cost performance	0.93	5th
3	Quality deliverables	0.97	1st
4	Environmental performance	0.89	7th
5	Client satisfaction	0.95	3rd
6	Risk management	0.65	10th
7	Innovation and value creation	0.94	4th
8	Compliance and regulatory adherence	0.85	9th
9	Safety performance	0.86	8th
10	Team collaboration	0.97	1st

Source: *field survey (2024)*

From table 2 it can be seen that the respondents ranked team collaboration and Quality deliverables as the most significant project performance indicators both ranking 1st followed by Client satisfaction which is ranked as the 3rd most significant project performance indicator. Similarly, compliance and regulatory adherence, Safety performance, safety performance are ranked as the least significant project performance indicators ranking 9th, 8th, and 7th respectively.

5. Discussion of results

From the survey carried out, it is impressive to know that the various human and cultural factors have high RII rating as it is above 0.60. The respondents ranked "cultural beliefs" with a very high RII rating of 0.87 as the most important human and cultural factor that influence the performance of construction projects in Abuja, while "Dietary and religious requirements" was the least important cultural factor with rating of 0.65. Traditional beliefs in Abuja, Nigeria, are crucial for project performance due to their deep-rooted cultural heritage, community-oriented society, and respect for authority. These beliefs influence decision-making processes, communication styles, team collaboration, risk management, and stakeholder engagement. Key traditional beliefs include respect for elders, ancestral worship, community ties, traditional medicine, and cultural festivals. However, challenges include resistance to change, miscommunication, conflicting values, inadequate stakeholder engagement, and cultural intelligence. From the survey on performance indicators the respondents' ranked "Quality deliverables" as the most relevant project performance indicator with a very high RII value of 0.97. Risk management was ranked as the least relevant factor with RII value of 0.65.

6. Conclusion and recommendations

The various human and cultural factors were identified from literature survey while the impact posited by the professionals and were used to obtain data. RII was used for data analysis with "traditional beliefs" identified as the most important human and cultural factor that influence the performance of construction projects in Abuja, while Quality deliverables was perceived to be the most relevant project performance indicator. Recommendations include costruction firms to implement cultural awareness training, leadership development programs, enhanced communication strategies on a monthly basis.

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Factors and Drivers of Entrepreneurial Orientation in Small and Medium Enterprises in Nigeria: Findings from a Literature Review

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Abstract

Entrepreneurial Orientation (EO) enhances performance of Small and Medium Enterprises (SMEs) in competitive environments. There currently exists a sustainability challenge for SMEs, where about 50 percent of SMEs in Nigeria close down within the first five years of existence. This necessitates better understanding of how EO can enhance the sustainability of SMEs and is why this research sought to identify the factors and drivers of Entrepreneurial Orientation (EO) in SMEs in Nigeria. Qualitative research approach was adopted for the study. A comprehensive search for applicable research works carried out using the popular Google Scholar search engine yielded a total of ten (10) papers that dealt directly with Nigerian SMEs and had been published in the past one year. The bibliometric analysis of these papers was done with PDFGear software that allows direct interaction with PDF documents, in five main areas; purpose of the paper, EO factors uncovered, EO drivers identified, methodological approach and the conclusions reached. The study has identified thirteen factors and thirty-five drivers of the sustainability of construction SMEs through the EO pathway. The main recommendation of the study was that further research should be carried out on these factors and drivers. The results of the study are applicability to SMEs and the construction industry.

Keywords: Construction, Entrepreneurial Orientation, SME, sustainability.

1. Introduction

Failure of Small and Medium Enterprises (SMEs) globally is of great concern to economic prosperity for both developed and developing countries. There is growing recognition of the important role SMEs play in economic development (Afum *et al.*, 2023). SMEs are growth-supporting businesses that contribute significantly to improving living standards, by bringing substantial local capital formation in developing economies (Arya *et al.*, 2022). The concept of Entrepreneurial Orientation (EO) emerged in the 1970s to enhance a positive performance of Small and Medium Enterprises (SMEs) to survive in any given competitive environment (Arunachalam *et al.*, 2018). Martínez *et al.* (2016) highlighted that an entrepreneurially oriented organization can be described as one that is always innovating with respect to its products, by making risky decisions and ventures, always thinks ahead of its competitors by developing pro-active innovations, and beats competitors by being highly competitive.

The failure rate of SMEs ranges from about 46.4 percent in the USA to about 95% in Canada each year, while in developing nations like Brazil between 43% and 50% always fail before their second and third years respectively (Manzoor *et al.*, 2019). In South Africa about 80 percent of SMEs fail in their first year (Martínez *et al.*, 2016). The need for the beneficial impact of Entrepreneurial Orientation (EO) on the sustainability of businesses has never been greater than now. This sustainability challenge is manifested in the Nigerian construction industry, where about 50 percent of SMEs close down within the first five years of existence (Ilori, 2017; Tsado, 2020). There is thus a need for better understanding of how EO can enhance the sustainability of SMEs within the context of the construction industry of an emerging economy such as Nigeria (Abu-Rumman *et al.*, 2021). Thus, this research seeks to identify the factors and drivers of Entrepreneurial Orientation (EO) in Small and Medium Enterprises (SMEs) in Nigeria.

This study is reported in five sections: the first section provides an introduction to the study setting by reviewing the general state of SMEs and EO, the research problem and the objective of the study. This was followed by the empirical review of literature which dwelt on issues such as factors of EO and drivers of EO for sustainability of SMEs. The third section discussed the methodology adopted for the conduct of the research and the fundamental basis for the choice of the research method. The fourth section presented the results and findings of the research. The last section was the conclusions and recommendations, as well as areas for further research.

2. Literature Review

2.1 Entrepreneurial Orientation (EO)

The entrepreneurial orientation construct was developed by Miller (1983). This construct focused the tendency of organizations towards venture creation. The purpose of developing this construct was to provide an appropriate framework to research on entrepreneurship (Naldi *et al.*, 2007). According to Miller (1983), EO construct is comprised of three dimensions that are risk taking, proactiveness and innovativeness. Later on, Covin and Slevin (1989) defined the EO construct more comprehensively on the basis of Miller's work as the entrepreneurial orientation of a firm is demonstrated by the extent to which the top managers are inclined to take business-related risks (the risk-taking dimension), to favour change and innovation in order to obtain a competitive advantage for their firm (the innovation dimension), and to compete aggressively with other firms (the pro-activeness dimension). Two additional dimensions of EO construct namely competitive aggressiveness and autonomy was included by Lumpkin and Dess (1996).

It is argued that entrepreneurial orientation is a business resource that is intangible and it helps companies get an edge in the marketplace and increase profitability. Entrepreneurial orientation is an intangible business resource since it refers to processes that lead to the new entrance (Lumpkin & Dess, 1996). There is still a lot of confusion when it comes to competitive advantage. Competitive advantage was based on various elements in the research undertaken by Hitt *et al.* (2017). A company's competitive advantage can also be evaluated by pricing or cost, quality, delivery reliability, innovation of products, and speed to the market.

2.2 Small and Medium Enterprises (SMEs)

The important role that SMEs play in the economies and technological development of countries is indisputable, generating increasing interest in the literature in studying the factors that allow them to increase their innovative capacity in order to remain competitive and to survive (Wang *et al.*, 2015). For SMEs to achieve these objectives, it is necessary for them to adopt innovative strategies that allow them to be efficient in increasingly complex environments (Valdez-Juárez *et al.*, 2019).

Organizational learning, the process by which an organization learns from experience, suggests the need to efficiently maximize the use of knowledge (Chiva & Alegre, 2005), and it strengthens the impact of entrepreneurial orientation on the positive forces of firm growth (Wang *et al.*, 2015). EO has become a crucial construct for the survival, growth and superior performance for SMEs of the modern era (Rauch *et al.*, 2009; Hakala, 2013). According to Kraus *et al.* (2011) the behaviour of proactive firm positively contributes to SME performance during the time of economic crisis. Proactive behaviour enables the SMEs to discover and exploit environmental opportunities before their competitors (Smith & Cao, 2007), which is crucial because SMEs are facing increasingly pressure from the marketplace (Zulkifli & Rosli, 2013).

2.3 EO factors that influence the sustainability of SMEs

Many scholars agree that EO is a combination of innovativeness, proactiveness, and risk taking (Ketchen and Short, 2012; Covin and Slevin, 1989). Innovativeness refers to the tendency of pursuing creativity and experimentation (Ketchen and Short, 2012). It reflects on engaging in new ideas and creative processes that lead to new products, services, and processes (Hult *et al.*, 2004). Innovativeness is an important aspect of EO because it helps firms to pursue new opportunities (Ketchen and Short, 2012).

Proactiveness refers to a process that aims at anticipating and acting on future opportunities in terms of products, technologies and markets (Schillo, 2011) rather than reacting to events after they unfold (Ketchen and Short, 2012). Proactiveness aims at introducing new products ahead of competitors, strategically eliminating operations that are in the declining stages of the business life cycle (Antoncic and Zorn, 2004). Proactiveness shows how firms relate to market opportunities by seizing the initiative in the marketplace (Ying-hong, 2007). Proactive firms have the desire to be pioneers (Reijonen *et al.*, 2014) by acting in advance and capitalizing on emerging opportunities (Ketchen and Short, 2012).

Risk taking is one of the internal organizational factors necessary to support entrepreneurship within organizations (Hornsby *et al.*, 2002). It refers to a firm's tendency to engage and the willingness to commit significant resources to opportunities with uncertain outcomes (Schillo, 2011). Risk taking ability helps firms to engage in bold rather than cautious actions (Ketchen and Short, 2012).

2.4 EO drivers of sustainability of SMEs

Entrepreneurship orientation drivers and sustainability of SMEs are still attracting attention from scholars since better understanding could provide a sustainable competitive advantage for those companies dealing with fast-changing environments (Zupic, 2014; Al-Omoush, 2020). Some research, such as Al-Omoush (2019) investigated the impact of e-banking entrepreneurship drivers on three dimensions of performance for banks operating in

Jordan, namely (competitiveness, financial performance and customer services) through the mediating role of e-entrepreneurship orientation. Other researchers, such as Bambang *et al.* (2021) showed the multi-applicability of entrepreneurship orientation in different fields, such as spiritual marketing to ensure sustainable competitive advantage. Nasution *et al.* (2021) examined the dimensions of entrepreneurial orientation (EO), knowledge management process (KMP) and dynamic capability (DC) toward the adoption of e-commerce by SMEs. Many previous studies investigated the companies' maturity level of entrepreneurship orientation practices, namely, the maturity of innovation, pro-activeness and risk-taking practices (Al-Swidi & Al-Hosam, 2012; Al-Omoush, 2019; Al-Hariri, 2020).

3. Materials and Methods

Bibliometric research approach was adopted for the study based on the need to establish current findings from relevant literature, with specific emphasis on research within the Nigerian SME environment. A comprehensive search for applicable research works was carried out using the popular Google Scholar search engine. Repeated searches using various keywords such as SME sustainability, SME and EO, 'EO and SME sustainability yielded a total of ten (10) papers that dealt directly with Nigerian SMEs and had been published in the past one year. One of the papers was subsequently discovered to have been published three years earlier; the authors decided to keep in the sample however, because of its innovative slant.

The bibliometric analysis of the research papers thus acquired was carried out using PDFGear software that allows direct interaction with PDF documents through the intervention of AI chatbot Copilot in MS Office. The research papers were interrogated in five main areas of interest; these were the purpose of the paper, the EO factors uncovered in the paper, EO drivers identified, the methodological approach of the paper and the conclusions reached in the paper.

4. Results and Discussion

4.1 Profile of the research papers analyzed

The basic details of the research papers that were analyzed in this study concern the authorship of the papers, location of study area and year of the study. This information was presented in Table 4.1. In terms of the focus of the studies reported in the papers, the results revealed that all the papers focused on entrepreneurial orientation, either fully or tangentially. Six of the papers also dealt fully with issues of sustainability, while three papers did not. All but one of the papers were concerned with SMEs; very conspicuously however, none of the papers were in the construction industry.

These results provide food for thought about the trend of research into EO generally, and more specifically, how the issue of EO in SMEs carrying on business in the construction industry has been studied. It can be observed from the results in Table 1 that almost no attention is being devoted to the study of EO of construction SMEs, not to talk of the role of EO in ensuring the sustainability of construction SMEs. It is known that construction activity accounts for a significant proportion of national economic outputs, a large of linkages with almost all other sectors of economic activity and the employment of a good percentage of the economically active population (Okoye *et al.*, 2020). The dearth of research into EO and sustainability of construction SMEs that has been discovered by this paper is therefore relatively significant and represents a gap in knowledge that is yet to be addressed.

Table 4.1: Demographics of respondents

Paper ID	Authors	Study area	Study Focus				
			Aim?	EO?	Sustainability?	SME?	Construction industry?
1	Aga (2024)	Benue State, Nigeria	Effect of entrepreneurial competence on the sustainability of manufacturing SMEs.	Yes, partially	Yes, fully	Yes, fully	No
2	Nkem (2024)	Delta State, Nigeria	Effect of entrepreneurial competence on the sustainability of manufacturing SMEs.	Yes, partially	Yes, fully	Yes, fully	No
3	Akpoghol, Hanmaikyur, Ucherwuhe, Umogbai & Utile (2024)	North Central Nigeria	Effect of supportive business environment factors on the sustainability of manufacturing medium enterprises.	Yes, partially	Yes, fully	Yes, fully	No
4	Awonuga Nwankwo Oladapo, Okoye, Odunaiya & Scholastica (2024)		Effects of innovation and sustainability of SMEs on the circular economy and management behaviour of SMEs.	Yes, partially	Yes, fully	Yes, fully	No
5	Orga (2021)	Enugu State, Nigeria	Role of digital transformation, project management and capture management in promoting sustainable growth for SME manufacturers.	Yes, partially	Yes, fully	Yes, fully	No
6	Afolabi & Aghaunor (2024)	Lagos State, Nigeria	Influence of women's leadership and financial literacy on the performance of SMEs.	No	No	Yes, fully	No
7	Levi (2024)	Anambra State, Nigeria	Factors that influence entrepreneurship development.	Yes, partially	No	Yes, fully	No
8	Ovivi, Kazeem, Esso, Dombut & Agulanna (2024)	FCT-Abuja, Nigeria	Impact of customer intelligence on the business performance of Shoprite.	No	No	No	No
9	Nosike & Egbunike (2024)	Anambra State, Nigeria	Relationship between succession planning and sustainability of SMEs.	Yes, partially	Yes, fully	Yes, fully	No
10	Adeniji, Salau, Joel, Onayemi & Alake (2024)	South West Nigeria	Relationship between personality traits, operational performance, and environmental performance of SMEs.	Yes, partially	Yes, partially	Yes, fully	No

Source: Author's compilation (2024)

4.2 EO factors that influence the sustainability of SMEs

This section reported on the entrepreneurial orientation factors that influence the sustainability of SMEs. Up to three factors were identified from each of eight research papers, as presented in Table 4.2; zero factors were obtained from two papers. As stated earlier all but three of the papers dealt with EO and sustainability of SMEs; none of the papers dealt specifically with the construction industry.

A total of thirteen factors were identified from the papers studied. Of these, there were four competencies (strategic, opportunity, networking, and learning). Two types of innovation were identified as EO factors (product, technological), while two types of management were also identified (project management, capture management). The EO factors that were identified comprises of entrepreneurship training, business mentorship, digital transformation, financial literacy, and openness to experience. These thirteen factors represent competencies that SME owners/managers need to have to ensure the sustainability of their businesses. The results of this study have agreed with the findings of past researchers that EO is a combination of innovativeness, proactiveness, and risk taking (Ketchen and Short, 2012). This study has however gone further to show that these basic building blocks of EO can be broken down further into up to 13 factors. More importantly, these 13 factors of EO are those that are specifically associated with the Nigerian business context, as all the research that produced these factors were carried out in Nigeria, by Nigerian researchers (see Table 1 for a list of these researchers).

Table 4.2: Level of adoption of BIM-based e-procurement

Paper ID	Authors	EO factors influencing SMEs sustainability?	EO Factors identified		
			Factor 1	Factor 2	Factor 3
1	Aga (2024)	Yes, partially	strategic competency	opportunity competency	networking competency
2	Nkem (2024)	Yes, partially	strategic competency	learning competency	
3	Akpoghol *et al.* (2024)	Yes, partially	entrepreneurship training	business mentorship	
4	Awonuga *et al.* (2024)	Yes, partially	product innovation	technological innovation	
5	Orga (2021)	Yes, partially	digital transformation	project management	capture management
6	Afolabi & Aghaunor (2024)	No	financial literacy		
7	Levi (2024)	No	learning		
8	Ovivi *et al.* (2024)	No			
9	Nosike & Egbunike (2024)	Yes, partially			
10	Adeniji *et al.* (2024)	Yes, partially	Openness to experience		

Source: Author's compilation (2024)

4.3 EO drivers for the sustainability of SMEs

This section investigated the factors that serve as drivers for the sustainability of SMEs through EO. Up to seven drivers were identified from each of nine research papers, as presented in Table 3; zero drivers was obtained from one paper. A total of 35 drivers were identified from the papers studied. Of these, 13 EO factors have been identified from the preceding section (EO factors that influence the sustainability of SMEs). The remaining 22 drivers included ease of doing business, access to finance, level of infrastructural development, research and development, product differentiation, customers' satisfaction, business partnership/alliance, and organizational structures.

Other drivers were identified as creativity, family background, business-minded friends, risk propensity, succession autonomy, leadership continuity, and conscientiousness. These drivers represent attitudes, circumstances and occurrences that could positively impact SME owners/managers' efforts to ensure the sustainability of their businesses. The relatively large number of drivers of EO identified by this study does not necessarily contradict the findings of other researchers; the drivers identified in past studies have only been refined as single drivers, rather than groups of drivers. For example, where Maditinos *et al.* (2014) refers to top management support (TPS) as a key driver of change, this study splits TPS into sub-drivers such as ease of doing business, organizational structures, and leadership continuity. Other groups of drivers from past studies include technological environment (Oliveira, 2011), as well as the quantity and quality of human capital (Ali *et al.*, 2017).

Table 4.3: Challenges of e-procurement implementation

Paper ID	Authors	EO Drivers identified						
		Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**
1	Aga (2024)	strategic competence	opportunity competence	networking competence	organizational responsiveness	conducive atmosphere for identifying opportunities (scanning)	developing viable opportunities	
2	Nkem (2024)	strategic competencies	learning competencies					
3	Akpoghol *et al.* (2024)	ease of doing business	entrepreneurship training	access to finance	business mentorship	level of infrastructural development		
4	Awonuga *et al.* (2024)	product innovation	technological innovation	research and development	product differentiation	Customers satisfaction	business partnership/alliance	organizational structures
5	Orga (2021)	digital transformation	project management	capture management				
6	Afolabi & Aghaunor (2024)	investment in entrepreneurial education	investment in training programs	financial literacy				
7	Levi (2024)	creativity	family background	business-minded friends	risk propensity	exposure to entrepreneurial learning		
8	Ovivi *et al.* (2024)							
9	Nosike & Egbunike (2024)	succession autonomy	leadership continuity					
10	Adeniji *et al.* (2024)	Openness to experience	neuroticism	Conscientiousness				

Source: Author's compilation (2024)

5. Conclusion

The study focused on identifying the EO factors that influence the sustainability of construction SMEs along with the drivers of such sustainability. To this end, using a comprehensive review of literature from Nigeria, the study has identified thirteen EO factors and thirty-five drivers of the sustainability of construction SMEs through the EO pathway. Given the right circumstances, all the EO factors can serve as drivers of SME sustainability. A unique feature of the findings of this study is that they have been derived exclusively from recent studies specific to the Nigerian context.

It must be understood that the findings of this study require more work and further refinement and analysis before being suitable for application by SMEs interested in sustainability. The main recommendation of the study was thus

that further research should be carried out on the factors and drivers that have been identified. The results of the study are limited in applicability to the construction industry in an ' as is' condition, by the fact that the studies from which these results were derived did not focus specifically or exclusively on the construction industry.

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Effect of Neighbourhood Crime on Residential Property Values: A review of the Literature

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Abstract

The effect of Neighbourhood crime has a detrimental effect on residential property values, often discouraging investment in residential real estate. This paper presents a review of empirical studies on the effect of neighbourhood crime on property values. The purpose of the review is to summarise current knowledge about the influence of neighbourhood crime on residential property value. The literature was rigorously sourced from platforms such as Emerald, ScienceDirect, SAGE, and Google Scholar. The findings reveal a consistent inverse relationship between property crime and residential property values, with higher crime rates leading to decreased housing prices across various geographic contexts, including Europe and developing economies. Proximity to crime hot spots and incidents of burglary and vandalism significantly reduce property values due to safety concerns among buyers. Methodologies such as hedonic pricing models and regression analyses were frequently employed. The review observed the limited focus on the effect of crime on residential property values in developing economies. It is recommended that further research be carried out on the impact of neighborhood crime on residential property values in developing economies to better understand the unique aspects of this social issue. Government and relevant agencies should also focus on this area of study, as it can contribute to promoting sustainable housing solutions that support healthier living environments.

Keywords: Crime, Neighbourhood, Residential Property, Property Value.

1. Introduction

Residential property serves a vital role in providing shelter while fulfilling psychological and economic needs. Globally, it remains a prominent investment option, considered less risky compared to other real estate assets due to its stability, consistent income, and liquidity (Waziri *et al*., 2013; Nishani, 2016). The attractiveness of residential property as an investment is further enhanced by its potential for profitability and security (Olajide *et al*., 2013; Adekunle and David, 2023).

Property value is defined as the estimated price a real estate asset would likely command in a fair transaction between knowledgeable and willing buyers and sellers (Nigeria Valuation Standards, 2019). Factors such as physical characteristics, economic conditions, government policies, and social dynamics influence property values (Olayonwa, 2012). However, challenges like urbanization, unemployment, and economic downturns have reduced the appeal of residential investments, with Neighbourhood crime emerging as a significant factor.

Neighbourhood crime such as burglary, theft, vandalism, robbery, and violent crime, affects property values by increasing insurance costs, security expenses, and instilling fear among residents (Andresen & Jenion, 2008; Roberts and Thompson, 2023). Studies from developed countries show that high crime rates lead to lower property values and disinvestment (Boggess *et al*., 2013; Valez *et al*., 2012). As a result, real estate stakeholders increasingly consider crime rates in property valuations (Pope and Pope, 2012).

In developing countries, however, investors often prioritize location quality and rental demand over crime rates, which can lead to poor investment decisions and a decline in property values (Aliyu *et al*., 2017; Bello, 2011). This review examines how Neighbourhood crime affects residential property values and explores the management of crime-related risks in real estate markets.

2. Literature review

2.1 Concept of neighbourhood crime

A Neighbourhood refers to a sub-segment of urban or rural areas, such as cities, villages, or towns, where people live near each other and form communities. It is typically defined by physical or social characteristics that set it

apart from other parts of a settlement (Suttor, 2016). These geographic units are often marked by boundaries like streets, parks, rivers, and railways, and exhibit homogeneity in housing and structures (Adama and Jinadu, 2015). Neighbourhood crime, especially in residential areas, has been increasing globally (Tita *et al*., 2006). Residential burglary, as defined by Ratcliffe (2001) and Moreto (2010), involves illegal entry into homes with intent to commit a crime. Other common crime include robbery, vandalism, street crime, and violent offenses, with theft and burglary often occurring during the day when homes are unoccupied.

An increase in crime negatively affects residents' sense of safety, leading many urban dwellers to relocate to safer areas (Tita *et al*., 2006). This migration often results in concentrated poverty and ethnic enclaves in urban centers as people flee to the suburbs (Adegoke, 2014).

2.2 Factors influencing neighbourhood crime

Residential Neighbourhood crime is shaped by various social and environmental factors. Social risks like poverty, unemployment, juvenile delinquency, illiteracy, and homelessness significantly contribute to crime rates (Olajide *et al*., 2017; Olajide *et al*., 2022). Environmental design elements such as natural access control, surveillance, maintenance, and target hardening also influence crime levels (Zainol *et al*., 2022). Issues like poor lighting, lack of pedestrian walkways, and inadequate landscaping can exacerbate access control problems, increasing crime risks (Othman *et al*., 2020). Additionally, Neighbourhood features like accessibility, visibility, and crime patterns impact crime occurrences (Zhang *et al*., 2022). Understanding these factors is crucial for developing effective crime prevention strategies in residential areas.

3. Materials and Method

The research design employed is a systematic literature review, chosen for its ability to synthesize scientific evidence and address specific research questions in a transparent way using well-evaluated topics (Lame, 2019). The search strategy for this systematic review used a combination of database searches, forward searches, and manual journal searches, relying on resources like Emerald, ScienceDirect, SAGE and Google Scholar, focusing on studies relevant to crime and housing prices in real estate investment. Many researchers prefer these resources as a search engine due to their ability to reduce publication bias. The journal selection process followed the updated guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), which includes three phases: identification, screening, and inclusion. From an initial pool of 81 identified and screened journals, 20 were selected for review as shown in figure 1 below:

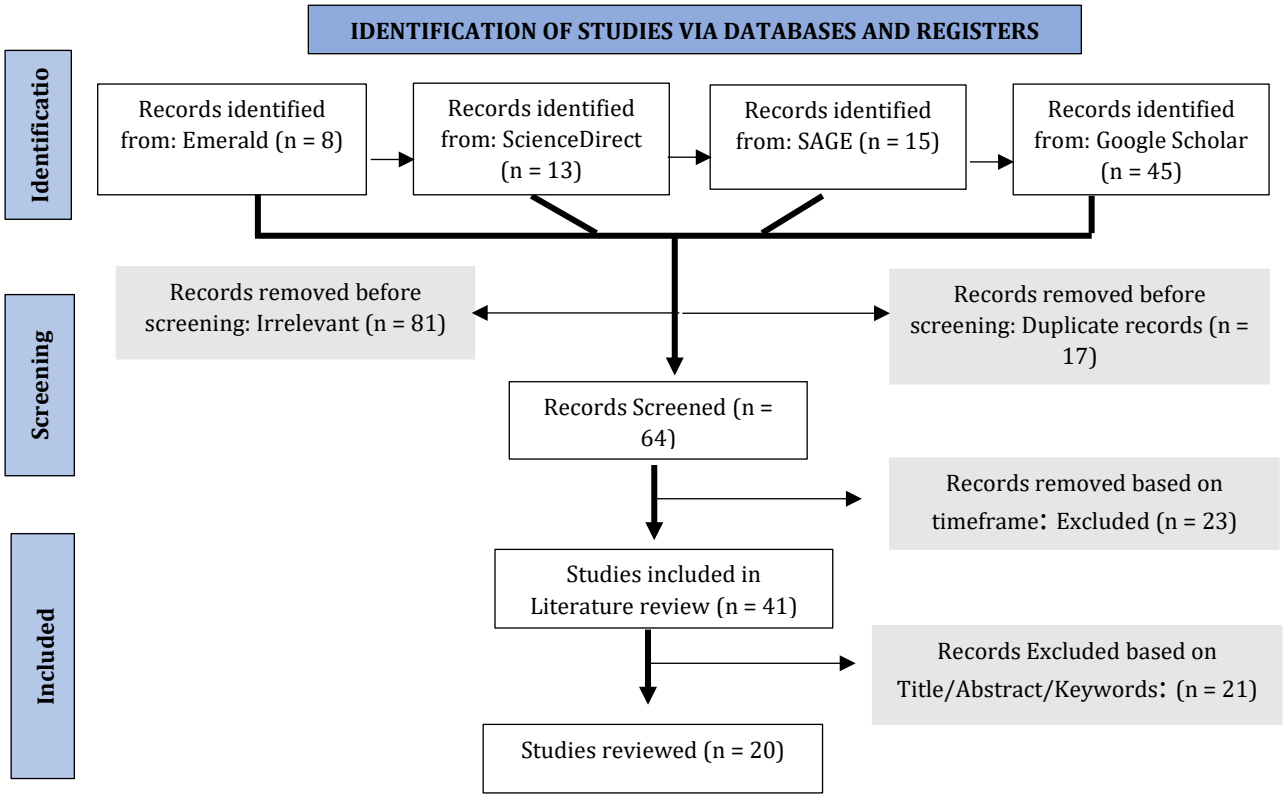

Figure1: PRISMA diagram for systematic reviews

4. Findings and Discussion

Exploring different variables commonly used in the literature is essential for understanding how crime affects residential property values. This review captures the variables and methodologies adopted in studies examining crime's impact on property values.

As shown in Table 1, approximately 20 articles from 2006 to 2023 were reviewed, supporting the theoretical findings that various factors significantly determine residential housing prices.

Table 1: Overview of Reviewed Studies

S/N	Author(s) and Year	Study Area/Continent	Sampled Residential Properties	Journal/Source
1.	Tita *et al*., (2006)	Colombus	438	Journal of Quantitative Criminology
2.	Bello (2011)	Akure, Nigeria	174	FIG Working Week 2011
3.	Buonanno *et al*., (2012)	Barcelona, Spain	1,653	Journal of the Institute for Advanced Studies
4.	Olajide and Lizam (2016)	South-Western State, Nigeria	467	International Electronic Scientific Journal
5.	Foryś and Putek–Szeląg (2017)	Szczecin	17,805	Real Estate Management and Valuation
6.	Thompson (2018)	Houston, Texas	532	University of New Mexico UNM Repository
7.	Senick (2018)	city of Akron, Ohio, USA	760	Honors Research Projects
8.	Owens *et al*., (2019)	Southern California	278	Planning Malaysia Journal
9.	Angelov, *et al*., (2020)	Pierce County, Washington	736	Issues in Information Systems
10	Bamiteko and Adebiyi (2020)	Lagos, Nigeria	573	American Journal of Environmental and Resource Economics
11.	Ceccato and Wilhelmsson (2020)	Stockholm, Sweden	378	Nordic Journal of Criminology
12.	Feldkamp (2020)	Groningen, Netherlands	561	Riksuniversiteit Groningen FSS
13.	Banks (2021)	Franscistown, Botswana	467	Selinus University of science and literature
14.	Yang-Lu *et al* (2021)	China	434	Journal of Physics: Conference Series
15.	de La Paz *et al*., (2022)	Los Angeles, USA	128,442	Journal of European Real Estate Research
16.	Kortas *et al*., (2022)	Heerlen, Netherlands	335	Cities
17.	Olajide *et al*., (2022)	South Western Nigeria	1,000	International Journal of Innovative Research & Development
18.	Koirala *et al*., (2023)	North Carolina, USA	317	American Business Review
19.	Ekpo *et al*., (2024)	Akwa Ibom, Nigeria	360	PM World Journal
20.	Odebode *et al*., (2023)	Kaduna, Nigeria	152	International Journal of Housing Markets and Analysis

Table 2: Empirical studies on the impact of neighbourhood crime on residential property values

Author(s) and Year	Title	Variable Used	Methodology	Result(s)/Finding(s)
Tita *et al*., (2006)	Crime and Residential Choice: A Neighbourhood Level Analysis of the Impact of Crime on Housing Prices	Intangible cost of crime, Crime rate and Housing prices	Hedonic regression	The findings imply that the average relationship between crime rates and home values may not be entirely accurate. According to our research, crime affects low-income, middle-class, and wealthy communities at different rates, with violent crime resulting in the greatest expenditures.
Bello (2011)	Impact of urban crime on property values in Akure, Nigeria	Crime rate and Rental values	Descriptive statistics and Multiple regression	The findings showed that the neighborhood's people had a negative opinion of living in high-crime regions and that there is an inverse relationship

				between property prices and the rate of crime.
Buonanno *et al*., (2012)	Housing prices and crime perception	Housing market data and Victimization survey data	OLS and Quartile regressions	The results showed that crime imposes significant costs that extend beyond its direct expenses. In actuality, the valuation of neighborhoods rises by 0.57% for every standard deviation increase in perceived security.
Olajide and Lizam (2016)	Determining the Impact of Residential Neighbourhood Crime on Housing Investment Using Logistic Regression	Residential Property values and Residential neighbourhood crime forms.	Logistic regression and Hosmer & Lemeshow (H-L) test of goodness of fit	The results indicate that crime in residential neighborhoods can significantly affect property values in the study area.
Foryś and Putek–Szeląg (2017)	The Impact of Crime on Residential Property Value - on the Example of Szczecin.	Average unit price and Numbers of crime and offenses by type	Correlation analysis	The findings indicate that low-cost apartment neighborhoods associated with their location (transaction price) are associated with higher non-financial crime rates, and rising crime rates lead to falling market apartment unit prices.
Thompson (2018)	How the Proximity of Crime Impacts Housing Prices: A Hedonic Pricing Study of Inner-Loop Houston.	Housing sales, Neighbourhood characteristics and Crime data	Hedonic Pricing model	The findings showed that crime does, in fact, have a discernible effect on the price at which homes are sold, and that crime proximity matters. A decrease in the value of a home is caused by an increase in violent crime.
Senick (2018)	Welcome to the neighbourhood: A spatial analysis of crime and housing values.	Criminal arrest records and Housing sale data	Spatial analysis and Ordinary Least Square (OLS)	The findings showed that violent crime typically cause more damage than property crime, and that crime become more damaging the closer they are to a property.
Owens *et al*., (2019)	impact of civil gang injunctions on crime and housing prices in the Southern California region	Zillow housing data, shapefiles and attributes related to gang injunctions, and crime data	Geographic regression discontinuity design	The outcome demonstrates each person's willingness to pay for the civil liberties that the injunction affects. The claim that gang injunctions are a financially viable method of reducing crime is called into question by the size of this net loss, which amounts to around 3% of property values between 2002 and 2015.
Angelov, *et al*., (2020)	Using machine learning algorithms to analyze impact of crime on property values	Physical attributes of a property and Crime data	EM (Expectation Maximization) algorithm and Algorithm models	The findings showed that, in Pierce County, Washington, crime had a considerable impact on predicting the price at which residential properties will sell.
Bamiteko and Adebiyi (2020)	The study examined the influence of Neighbourhood security on housing price	Housing price and Crime rate	Ordinary Least Square (OLS)	The results indicate that fenced apartments, local security services, and the presence of gatekeepers positively influence housing prices in Lagos State, whereas high crime rates negatively impact those prices.
Ceccato and Wilhelmsson (2020)	The impact of crime on housing prices; a case study of the	Panel data on housing prices, crime statistics and	Hedonic pricing through multilinear	Based on the results, it was determined that vandalism and assault have the largest estimated effects on housing

	municipality of Groningen	neighbourhood attributes.	regression model	value, declining it by 0.0317% and 0.0816%, respectively.
Feldkamp (2020)	Do crime hot spots affect housing prices?	Property prices, Property attributes, and Crime variables	Hedonic price model and Descriptive statistics	The findings showed that while crime rates do have an effect, it gets even more noticeable when one takes into account how far away a crime hot zone is. More specifically, a property moved 1 km away from a crime hotspot increases in value by more over SEK 30,000 (or roughly EUR 2,797).
Banks (2021)	Assessment of criminal activities on residential property values	Residential Property values and Residential neighbourhood crime	Logistic regression and Hosmer and Lemeshow (H-L) test of goodness of fit	The results indicate that crime in residential neighborhoods can significantly affect property values in the study area.
Yang-Lu *et al* (2021)	Crime Prediction: An Empirical Study on the Impact of Housing Prices on the Regional Criminal Rate.	Crime rate, Housing prices and Control variables such as economic indicator, demographic indicator and social governance indicators.	Linear regression model and a random effect model	The findings showed that employment opportunities, population density, and area economic development all had an effect on criminal activity.
de La Paz *et al*., (2022)	The impact of crime on house prices in LA County.	Data on different type of crime, and Housing prices	Spatial analysis techniques and Correlation	The findings indicate a strong two-way relationship between crime and home transaction prices. The levels of drugs and violent assaults are endogenously inversely correlated with housing prices. The effect of distance is smaller (1000 meters) for drugs. The price response, however, indicates a positive correlation for burglary, vandalism, and non-aggravated assaults: the greater the price, the farther away the crime occurs.
Kortas *et al*., (2022)	Urban Crime and Its Net Implicit Price to North Carolina Households	Crime rates, Wages and Rents	Regression estimates and Hedonic model	The average net marginal implicit price for residing in a city with a high rate of crime was found to be a negative value of $51.80 per month. It appears from this negative value that households are receiving compensation for residing in high-crime cities.
Olajide *et al*., (2022)	Exploring multi-scale variability in hotspot mapping: A case study on housing prices and crime occurrences	Geographical information on difference crime types and Housing prices	Geospatial analysis and Correlation analysis	The findings showed that, with the exception of home burglaries, all crime types had a consistent negative link with housing prices. The relationship between home burglaries and housing prices varied considerably in direction based on the hotspot maps' location and scale.
Koirala *et al*., (2023)	The aim of the study is to examine the Socio-	Socio-Environmental Design Factors	Logistic regression and Structural	The result shows that implementing social development programs to address social risk factors and

	Environmental Design Factors (SEDeF) model for residential neighbourhood crime toward improving property value	(SEDeF), Residential neighbourhood crime rateand Residential property values	equation modeling (SEM)	deliberately modifying residential Neighbourhoods through architecture could significantly reduce crime in the area and increase property values.
Ekpo *et al*., (2024)	The aim is to examined the impact of crime on rental values of residential properties	Rental values and Crime rates	Regression analysis	The outcome demonstrates a noteworthy inverse association between Ikono South's property values and crime rate. It is important to remember that high crime rates discourage potential residents and encourage those who can to relocate to neighborhoods with lower crime rates.
Odebode *et al*., (2023)	Influence of urban violence on residential property rental value	Rental values and Various urban violence types	Regression analysis to test for variability and Correlation to test for the relationship	The findings showed that the rental value of residential property in the research region decreased as a result of urban violence in Kaduna metropolis, accounting for 21.6% of the observed variability.

Researcher's compilation

4.1 General discussion

The findings from the papers reviewed indicated a clear inverse relationship between neighbourhood crime and property values, revealing that higher crime rates correlate with lower property values and rental prices across different Neighbourhoods and in developing economies little attention has been given to research in this direction. Neighburhood crime, such as burglary and vandalism, have been shown to consistently reduce residential property values across various geographic contexts. Studies indicate that proximity to crime hot spots significantly lowers property prices, as seen in Stockholm, Sweden, where moving a property just 1 km away from a crime hot spot increased its value by SEK 30,000 (EUR 2,797). Similarly, research in Heerlen, Netherlands, and Barcelona, Spain, revealed that property crime, particularly vandalism and burglary, lead to decreased housing values due to buyers' perceptions of safety. In Barcelona, a 1 standard deviation increase in perceived safety resulted in a 0.57% rise in property values, while properties in less safe areas saw a 1.27% reduction in price.

The impact of neighbourhood crime is not limited to Europe. In Lagos, Nigeria, neighborhoods with higher burglary rates saw significant reductions in housing prices, whereas secure neighborhoods commanded higher values. Similarly, in LA County, USA, complex relationships between neighbourhood crime and housing prices were observed, with burglary and vandalism negatively affecting property values. Overall, the presence of property crime drives down housing prices, as buyers tend to avoid areas perceived as unsafe, and the closer a property is to crime incidents, the more severe the impact on its market value.

5. Conclusion and Recommendations

The studies reviewed consistently demonstrate that crime has a significant negative impact on residential property values, with various methodologies revealing similar trends across different regions. Most studies found an inverse relationship between crime rates and property prices, particularly in areas with higher levels of violent crime, which tend to cause the greatest reduction in housing values. Factors such as proximity to crime hotspots, types of crime (e.g., vandalism, burglary, assault), and the perception of neighborhood safety also play crucial roles in shaping property values. Some studies highlighted that crime influences low-income and high-income neighborhoods differently, while others emphasized that social interventions and urban design improvements can mitigate crime's negative effects. Overall, the studies reinforce that reducing crime and improving neighborhood safety can positively impact real estate values, benefiting both property owners and prospective buyers. Based on the findings, it is recommended that Government and relevant agencies should focus on this area of study, as it can contribute to promoting sustainable housing solutions that support healthier living environments. And also invest in community policing initiatives and social development programs that address the root causes of crime, such as unemployment and social inequality.

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Impact of Central Business District Attributes on Land Use and Value in Niger and Nasarawa States, Nigeria

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Abstract

The dynamics in central urban landscape is significantly stimulating land use and value in the adjourning residential neighbourhoods. However, identifying and extricating these geo-economic indices of the central districts which influences urban land use and value have been an unresolved challenge. This problem has made land use decision process shrouded with ineffectiveness, thereby undermining the impact that continues sprawling of economic activities has on residential property rental value within the fringe of central business districts. In this context, the study reviews literature relating to the subject of the study. This study examines the impact of central business district (CBD) attributes on land use and value in Karu and Suleja, urban centres in North-central Nigeria. The study employed conceptual framework approach to collect qualitative data via databases. The data collected were presented through a desktop review of concepts relating to the study. The findings reveal that characteristics such as extensive business services, peak land value intersection, high employment density, vertical building density, and concentrative traffic transfer significantly influence land use patterns and residential property values in fringe areas. Recommendations include strategic planning for commercial land use allocation to mitigate uncoordinated urban sprawl and harness residential property investment potentials.

Keywords: Adjourning Residential Neighbourhoods, Central Business District Attributes, Land Use Pattern, Urban Planning, Urban Fringe, Residential Property Values.

1. Introduction

The exponential growth of economic activities around the central business districts is global phenomenal occurring over time in cities of developing countries (Afolabi *et al.*, 2018). The physical and socioeconomic characteristics of central districts' activities have become a source of concern in land use decision process, as the urban land values in the adjourning residential neighbourhoods are greatly influenced (Gwamna *et al.,* 2016). Most often, owing to high intensity of land exploitation and uses, central business districts usually command peak land value intersection in urban centres (Yagang 2021; and Baadam *et at.,* 2024). In most Nigerian mega cities, the characteristics of central business districts are basically assessed by their functional services, physical layout and varying degrees of economic activities around the urban areas (Burdett, 2019 and Oduwaye, 2013). Nelson (2020),

Since the central business districts represent the comprehensive gathering of urban population and distributing of land uses. The great variety of interdependent activities characterising the central districts account for about 70% of the urban function (Baadom *et al.,* 2024). As submitted by Mayaki (2017) and Yagang (2021), the fabrics of modern central business districts, are basically ranging from high employment density, peak land value intersection, vertical building density, extensive business services, as well as concentrative traffic transfer. The interplay of these components has significant impact on land use and value in the adjourning residential neighbourhoods (Baadam *et at.,* 2024).

As the urban population grows rapidly, there has been a general increase in the level of demand for land uses; of a particular note is the commercial land uses, resulting to economic activities sprawling on to the fringe of central business districts; having a sharp corresponding increase in rental value of residential property/land (Oduwaye, 2019 and Baadom *et al.,* 2024).

The rising pressure on demand for commercial land uses generally, is accompanied by specific form of land use changes; a particular note is the residential to commercial properties conversion, (Gwamna *et al.,* 2016; and Salihu *et al.*, (2020). Phenomenally, the numbers of residential land/building taken over by commercial uses are not proportionately replaced within the same fringe of the central districts. This disproportionate replacement of converted residential property has caused a shortfall in the overall housing stock, and consequently stimulating rental values of the existing housing stock (Adebayo *et al.,* 2020). This has been a case for most urban areas in North-

Central Nigeria. This paper therefore attempts to reviews the impact of central business districts' characteristics on residential land use and value in Karu and Suleja urban areas of North-Central Nigeria.

1.1 Contemporary Issues in Land Use and Value around CBD-Fringe of Urban Centres

Since commercial land use occupies the centrality of modern cities. This phenomenon is crucial in determining the shape, layout pattern and intensity of activities around the central business districts (Baadom *et al.,* 2024). However, the uneven distribution of commercial land uses around the central districts have been responsible for sprawling of economic activities on to the adjourning residential neighbourhoods in Nigerian mega cities; and consequently, resulted to indiscriminate and uncoordinated changes in land use (Baadam *et at.,* 2024; Mukherjee, 2024; and Markus *et al*., 2020). As investigated by Sydney, (2012); an urban centre experiencing rapid economic growth faces continuous changes in residential to commercial land uses; and resulting to degradation of urban quality in diverse ways. These attendants' urban issues generated from the central districts is apparent in heavy traffic, serious pollution and excessive utilization of urban infrastructures (Yagang (2021).

Several studies have examined the causal factors responsible for residential land value increase in the fringe of the central areas; focusing more on the demand pressure on commercial land uses (Markus *et al*., 2020). It has been proven in the work of Ooi and Lee (2016), that urban land values are modeled as a function of macroeconomic factors like demographic, national income, inflation rate, interest rate, and the overall housing portfolio in a given economy. From the supply side of land market, a number of studies have also examined the issue of land value variation as attributed to the dynamism around the central business districts fabrics, by focusing on the effect of limited land supply in urban centres on residential property development. Ooi and Lee (2014), reported that about 35% of escalation of residential land value in transition areas of London between 1970 and 1990 could be linked to land supply constraints. Adebayo (2009), similarly contend that a substantially, rapid increase in urban land value experienced in the metropolis of Lagos resulted from an under-allocation of land for commercial and residential property development.

An in-depth analysis of the dynamics in land use and value relating to functional attributes of central business districts has warranted for articulation of a logical thought as regards to the characteristics of central business district activities vary across cities; factors necessitating for commercial activities changing location from the central business districts to the adjourning residential neighbourhoods; encroachment of commercial land uses on to the residential areas contribute to variation in land value; and land use changes at different spatial scales in residential areas adjourning to the central business districts. Obviously, the characteristics of central business districts' activities and how it affects land uses at different spatial scales.

2. The Study Area

At both general and specific scales, the study focuses on the review of contemporary issues on central business districts characteristics as it affects land use and value in the adjourning residential neighbourhoods. Rental values of residential property are taken into consideration instead of sales values or capital values due to the fact that lettings are more frequent or regular than sales in most cities of Nigeria (Ajayi *et al.*, 2013; Oduwole and Eze, 2013); a particular regards to Karu urban in Nasarawa state and Suleja town in Niger state in North-central region of Nigeria. Geographically, North Central Nigeria otherwise known as the Middle-Belt Region, situating around the confluence of the River Niger and the River Benue. This region consists of the nation's capital city, Abuja and six other states such are Nasarawa, Niger, Benue, Kogi, Kwara, and Plateau States.

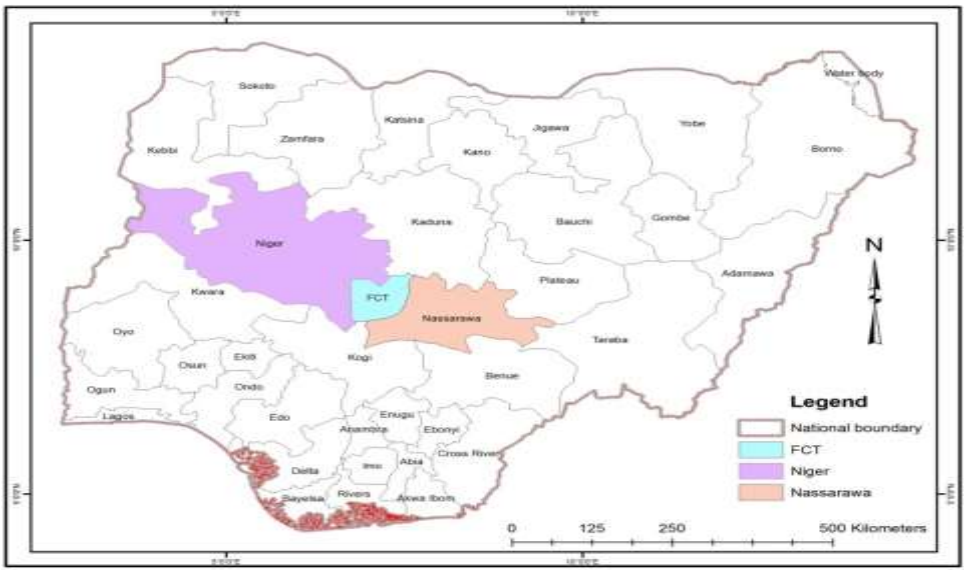


Figure 1.1: Map showing Land Mass Area in Niger and Nassarawa States of North-Central Region of Nigeria. Source: Niger State Ministry of Lands and Housing, (2015).

However, the description of the study area is strictly dwelt on Nasarawa and Niger states. The economically valuable minerals found in the zone are coal, tin and columbine, coal, limestone, iron, petroleum, tourmaline, tantalite, gold, marble, kaolin, bauxite, quartz, granite stones, kaolinite, barite, gypsum, feldspar, salt and gemstone.

Table 1.1: Some Demographic and Economic Indicators in Nasarawa State and Niger State of North Central Zone of Nigeria

States/FCT	A Land Mass Km	B Population (Million)	C GDP ($Billion) 2007	D Per Capita ($) 2007	E HDI 2018
Nasarawa	27,117	1.86	3.02	1,588	0.574
Niger	76,363	3.95	6.00	1,480	0.482

Sources: National Population Commission-National Census (2006); Canbac Global Income Distribution Database & Sub-national Human Development Index (2018).

Almost half of the developed areas are in the high density of the selected cities within the region. There are variant classes of informal sector activities in the region; the first class consists of farmers, hunters, etc. While commercial activities constitute the second larger activities and service/industrial activities. The sudden and enormous increase in the population and commercial activities in the region has led to an intensification of CBD-Activities (Ijaiya and Ijaiya, 2021).

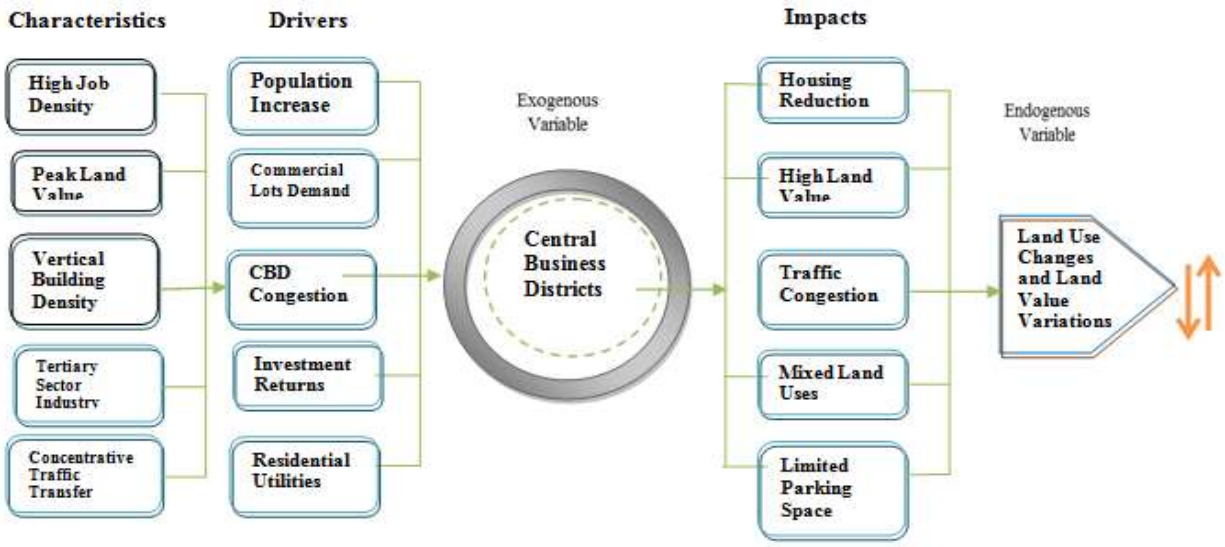
2.1 The Conceptual Clarification

The Central Business Districts remain the predominant and prevailing component of mega cities in Nigeria; offering strong radiating functions that shape the pattern and of land uses and property values (Adebayo *et al*., 2020). This phenomenon may have high grade of positive or negative impacts on the adjourning residential neighbourhoods. Positive impact is when activities characterizing the central business districts tend to bring about coordinated land uses and thereby, enhances land/property values in the adjourning residential neighbourhoods. (Lyaruu and Sanga, 2023); while, the negative impact of the characteristics of central districts concurrently lies on the increase of economic activities and reduction in housing stock in closed distance residential areas (Daniel *et al.,* 2013).

The overall factors driving central business districts activities were obtained from relevant literature on spatial analysis of land use changes and it impact on land values across the Nigerian urban centres and the globe. It is pertinent to express that, literature on urban land use changes especially the spatial dimension of central business districts characteristics is not substantially available in Nigeria. This therefore, prompts this study to analyse previous studies that have been carried out relating to this research at a global perspective. This framework therefore, reviews a logical procedure of conceptualising the impact of central business district characteristics on land use and value (Adebayo *et al*., 2020); thereby adopting from the Drivers –Trends-Impacts in analysing the

changes in land use as well as land value variation on the basis that central business district is a critical component of urban areas that determine the pace of the urban development (Saynajoki *et al*., 2014).

The framework is diagrammatically represented as thus:



26. Figure 2.1: The Conceptual Review for the Study.
(Adapted from (Sydney, 2012, Tomisi et al., 2016, Gwamna et al., 2016; Burdett, 2019; and Mayaki, 2017; Yagang, 2021; and Lyaruu and Sanga, 2023).

2.2 Assessing the Drivers, Trends and Impacts of Central Business Districts Characteristics on the Adjourning Land Use and Value in Urban Centres

In most cities in Nigeria, the central urban land scape is basically assessed by their functional services provided which comprises of middle and high order economic activities (Burdett, 2019); the socio-physical compositions and layouts to include high employment density, peak land value intersection, vertical building density, concentrative traffic transfer, extensive business services and tertiary sector industry; as well as the varying degrees of economic activities interplay in spatial distribution of land uses ranging from financial activities, professional activities, educational engagements, retail activities, as well as art and cultural activities.

This study firstly, adopts the research frameworks by Sedney (2012), Tomisi *et al*., (2016), Gwamna *et al*., (2016) Burdett, (2019); Mayaki, (2017); Yagang, (2021); Lyaruu and Sanga, (2023). In their various studies, it was reviewed that the factors driving commercial activities from the central business districts to the adjourning residential neighbourhoods are mainly urban population growth, congestion in central areas, maximising investment returns, intra-urban migration effects, availability of residential infrastructural amenities, increase demand for commercial premises, changes in choice of location, accessibility, safety and security. The findings from previous researches relating to this study indicate that land use succession, has the propensity in resulting to variation in property values, other noticeable impacts are increase in residential properties rental values and reduction in housing stock (Sydney, 2012). Among several others could be: traffic congestion, residential facilities over stretch and mixed land uses (Adebayo, 2009).

Economic conditions play an essential role in shaping the spatial orderliness of cities with employments and fiscal frameworks as key economic indicators (Zhang and Gu, 2021). In a related vein, demographic variables emerges as crucial driver of activities of the central districts to the adjourning residential neighbourhoods which shapes the human settlement pattern by giving insights into locational preference of commercial uses (Shimizu, 2021). In urban land market and the composition of central districts significantly influences spatial distribution of landed properties and invariably determines property values (Yawaldi, 2012).

The philosophy of this study dwells on demand and supply forces; emphasing that drivers of central district activities are between those that have a long-run impact and those with short term impact on land uses and values. Nigel and Williams (2019), illustrate the significant interrelationship that exists between central business districts characteristics and residential land uses; explaining that when the total quantity of residential lots in an urban area remain constant, and that there is a boom in the overall economy, the demand for housing would increase resulting to upward rise in land price. Land users in the low and moderate households have the tendency to move peripherals for relatively cheap lands (Gwamna *et al.,* 2016). In this scenario, it's obvious that urban gentrification is realistic through the lenses of central business district activities sprawling onto adjourning residential

neighborhoods; and consequently, results to shortfall in the overall housing stock in a given urban area (Sydney, 2012).

2.3 Land Use and its attendant determinants

Land is a platform of all man's activities to include economic, social and spiritual element for living and production (Lu and Guldmann, 2012; (Lu and Guldmann, 2012; Alam, 2014; and Alam, 2014). Wyatt and Subedi (2013), submits that land is the focal point of human engagements upon which food, water, air and other resources are found for life continuity. Land use in the urban areas is the basis of urban function, upon which basic and social needs like food, shelter, space and room to relax are obtained (Chiwuzie *et al*., 2019). The use of land encompasses all the numerous uses in which land enable man to meet up with needs which may be for purposes of Shelter; Trade, Commerce and Industry; Agriculture and Leisure; and road network development ((Johnbosco and Nnaji, 2011). The concept of land entails modification of the natural environment in to the built environment by a way of integrating human activities through harnessing services provided by terrestrial ecosystem (Mothorpe and Wyman, (2021).

Badland *et al*., (2023), established that the determinants of land use can be viewed from two perspectives: the economic determinants of land use are characterised by the forces of demand and supply; and the socially rooted determinants of land use include ecological processes with their physical context as well as organisational processes with their social structural context.

2.4 Land Value and its Influencing Factors

Shapiro *et al.* (2009), have opined that the value of a particular interest in landed property may be viewed as the amount of money which can be obtained for the interest at a particular time from persons able and willing to purchase it. Value is not intrinsic but results from estimates, made subjectively by able and willing purchasers, of the benefit or satisfaction they will derive from ownership of the interest. Several factors are therefore, attributed to influence urban land values, residential lands in particular. The major subthemes influencing residential land values to include demand and supply, location, economic atmospheres, public regulations, demographic size, geospatial features and financial mechanisms (Van Dijk *et al*., 2022).

2.5 A Review of Empirical Studies on CBD-Characteristics and it impact on Land Use and Values in Cities

John and Ming (2013), in an empirical study of the America residential property market, titled: 'The evolution of Commercial Strip', reviewed the influence of an arterial commercial strip in an residential neighbourhood which reveals that automobile businesses were steadily trooping in to the district; and indicate a significant relationship between residential land converting to commercial land use; thereby resulted to variation in housing prices in close proximity to the central area of Chicago. Ooi and Lee (2014), in a study of the relationship between residential land value and housing market in Singapore, which reported that about 35% of escalation of residential land value in transition areas of London between 1970 and 1990 could be linked to land supply constraints. Adebayo (2009), in a similar direction, carried out a study on impact of urban Land use changes on property values in Metropolitan Lagos; and contend that a substantially, rapid increase in urban land value experienced in the metropolis of Lagos resulted from an under-allocation of land for commercial and residential property development.

Yi and Lee (2014), in their study of demand and supply of housing stock in China Republic, the findings of the study identified that the residential property rental values appreciation in the fringe of central business districts was one of the positive impacts of sprawling of commercial land uses to the residential areas. Brent and Gonas (2013), conducted an investigation on economic implications of planning regulations on the Lexington kentucky housing market in order to ascertain the future possible scenario in the land use changes as well as variations in property value that might occur in years ahead; and discovered that extension of commercial land uses onto the residential areas is critical in changing the structure of the housing environment.

3. Methodology

The study employed a longitudinal approach to collect qualitative data. The data collected were analysed with the aid of qualitative method of data analysis by a desktop review of concepts relating to the dynamics in central business districts as it influences urban land use and value.

This study engages secondary Source of data collection that is, archival data and extracts from the relevant planning offices. Other published materials were journals, conferences papers, related academic thesis and dissertations, consultancy reports and online sources.

4. Conclusion and Way Forward

The implication of this study is that there are raising expectations on further commercial land use sprawling on the adjourning residential areas, due to congestion in the central business districts; thereby, triggering rental values of

residential property. This is a signal for real estate investors in channeling their investment windows, being that residential property is prevailing in the real estate market in Nigeria. The concludes that extensive business services, peak land value intersection, high employment density, vertical building density, and concentrative traffic transfer among others are the top most characteristics of central districts influencing land use and value in the adjourning residential neighbourhoods of the study area.

The study therefore, recommends that emergence and development of central business districts should be remotely monitored and adequate space for commercial land uses along the access roads of residential areas be reasonably allotted in the planning schemes; in order that sprawling of economic activities into the adjourning residential areas could be controlled and thus, harnessing the potentials in residential property investment in the study areas.

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Factors Influencing Facilities Management Strategies in Northeast Nigerian Universities

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Abstract

Facilities management (FM) plays a crucial role in ensuring the efficient and effective operation of university campuses. This highlights the importance of a comprehensive evaluation process to ensure the selected FM strategy aligns best with the university's needs. In North East region of Nigeria, Universities have witnessed significant growth in student enrolment. As a result, the universities are struggling to meet the needs of their students and staff as a result of some issues that include inadequate funding, lack basic facilities such as energy and running water. However, the choice of strategies adopted in FM can significantly impact the success of these institutions. Therefore, this study aims to investigate the factors influencing the selection of FM strategies by universities in the North East region of Nigeria. Qualitative approach using exploratory and descriptive designs was employed. Data was collected from 14 interviewees of works and maintenance department across 7 federal universities with in North East region of Nigeria. Purposive sampling technique was used in the selection of interviewees and the data was analysed using thematic analyses. The study revealed majority of interviewees (64.3%) believe quality is the primary factor influencing their universities' strategy adoption, while a significant minority (35.7%) consider technological, economic, and functional factors equally important. To ensure long-term success, universities should allocate at least 15% of their annual budgets to FM services, this will help in modernizing facilities, implementing energy-efficient systems, improving FM and prioritizing preventative maintenance. Also, Universities should regularly monitor and evaluate the implementation and impact of their adopted strategies. This can help identify areas for improvement and ensure that strategies are achieving their intended outcomes.

Keywords: Strategies; Factors; Facilities Management; Choice: Universities.

1. Introduction

The effective management of facilities is crucial for the successful operation of any organization, especially educational institutions (Osaigbovo & Osaigbovo, 2021). Universities, as complex institutions with diverse facilities, face unique challenges in managing their physical assets (Pavón *et al*., 2020). As such, the choice of strategies adopted for FM can significantly impact the quality of the learning environment, operational efficiency and overall institutional performance (Munajat Zurainan *et al*., 2021). Tannor *et al*. (2024) pointed that studies revealed that factors influencing FM strategy adoption include resource availability, organizational culture and external factors. Limited financial and human resources limit the adoption of sophisticated FM strategies. Organizational culture, focusing on sustainability lead to green FM practices, while external factors like government regulations, economic conditions, and technological advancements impact compliance with legal requirements. For instance, Melles *et al*. (2022) confirmed that organizational culture, available resources and government regulations were key determinants of FM strategy choice in Australian universities.

Recently, Nigeria has witnessed significant growth in higher education in recent years. However, the challenges associated with FM are substantial, including inadequate funding, infrastructure deficits, corruption and misappropriation of funds, inefficient management practices and poor maintenance culture (Marocco & Garofolo, 2021). These factors interact and compound each other, making it difficult for Nigerian universities to implement effective FM strategies. To address these challenges, universities in Nigeria must adopt effective strategies that align with their specific needs and priorities (Sule, 2024). Therefore, understanding the factors that influence FM strategy choices is essential for developing appropriate policies and interventions that can curtail these issues and improve FM practices (Simpeh *et al*., 2022). In consideration of that, studies have explored FM globally and within Nigeria, there remains a significant gap in understanding the specific factors influencing FM strategies in Northeast Nigerian universities. This region, characterized by unique socio-political, economic and infrastructural challenges, necessitates a focused investigation into the factors shaping FM practices within its educational institutions

(Adegoriola, 2023). By considering the importance of these factors, this study aims to provide a comprehensive understanding of the factors influencing FM strategies in Northeast Nigerian Universities. This knowledge can inform policy decisions, improve facilities management practices, and contribute to the overall sustainability and efficiency of universities in the region.

2. Factors Influencing Choice of FM Decision on Strategy Adoption in Nigeria

In Nigeria, Nngidi (2023) explained that organizational factors such as culture, size, structure, strategic alignment, environmental conditions, managerial expertise, decision-making processes and risk tolerance influence the adoption of new FM strategies. Cultural factors, such as risk tolerance and adaptability, can influence the willingness to adopt new strategies. Environmental factors, such as economic conditions, technological advancements and regulatory frameworks, can limit the scope of strategic initiatives. But the study of Ikediashi *et al.* (2014) highlighted the need for improved funding and efficient resource utilisation. With respect to Hassanain *et al.* (2024) on factors influencing IoT adoption for sustainable facilities management, there is need for collaborative approaches on factors such as human resources, expertise technology and innovation (Odediran *et al.*, 2015; Yusuf *et al.*, 2022). Similarly Bibri and Krogstie (2020) explore the potential of technology and innovation to improve FM effectiveness in universities and advocated for data-driven decision-making and smart solutions. But according to Ikediashi (2014) and Ezeudoye *et al.* (2022), the choice of FM strategies in Nigerian universities is influenced by a complex interplay of internal and external factors.

2.2.1 The internal factors

Extant studies have identified the following factors as internal influence to the choice of FM strategies adopted in Nigerian universities (Tanpipat *et al.*, 2021). These factors include; resource availability where budgetary constraints are a major hurdle. Limited funding often restricts universities to reactive, short-term strategies focused on repairs and maintenance rather than preventive or strategic approaches. Leadership and governance where the commitment and expertise of university leadership significantly affect FM decision-making and lack of understanding of FM's contribution to institutional goals can lead to inadequate support and hinder strategic implementation (Tanpipat *et al.*, 2021). Human resources where universities often lack qualified FM personnel due to limited training opportunities and unclear career paths. This can hinder effective strategy implementation and limit the adoption of innovative approaches. Organisational culture that involves a situation where traditional hierarchical structures and bureaucratic processes slow down decision-making and impede change and building a collaborative and performance-oriented culture is crucial for effective FM strategy adoption.

2.2.2 The external factors

The following factors constitute the external factors that affect the choice of FM strategies in Nigerian universities. These include Government policies where national policies and funding allocations for education significantly impact universities' financial resources and influence their ability to invest in FM strategies. Study by Dimunah (2017) explored the challenges posed by inadequate government funding in Nigerian universities. The study revealed regulations related to building codes, environmental standards, and safety requirements can influence the choice of FM strategies and technologies adopted by universities. Study by Ikediashi *et al.* (2014) emphasised the need for clear and enforceable regulations to promote sustainable FM practices.

Economic climate: inflation, exchange rate fluctuations, and access to international funding can affect the cost and availability of resources needed for implementing FM strategies. Social and technological trends such as growing awareness of sustainability, digitalisation, and user-centric design are influencing FM practices globally. However, Nigerian universities face challenges in adopting these trends due to resource constraints and limited access to technology (Onyema, 2020).

Lawrence and Moveh (2019), Samuel (2020) and Alhassan *et al.* (2023) argued that the decision to secure FM services can be made following three main approaches; outsourcing, in-house and a combination of both (hybrid). Steiss (2019) posited that the approach taken depends on the priority set by the organisation for the services to be provided. A range of criteria for consideration as part of the decision-making process will have to be explored by the organisation which includes but is not limited to the cost of providing the current services, improving process responsiveness and cycle time and identifying cost efficiency routes. The role of facilities management has gradually evolved from merely helping the organisation to survive, to a platform that enhances organisations potential to prosper in a volatile commercial climate. It then follows that the challenge for facilities managers is indeed the same challenge facing the organisation. Twumasi (2019) and Sayed *et al.* (2021) argued that outsourcing is a strategic tool and if used appropriately can generate significant improvements in service and cost for many organisations. If done well, it guarantees an improved understanding of the services provided and their costs. Most importantly, it allows a company to redirect time and resources to its core competency. At the same time, a well-run in-house

operation could conceivably operate at 10 to 15 percent less than an outside organisation, simply because it does not have to generate a profit. A sourcing decision can be made by taking into account both the scope and purpose of sourcing (Zimon *et al*., 2020). Soh *et al*. (2019) demonstrated that many factors may impact on an outsourcing decision and these are grouped into four categories of strategy that include cost, function characteristics and environment. Strategic factors include core competencies, critical knowledge, lack of internal human resource, impact on quality and flexibility. Function characteristics include complexity, degree of integration, structure and asset specificity. Environment functions include the internal and external environment faced by the organisation. In a broader perspective, Berry (2020) posited that the priority of outsourcing depends on which chair one sits. Outsourcing requires professional and strategic manner approach as it has long term inferences.

Hosseini and Al Khaled (2019) and Parhi *et al*. (2022) demonstrated that the factors affecting choice of the hybrid procurement route comprises developing internal staff, improving process responsiveness and cycle time and efficiency. This goes to show that the hybrid process encourages organisations to develop their staff to be able to work within and with the organisations service providers. Moons *et al*. (2019) stated that adoption of hybrid strategy will improve process responsiveness, faster work delivery and greater efficiency of work done. Mutswiti (2019) showed that factors considered to be the least important in the choice of the hybrid route are, specialisation and diversity, investment in asset and reduced overhead. This is due to the fact that these organisations are not aiming to be sole providers of the services they execute in hybrid form; they do not need to build special skills in this field. These types of organisations are not required to employ staff directly as they can operate using service provider's employees, thereby reducing costs and redirecting funds for investing in assets to other core activities. Talamo and Atta (2019) and Amos *et al*. (2020) identified efficiency of the service delivery process, continuity and risk management as major factors affecting the choice of FM strategy which an organisation may adopt. This correlates with the study of Patrucco *et al*. (2019) which posited that the levels of satisfaction is a major factor affecting the choice of FM strategy been adopted by organisations. These two studies are however in contrast to a similar study carried out by Ikediashi and Aigbavboa (2019) which shows practical skills of in-house personnel and expertise from outsourcing as the major factors influencing the choice of procurement route organisations adopt. Maletič *et al*. (2020) argued that it is evident that in the face of the need for organisations to optimize resources and the availability of finding options for FM services, senior management of organisations are saddled with the responsibility of attaining a balance among the crucial factors influencing decisions on FM gaining route. If these factors are well balanced, firms/organisations can achieve optimal benefits and sustainable competitive advantage among competitors in the industry.

2.3 Conceptual framework

The effectiveness of FM strategies in Nigerian universities is influenced by a complex interplay of factors. A conceptual framework can help visualize these factors and their relationships. These factors are uncovered from inside and outside factors as recommended by Ikediashi (2014) and Ezeudoye *et al*. (2022). With respect to internal factors: Bello *et al*. (2024) reported that a strong culture of maintenance and efficiency can significantly impact FM practices. However, bureaucratic tendencies and resistance to change can hinder effective FM. For example, a culture that prioritizes teaching and research over maintenance may lead to neglect of facilities. Nngidi (2023) also stated that a clear managerial structure with defined roles and responsibilities for FM can streamline operations. However, fragmented structures lead to inefficiencies. For example, if FM is not centralized, it may be difficult to coordinate maintenance activities and ensure consistency across the university. But Weeks and Leite (2021) explained that adequate funding is crucial for implementing effective FM strategies. However, limited budgets can constrain maintenance activities and hinder the adoption of new technologies. For example, a lack of funding may lead to deferred maintenance, which can eventually lead to more costly repairs. Also, skilled workforce is essential for efficient FM. However, a shortage of qualified FM professionals and inadequate training impact performance. For instance, if FM staff are not properly trained both manually and technologically, they may not be able to identify and address potential problems. Wills, N., & Bartels, N. (2023) The use of technology can improve FM efficiency. However, lack of investment in technology and digital literacy can limit its potential. For example, if FM staff are not trained to use computerized maintenance management systems (CMMS), they may not be able to take full advantage of the benefits of these systems.

In consideration of the exterior factors: Durdyev *et al*. (2022) confirmed that new technologies can improve FM practices. However, rapid technological change requires significant investment and funding. But Oyinkansola (2023) revealed that economic downturns impact funding for FM, leading to deferred maintenance and reduced services. For example, during a recession, universities in Nigeria are forced to cut back on FM budgets, which lead to deterioration of facilities. Based on Hu (2021), social and cultural factors can influence the design and use of facilities. For instance, cultural practices may impact the layout and maintenance of certain spaces; also in some cultures it is customary to remove shoes before entering a building. This can lead to increased wear and tear on floors. Also, climate change and natural disasters can impact facilities. Sustainable FM practices can help mitigate

these risks. For example, Oyedepo *et al*. (2021) displayed that by installing energy-efficient lighting and HVAC systems, universities can reduce their carbon footprint and save money on energy costs. Therefore, by understanding the key factors that influence FM strategies in Nigerian from relevant conceptual studies. The study conceptual framework is developed based factors that include superiority, management, scheduling, financial, technological and functional in the study.

3. Methodology

A qualitative research approach using exploratory and descriptive designs was employed to investigate the factors influencing the choice of the strategies adoption in facilities management by university in North East Region of Nigeria. The targeted population for the study comprises 14 interviewees with a supervisory or managerial role in facilities/maintenance management and had not less than 5yrs minimum years of experience in FM were considered from works and maintenance department (W&M staff) across the seven federal universities in the study area. This number was deemed adequate as Alam (2021) argued that a minimum of six participants is ideal for qualitative research where substantial information is collected from the interviewees. Table 1 present the total number of federal universities within the study area.

Table 1: Federal Universities within North East, Nigeria

S/N	State	Universities
1	Bauchi	Abubakar Tafawa Balewa University Bauchi
2	Gombe	Federal University Kashere
3	Adamawa	Modibbo Adama University of Technology Yola
4	Taraba	Federal University Wukari
5	Yobe	Federal University Gashua
6	Maiduguri	University of Maiduguri
7	Maiduguri	Nigerian Army University Biu

Source: National Universities Commission, (2024)

The technique adopted was purposive sampling because is a technique in which particular respondents are selected deliberately in order to provide important information that cannot be obtained from other choices. It is the view of the researcher that only experience staffs in managing facilities are particularly strong enough to answer the questions required for the interview rather than all staff in the universities. The study instrument comprises semi-structured interviews to source information. Semi-structured interviews were chosen to allow for follow up questions as the research is exploratory in nature as mentioned earlier. The approach allowed for the interviewees to freely express their views and contribute as much information as possible with the researcher moderating the process. All the interviews were conducted face-to-face with the interviewee in his/her office at the institutions. The interviews were conducted at different times across the 7 universities in the study area and each interview was recorded and then written on a separate sheet and later transcribed into Microsoft word as soft copy for further analysis. The interview lasted between thirty to fourty minutes with each interviewee. In compliance with the ethical requirement, the information written was kept anonymous to guarantee confidentiality.

The semi-structured interview guide contained eighteen questions. The questions were categorised into two sections A and B. Section A, contained questions in relation to demographic information about the interviewees to help provide credibility of the interviewee to the research while the section B contained questions about the factors influencing the adoption strategies utilised in managing universities building facilities. Furthermore, the data obtained from the interview was in the form of verbal statements of the interview participants. Thereafter the textual data was then read several times in order to make meaning out of the data. Subsequently, initial data coding was conducted in order to highlight the significant words and short phrases that occurred in the data. Upon completion of the coding, the actual coding process was undertaken to identify themes and sub-themes (node) that emerged from the data.

The analysis was conducted with Nvivo 10 statistical tool, using thematic analysis because of its flexibility and power in analyzing qualitative data, making it well-suited for investigating FM strategies in the study area. To ensure the validity and reliability of the findings, inter-coder reliability was used through involving colleagues and experts in the field of FM to review and critique the analysis and findings, sharing the findings with participants to confirm their accuracy and relevance and maintaining a detailed record of the study process, including data collection, analysis decisions and interpretations. The data was finally prepared based on DePoy and Gitlin (2019) procedure that involved

1. **Data collection:** This entailed gathering qualitative data relevant to facilities management strategies from the participants
2. **Coding and theme identification:** This involved reading and re-reading the data to submerge the content, then developing a coding scheme to categorise recurring concepts, ideas, and experiences related to strategy and influencing factors. The results were used to further group codes into broader themes, refining them iteratively as understanding deepens.
3. **Theme analysis and interpretation:** Each theme was analysed considering its meaning, significance, and relationships with other themes thereafter how themes connect to existing literature on facilities management and higher education was explored. Conclusions were drawn about the strategies utilised, factors influencing these choices, and potential implications for practice.
4. **Description and reporting:** This involves the presentation of the findings clearly using specific examples from the data to illustrate each theme, followed by discussion of the context, significance and potential implications of the identified themes.

4. Data presentation and analysis

Demographic attributes of interviewees are presented in Table 2; the Table comprises the respondent's institution, position, working experience, age and educational qualification

Table 2: Demographic Characteristics of Interviewees

Institutions	Position	Working experience	Educational qualification	Gender
ATBU	Quantity surveying 2	7years	B. Tech	Male
	Senior quantity surveyor 1	9years	MSc (Quantity surveying)	Male
Federal University Gashuwa	Maintenance manager 1	5years	B.Tech (Building)	Male
	Head of maintenance (physical infrastructure)	9years	M.Sc (Architecture)	Male
Federal University Kashere	Senior civil engineer	10years	B.Sc (Civil Engineering)	Male
	Maintenance manager 2	8years	MSc (Construction Management)	Female
University of Maiduguri	Facility manager 1	7years	B.Tech (Estate Management)	Male
	Estate manager 2	5years	HND. (Estate Management)	Male
Modibbo Adama University Yola	Director of planning	8years	MSc (Project Management)	Male
	Engineer 2	7years	MSc (Building)	Male
Federal university Wukari	Physical planning officer	6years	B.Tech (Estate management)	Male
	Head of maintenance	5years	MSc (Construction Management)	Male
Nigerian Army University, Biu	Maintenance manager	5years	B.Tech (Quantity Survey)	Male
	Head of maintenance (physical planning)	6years	M.Sc (Architecture)	Male

Source: Field survey (2024)

The result in Table 2 shows that the interviewee's positions fall between the range of senior officer's cadre and the academic qualification of each participant is not less than HND. These indicate that the interviewees are highly educated, and the qualification of each interviewee shows that they are within the built environment professions. The result also demonstrated that all the interviewees have working experience of not less than 5years in their units/departments. These affirmed the earlier assessment that the interviewees stayed for a reasonable time in the units responsible for managing building facilities in the universities which qualified them to be interviewed because of the experience obtained. The result also demonstrated that majority of the interviewees are male with professional qualifications from their respective professional bodies. This contributed to the selection of the

interviewees because of the requisite knowledge and experience expected from them in managing building facilities in the study area

4.1 Factors influencing choice of strategy adoption in North East Universities, Nigeria

Qualitative data was used to present the results on factors influencing choice of a strategy adoption in the study area. Table 3 present the qualitative frequency response of the interviewees and its sources of adoption, while Fig.4.1 shows the figurative model that displays the codes from each university interviewees interviewed. The result was finally explained in sub-sections 4.2.1 to 4.2.6

Table 3: Factors influencing the Choice of Strategy Adopted and their Sources in North East Universities, Nigeria

S/N	Factors	Source	Frequency	Percentage
1	Quality	ATBU 1 & 2, Biu, Wukari, Yola 2, Gashuwa 1, UniMaid 2, Kashere 2, Wukari 2	9	64.3
2	Management	ATBU 2, Biu 1 & 2, Wukari, Uni Maid, Kashere and Yola 2	7	50.0
3	Planning	Biu, Wukari, Yola, Gashuwa 1, Kashere 2	5	35.7
4	Economic	Wukari 2, Biu 2, Wukari 2, Gashuwa 1, Uni Maid, Kashere	6	42.9
5	Technological	Wukari, Yola, Gashuwa 1, Uni Maid, Kashere	5	35.7
6	Functional	Wukari 2, Yola 2, Gashuwa, Uni Maid 2; Wukari 2	5	35.7

Source: Field Survey, (2024)

The factors generated from the interview codes are grouped into six themes. Table 3 shows the frequency result from the interviewees indicating that the factors influencing choice of FM strategy was based on quality, management, economic, planning, technological factors and functional in the study area. The Table further indicates that 64.3% of the interviewees identified quality as the major factor influencing choice of strategy adoption in their universities while 35.7% identified technological, economic and functional as their factors. The figurative model from the Figure 1 shows how each factor was chosen from the institutions through an arrow mark indication. The arrow shows that the institution considered the factor in its choice of strategy utilisation. The total arrows pointing a particular university from a particular factor indicates that those universities sighted that factor as their choice consideration on strategy adoption. Sampled opinions from the interviewees are intensely explained in sub-sections 4.2.1 to 4.2.6. The model was developed based on the data presented in Table 3

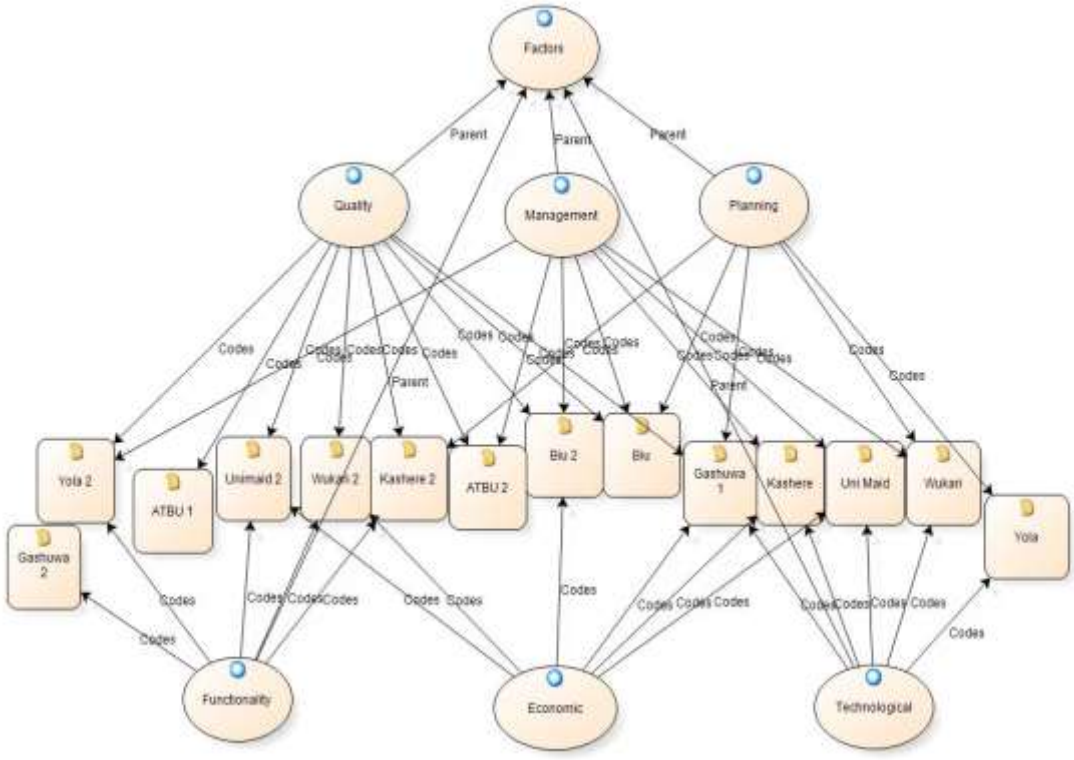

Figure 1: Factors influencing Choice of a Strategy Utilised (Field survey, 2024)

4.2.1 Quality consideration

The interviewees indicated that quality is among the important factors considered when making choice of strategy to adopt in FM services in the universities. The following are some excerpts of the precise expressions of the interviewees:

> *"While initial costs may vary, we focus on strategies that prioritize quality and durability. Investing in high-quality materials and skilled labor may have a higher upfront cost, but it leads to reduced maintenance costs and increased asset lifespan, making it a more cost-effective choice in the long run." (Yola 2, Unimaid, Kashere 2) "It may be based on excellence, such as achieving high service quality to gain a competitive advantage, enhancing service quality, boosting productivity and operational effectiveness, and raising standards of quality. Typically, the decision is made to increase process responsiveness and cycle time as well as obtain higher reliability and competency". Alhassan et al. (2023) shows a dissimilar finding that shows number of different strategies that universities can adopt to deliver high-quality facilities management services. One common approach is to use an in-house team of facilities professionals to manage and maintain the university's buildings and grounds. This approach can provide a high degree of control and flexibility, but it can also be expensive and require a significant investment in staff and resources.*

4.2.2 Management factor

The result from the interview also revealed that institutions considered management as a factor influencing choice of FM strategy. The interviewees hinted that reducing management load as well as timing and coordination of maintenance activities are considered in most cases. Sampled opinions from the interviewees on this as follows:

> *The aspects include reducing management workload, time savings, coordination of maintenance activities, potential conflicts of interest between subcontractors and universities, difficulty finding subcontractors with compatible organisational cultures, and faster implementation are some of the factors to be taken into account (ATBU 2; Yola). The consideration factors also include consolidation and decentralisation, difficulty in finding required company with a compatible organisational culture and need for specialised management (Biu; Uni Maid; Wukari). A skilled and experienced workforce is essential for effective FM services. Well-trained staff can identify potential issues, implement preventive maintenance strategies, and respond promptly to emergencies. Investing in staff development and training is crucial for long-term success (Biu). Fuertes et al. (2020) display a similar outcome by revealing that when choosing a strategy, managers must consider a variety of factors, including the organisation's internal capabilities, the external environment, and the desired outcomes. Management load is one important factor to consider, as it can impact the organization's ability to implement the chosen strategy successfully.*

4.2.3 Planning factors

The extent of planning was found to be among the factor influencing the choice of FM strategy among the universities. It is believed that when there is proper planning there is tendency that the strategy will lead to developing internal staff and avoiding potential damage to reputation of university. This assertion is supported by the views expressed by interviewees who mentioned that:

> *Sustainability is a key factor in our decision-making process. We choose strategies that promote energy efficiency, reduce waste, and minimize our environmental footprint. This can be adopted based on strategic partnerships with contractors, regulations governing outsourcing practices, access to world-class capabilities, focus on core activities, potential damage avoidance to university reputation, and planning that leads to the development building facilities (Biu, Kashere, and Biu). It might be built on resource liberation for essential tasks, risk sharing with contractors, and strategic alliances with contractors (Gashuwa; Wukari; Yola). Mercade and Gairín (2020) supported this finding by showing that one reason why planning is so important is that it helps universities to identify and assess the risks associated with different strategies. By carefully considering the potential risks and benefits of each strategy, universities can make more informed decisions about which strategies to adopt.*

4.2.4 Economic consideration

Economic factor was found to be one the factors influencing strategy adoption among universities in the study area. The participants pointed out that activities such as maintenance cost reduction and economic efficiency are considered when adopting a particular strategy. This is evident considering the responses of interviewees who stated that:

"We carefully evaluate the long-term financial implications of different FM strategies. While initial costs may vary, we prioritize options that offer sustainable cost savings and improve asset life cycles. This ensures optimal value for our limited resources (Gashuwa 1)." The elements taken into account include overall maintenance cost reduction, increased economic efficiency, economies of scale, potential loss of savings, accountability, and improved cash flow (Wukari 2; Unimaid 2; Gashuwa and Kashere). Grossi et al. (2020) provided a similar finding that shows how universities are facing increasing financial pressures, due to factors such as rising costs, declining government funding, and increased competition from private institutions. As a result, universities are under pressure to find ways to operate more efficiently and effectively.

4.2.5 Technological consideration

The result from the interview also revealed that universities in the study area considered technology as a factor influencing choice of FM strategy. It was also revealed that consideration of strategy sometimes was based on acquiring new skills or technical knowledge that will help in achieving effectiveness in the performance of the facilities. This assertion is supported by the view expressed by some interviewees who mentioned that:

The elements impacting the decision of strategy adoption include achieving flexibility with evolving technology, obtaining new skills or technical knowledge, starting novel ideas and procedures, and upgrading the technology for competitive advantage Gashuwa; Wukari; Wukari and Yola. Rodríguez-Abitia et al. (2020) demonstrated a similar finding that shows universities considering technology as a factor influencing choice of a strategy adoption is significant, as it suggests that universities are increasingly recognising the importance of technology in their strategic planning. This is likely due to the fact that technology can play a major role in improving the effectiveness and efficiency of university operations, as well as in enhancing the quality of teaching and learning.

4.2.6 Functional consideration

The interviewees agreed that functional consideration is among the important factor considered when making choice of the FM strategy to adopt in facilities management services in the universities. The level of integration of facilities function and availability influence the strategy to be adopted for subsequent use. This is evident considering the responses of some interviewees who stated that:

"Technology empowers us with valuable data and analytics, enabling informed decision-making. For example, real-time monitoring systems provide insights into energy consumption patterns, helping us identify areas for improvement and implement energy-saving measures (Unimaid, Wukari)." The degree of structure and function integration, as well as the lack of equipment and tools, it was also discovered that factors influencing the choice of strategy adopted in universities include a lack of internal resources for a service, function complexity, and difficulty in contracting unpredictable activities Gashuwa 2; Yola 2. Hosseini et al. (2023) demonstrated a dissimilar finding that shows university facility as a complex and has a high level of integration; it may be more difficult to outsource its management. In this case, the university may want to consider an in-house or hybrid approach. On the other hand, if a facility is relatively simple and has a low level of integration, it may be more feasible to outsource its management. This could free up the university's resources to focus on its core mission of education and research.

4.3 Comparative Analysis

While all institutions recognize the importance of these factors, their priorities and emphasis may vary: institutions like Yola 2, Unimaid and Kashere 2 prioritize quality and durability, service excellence, process efficiency, workload reduction, risk mitigation, strategic partnerships, regulatory compliance, core competency focus, financial considerations and sustainability in their FM strategies. These institutions focus on long-term value, efficiency and sustainability, aiming to streamline processes, reduce administrative burden, mitigate risks associated with outsourcing, and leverage strategic partnerships for sustainability goals. Regulatory compliance is a crucial factor in their decision-making process, while core competency focus is emphasized. Financial considerations are also a key consideration, with institutions evaluating the financial implications of different FM strategies to prioritize long-term value and sustainability. Sustainability is explicitly mentioned as a key factor in their decision-making process. By prioritizing these factors, institutions can optimize their FM strategies and achieve their overall goals.

5. Conclusion and Recommendation

The study concluded that (quality, management, economic, planning, technological, and functional) all play a significant role in choosing a facility management (FM) strategy. But majority of interviewees (64.3%) prioritize quality as the primary factor influencing their universities' choice of strategy adoption. This suggests that universities place a significant emphasis on maintaining high academic standards and student satisfaction when formulating and implementing strategic plans. However, a substantial minority (35.7%) consider technological, economic, and functional factors as equally important. This indicates that universities also need to adapt to technological advancements, economic constraints, and operational efficiencies when making strategic decisions. Overall, the results highlight the complex interplay of various factors that influence strategy adoption in universities. While quality remains a central concern, universities must also consider the broader context of technological, economic, and functional considerations to ensure their long-term success. In view of that the study recommended that universities should allocate a minimum of 15% of their annual budgets to FM services. This increased investment will enable institutions to modernize facilities that will enhance learning and work environments. Implement energy-efficient systems and sustainable practices to reduce costs and environmental impact. Improve facility management operations by streamlining processes and empowering staff. Prioritize preventative maintenance to reduce downtime and asset lifespan.

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Biophilic Architecture for Event Centers: A Review

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Abstract

Biophilic architecture offers a transformative approach to designing event centers by integrating natural elements to enhance user experience, sustainability, and ecological balance. This review identifies key biophilic design elements, such as indoor vegetation, natural lighting, water features, and organic forms, as the most impactful in creating vibrant and engaging spaces. These elements improve indoor air quality, reduce stress, and foster a sense of connection with nature, significantly enhancing the experience of event participants. Furthermore, incorporating biophilic principles can reduce energy consumption through passive design strategies, such as daylighting and natural ventilation, contributing to sustainability goals. This paper provides a comprehensive analysis of existing studies, highlighting best practices and practical applications for architects and developers seeking to incorporate biophilic design into event center projects. The findings underscore the potential of biophilic architecture to redefine event spaces as both functional and restorative environments, promoting human well-being and environmental stewardship.

Keywords: Biophilic Architecture, Design, Event Center, Integration.

1. Introduction

While creating protected and controlled environments, we are designing our cities in a way that is harming our natural environment and moving us away from nature. Even though there is abundant research and practice prioritising design strategies that minimise the impact of buildings on natural resources through the development of sustainable architecture, it does not explicitly focus on reinforcing how to link us back to nature. The emergence of biophilic design as a discipline, therefore, aims to cover this shortcoming: Biophilic design refers to the innate human connection to nature and the natural processes that promote health and well-being in the spaces we inhabit (our built environment). This is becoming more critical since research conducted by the United Nations in 2018 confirmed that 55% of the world's population lives in urban areas. Moreover, according to United Nations projections, this ratio will reach 68% in 2050 (United Nations, 2018). Today, the most urbanised regions are North America (82%), Latin America and the Caribbean (81%), Europe (74%), and Oceania (68%). The level of urbanisation in Asia is now approaching 50%. Furthermore, recent surveys show that we spend about 90% of our lives indoors (Ibid.). This increasing urbanised lifestyle brings some health problems due to the lack of natural elements in indoor spaces. For instance, sick building syndrome (SBS), seasonal affective disorder (SAD), or probably the most important one, a shortage of vitamin D, which is vital for human beings, at least a billion people worldwide are estimated to be vitamin D deficient (Holick, 2008), mainly in the northern hemisphere at latitudes higher than 40°N, because of inadequate exposure to sunlight (Spiro & Buttriss, 2014). Despite the new trend of architectural design known as biophilia, which has become a source of great interest to many architects and designers around the world, aiming to create a relationship between man, nature, and building, this is what has been observed through a review of previous literature (Heschong *et al*., 2013; Ryan *et al*., 2014; Grey & Birrell, 2014; Movahed, 2015; Gurung, 2014; Browning & Cooper, 2015; Benfield *et al*., 2015; Düzenli *et al*., 2017, amongst many others), as scholars seek to link the internal environment of building with nature, as the world is in dire need of moving towards more environmentally friendly buildings. Event centers are dynamic spaces designed to host diverse activities, ranging from social gatherings and cultural performances to professional conferences. Despite their functional importance, many traditional event centers face challenges, including poor indoor environmental quality, high energy consumption, and a lack of user engagement. These issues often lead to discomfort, reduced satisfaction among occupants, and unsustainable operational practices. Addressing these challenges requires innovative design approaches that prioritize human well-being and environmental sustainability. Biophilic architecture, characterized by the integration of natural elements such as vegetation, natural light, and organic forms into built environments, has emerged as a promising solution. Studies indicate that biophilic design can improve psychological well-being, enhance cognitive function, and reduce stress levels among occupants, while also contributing to energy efficiency and environmental sustainability (Kellert *et al*., 2012; Browning *et al*., 2014). However, the application of biophilic principles in event centers remains underexplored, creating a significant

research gap in understanding how such designs can optimize user experiences and operational outcomes. This review seeks to address this gap by examining the potential of biophilic architecture to transform event centers into spaces that balance functionality, user engagement, and environmental responsibility. It focuses on identifying the most effective biophilic design elements and their practical implications, offering insights for architects, designers, and stakeholders committed to reimagining event spaces. By addressing this niche, the study contributes to the growing discourse on sustainable and human-centered design strategies in the architectural domain.

2. Biophilic Architecture

Biophilic architecture is an approach to building design that seeks to reconnect people with nature by incorporating natural elements, materials, and patterns into the built environment. It aims to enhance occupants' well-being and comfort by integrating features such as natural light, greenery, water elements, and organic shapes. This design philosophy recognizes the inherent human need for a connection with nature and strives to create spaces that not only look aesthetically pleasing but also promote health, reduce stress, and improve cognitive function (Kellert 2011).

Biophilic Architecture (BA) is a design approach that seeks to reconnect people with nature in the built environment. At its core, BA is based on principles of biophilia, the innate human affinity for the natural world, as articulated by Wilson (1984). Key principles of BA include:Incorporating natural elements such as plants, water features, and daylight into indoor and outdoor spaces. Using natural materials, colors, and patterns inspired by the natural world. Designing spaces that mimic natural environments, with diverse layouts, open spaces, and transitions. Utilizing energy-efficient and environmentally friendly practices to align with ecological principles.

Integration of BA into Event Center Design

Event centers, as multifunctional spaces, can benefit significantly from biophilic principles. The integration of BA can address key challenges, such as creating engaging and sustainable environments while enhancing user experience. Specific applications include: Incorporating green walls, potted plants, and indoor gardens to improve air quality, reduce noise, and create visually appealing spaces. For example, a conference hall with vertical gardens can provide a calming backdrop, reducing stress for attendees. Maximizing daylighting through large windows, skylights, and light wells. A ballroom with ample daylighting can reduce energy consumption and enhance the ambiance of events. Including indoor fountains or outdoor reflective pools near entry points. These features can create soothing auditory and visual effects, contributing to a serene atmosphere. Using wood, stone, and bamboo for finishes and furniture to evoke warmth and connection with nature. For instance, wooden beams and flooring in exhibition halls can enhance aesthetic appeal while maintaining functionality. Designing terraces, courtyards, or open-air spaces that blur the boundaries between indoor and outdoor areas. This can provide event attendees with spaces for relaxation and networking in natural settings. By incorporating these elements, event centers can become not just functional spaces but environments that promote well-being, reduce environmental impact, and provide memorable experiences for users.

2.1 Essence of biophilic architecture

Regarding the main essence of BA, a literature analysis (Table 1) shows that nearly half of the experts (45%) believed in human connection with nature, whereas 33% considered a balanced relationship between human and nature, which would also contain the concept of human-nature connection. Others misled and downgraded the main essence of BA to only some ways of BA practices in architecture through nature-based dialogues and rules governing the natural forms. Therefore, resembling the BD, the main essence of BA is the human-nature connection in a built environment. Table 1 presents some keywords that can help define the BA in fact, 78% of definitions contain the word “nature”, whereas the rest of them use such words as “ecology, habitat, life, culture, and environment”, instead.

Table 1- Biophilic Architecture Definitions in Existing Literature

	Year	Name	Main idea	Keyword	Nature	More than Nature
Nature-based inspirations	2014	Ramzy.	nature-based dialogue between architectural spaces and a set of human inborn affiliations	Nature based	Y	-
	2015	Ramzy	understanding the rules governing natural forms	-	Y	-

Human and nature connections	2015	Soderlund and Newman	innate connection with nature should be expressed in their daily lives, better contact with nature within and on buildings	connection, contact	Y	-
	2015	Movahed Kh	healthy spaces connected with nature	connect	Y	-
	2017	Amanda Sturgeon	reconnect people and nature through buildings, building that will regenerate life	reconnect, regenerate	Y	Ecology, culture, history, life
	2019	Abdelaal And Soebarto V	connecting the built environment to nature	connect	Y	-
Balanced existence between human and nature biophilia	2020	Totaforti,	formation of balance between human and environment	formation of balance	N	Culture, environment
	2021	Hakala	overcoming the discrepancy between ancestral and current habitats	-	N	Habitat
	2022	Hung and Chang,	nature, life and architectural conjecture merge, lively habitable edifice	merge		Life, environment

3. Methods

Addressing the literature on BA thoroughly, this paper reviews nearly all of the existing papers and books regarding BD in the past 14 years (2010 – March 2024). The term "biophilic" per se and also accompanied by "design, architecture, or building" were searched for in titles of papers in Web of Science, Scopus, and ScienceDirect databases. The search results included 65 studies of different types such as journals, book reviews, conference papers, and reports. Abstracts and conclusions were analyzed in the first stage of the literature review. The resultant information showed that seven papers were mainly about biophilia hypothesis, whereas seven other papers were about BD and ethics. Accordingly, 56 papers were selected in direct relation to BD. As the thematic diagram (Figure 1) indicates, the existing materials were classified as different categories in terms of their main topics. At first, 9 books and papers on the BD theory were reviewed in total, whereas 20 papers and 2 books on the BA were then evaluated and analyzed accurately based on the leading purpose of this review study. The criteria for selecting studies centered on the inclusion of research specifically addressing biophilic design applications in event centers. The review process prioritized studies that examined the direct and indirect impacts of biophilic elements—such as natural lighting, vegetation, water features, and organic materials on user experience and space functionality in event-related environments. Studies with broader applications o biophilic design in commercial, office, or residential settings were considered only if they provided transferable insights relevant to event center design. Compared to other reviews on biophilic design, which often focus on workplaces, healthcare, or educational settings, this study uniquely concentrates on event centers. While previous reviews explored the general benefits of biophilic design for enhancing well-being, productivity, or healing, the present study aims to fill a gap by examining how biophilic elements can be specifically tailored to improve atmosphere, attendee engagement, and spatial versatility in event-oriented environments. This targeted focus on event centers distinguishes the review from other works that address biophilic design in more generalized contexts.

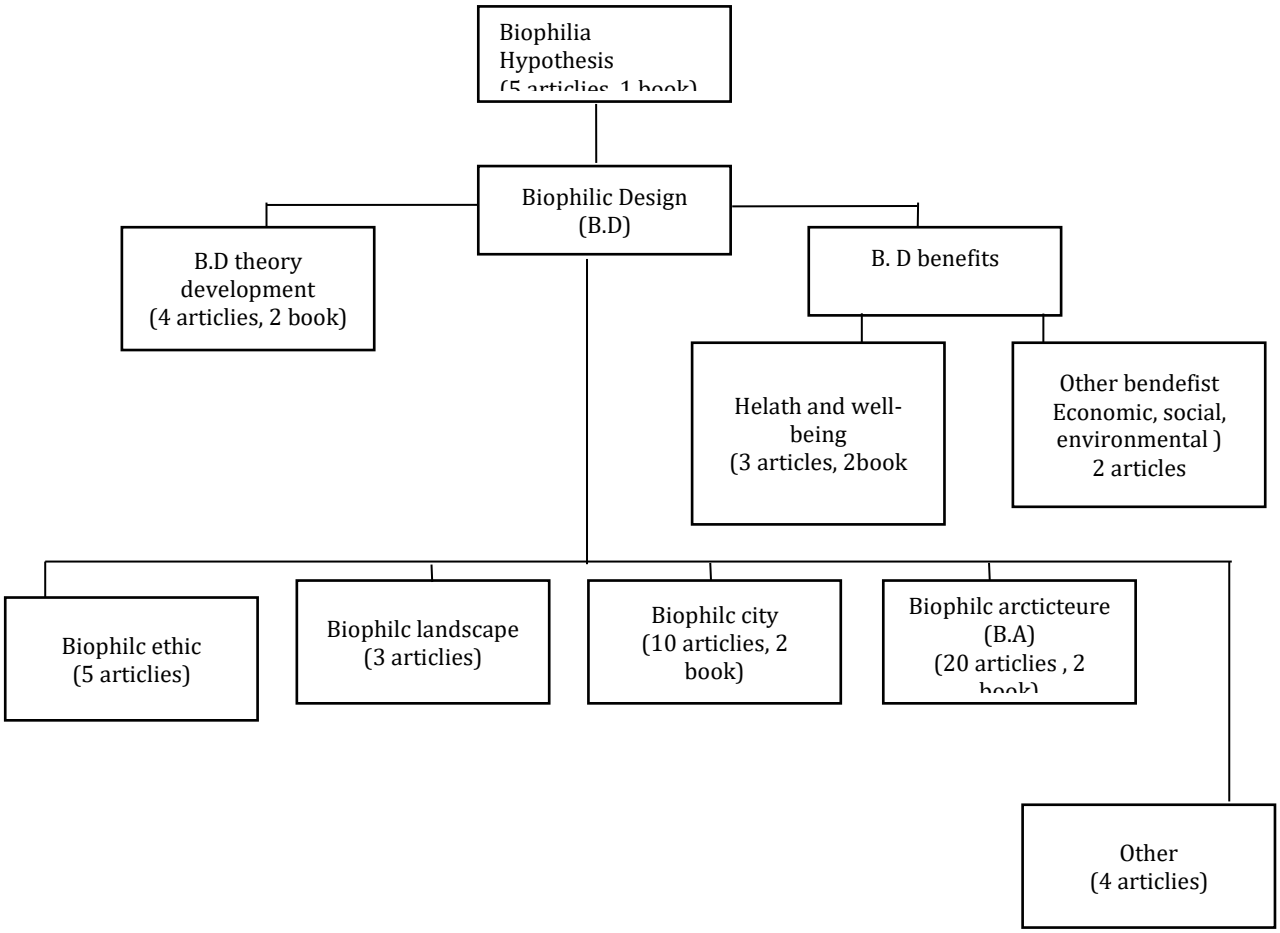

Figure 1: Thematic diagram of Biophilic design's publications from 2010 to 2020(March)
Source : Authors (2024)

4. Place of origin of publications

In order to know the place where most studies on the topics were conducted, an analysis was made of the country where the research was carried out. For practical reasons and a better understanding, they were grouped by continents see Table 2. It can be seen that the majority belong to the European continent, since it accounts for 28 publications out of the 65 total, followed by the Asian continent with 20. In Table 2, this paper can graphically observe a large difference in the percentages obtained between the continents with the lowest (America) and the highest (Europe) number of documents. This is due to the fact that the continents with the lowest percentages are America with 6, the continent with the lowest productivity of scientific studies published in the databases on application of biophilic architecture in public buildings over the last fourteen years.

Table 2: Place of origin of publications

Continents	Publication
Africa	11
America	6
Asia	20
Europe	28
Total	65

Source: Authors (2024)

4.1 Analysis of Regional Trends in Biophilic Architecture Research

The distribution of research on biophilic architecture (BA) demonstrates notable regional trends that influence its development and application, particularly in the context of event centers. Table 2 highlights significant contributions from Europe and Asia, while regions like America and Africa lag in research output.

4.1.1 Regional Contributions

Europe

Strengths: Europe's dominance (28 publications) reflects strong institutional support for sustainability, advanced regulatory frameworks, and an emphasis on well-being in architectural practices. Influence on BA: The European focus often integrates biophilic elements into urban landscapes and adaptive reuse of historic buildings, making it well-suited for multifunctional event centers that require aesthetic and functional harmony.

Asia

Strengths: Asia's significant contributions (20 publications) are driven by the rapid urbanization of countries like China, Japan, and Singapore, where integrating nature into high-density environments has become a priority. Influence on BA: Research often emphasizes compact, innovative designs that maximize natural elements within limited spaces, which is crucial for urban event centers.

Africa

Strengths: Africa (11 publications) demonstrates emerging interest, often focusing on resource-efficient and climate-adaptive designs due to pressing environmental challenges.Influence on BA: While limited, African research often emphasizes cost-effective and localized biophilic solutions, which could inform context-specific applications in event centers, such as natural ventilation and use of indigenous materials.

America

Strengths: With only 6 publications, America's lower output contrasts its robust architectural industry. However, existing studies often emphasize cutting-edge sustainability practices. Influence on BA: American research highlights energy-efficient designs and occupant well-being, valuable for large-scale event centers but with less emphasis on integrating cultural or regional identity.

4.1.2 Impact of Regional Differences on BA Application in Event Centers

Climate Considerations:

European designs often adapt to temperate climates, utilizing daylighting and insulation, while African approaches focus on mitigating heat with shading and natural ventilation. Event centers must align with these climatic strategies to optimize energy use and occupant comfort.

Cultural Influences:

Asian designs incorporate spiritual and aesthetic elements, like water features and gardens, reflecting cultural connections to nature. In Africa, BA could draw from indigenous knowledge and practices, incorporating local materials and natural forms into event center designs.

Economic Factors:

Limited research in Africa and America may reflect resource allocation challenges or competing priorities. However, biophilic design in these regions could provide cost-effective solutions by reducing energy reliance and improving long-term sustainability.

5. Conclusions

Biophilic architecture has the potential to redefine event center design by addressing challenges related to user experience, sustainability, and environmental integration. This review underscores the importance of incorporating key biophilic principles, such as natural lighting, indoor vegetation, and spatial variability, into event centers to create vibrant, functional, and restorative spaces. While Europe and Asia lead in biophilic research, under-represented regions like Africa and America offer opportunities for developing innovative, context-specific solutions. The study recommends using indigenous materials and climate-adaptive design strategies to align with regional environmental conditions. For instance, incorporating natural ventilation systems in tropical climates or thermal insulation in temperate zones can improve user comfort and energy efficiency. Integrate diverse natural elements, such as water features, vegetation, and natural textures, to create immersive environments that enhance event attendees' well-being. Utilize passive design techniques, like daylighting and strategic building orientation, to reduce energy consumption while maintaining aesthetic appeal. To fully unlock the potential of biophilic architecture in event centers, future research should focus on the following areas: Conduct studies to quantify the economic and operational benefits of integrating biophilic architecture in event centers, focusing on long-term energy savings, increased user satisfaction, and enhanced facility utilization. Investigate how biophilic design impacts attendees' psychological well-being, productivity, and overall satisfaction during events. Research could

also explore how to optimize irrigation and nutrition systems to reduce maintenance. Explore how cultural, climatic, and socio-economic factors influence the implementation and effectiveness of biophilic principles in under-researched regions, particularly in Africa and Latin America.

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Drivers of Digital Technology Adoption for Enhancing Trust and Transparency in Nigeria's Construction Sector

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Abstract

The objective of this study is to explore the factors that drive the adoption of digital technologies to improve trust and transparency in the Nigerian construction industry. Despite its significant contributions to the economy, the industry faces challenges such as low technology adoption, which undermines efficiency and stakeholder confidence. To address these issues, we employed a quantitative research approach, distributing self-administered questionnaires to a sample of 4722 professionals from various construction organizations in Abuja, Nigeria. Our analysis revealed that clear project goals emerged as a critical factor in technology adoption; notably, the study found that clear project goals were rated as the highest-ranked driver with a mean importance score of 4.91 (MIS), underscoring their significance in enhancing trust and transparency within construction projects. Additionally, other key drivers identified include leadership commitment, adequate technological infrastructure, employee engagement, and effective data management practices. These findings suggest that enhancing these drivers can substantially improve trust and transparency in project delivery, thereby attracting more investment and boosting stakeholder confidence in the Nigerian construction sector. This research contributes valuable insights into how digital technologies can serve as vital tools for fostering sustainable development and growth within the industry.

Keywords: Adoption, Construction, Drivers, Digital Technologies, Trust, Transparency.

1. Introduction

The Nigerian construction industry is a pivotal sector in the nation's economy, significantly contributing to GDP growth, job creation, and infrastructure development. It encompasses two main categories: building construction, which includes residential, commercial, and institutional projects, and civil engineering, focusing on infrastructure such as roads, bridges, and utilities. Major players in this industry include prominent local companies like Julius Berger Nigeria PLC and international firms such as China Civil Engineering Construction Corporation (CCECC). The interplay between these entities facilitates the industry's growth and development (Waziri *et al*., 2017; Nanayakkara *et al*., 2019; Bello *et al*., 2021).

Despite this growth, the literature indicates that the Nigerian construction industry lags behind peers from other developing nations regarding GDP contribution due to low acceptability, usage, and adoption of modern technologies (Buba *et al*., 2018; Bamgbose *et al*., 2024). The persistent low level of information technology (IT) utilization in the Nigerian construction industry continues despite numerous calls for innovative technology adoption (Usman & Said, 2014; Waziri *et al*., 2017; Bamgbose *et al*., 2024).

This low adoption of digital technology has led to various challenges that hinder the effectiveness, efficiency, and sustainability of the industry. Among these challenges are trust deficits and transparency shortcomings, which have emerged as critical barriers to progress, impacting project delivery, investment attractiveness, and stakeholder confidence (Usman & Said, 2014; Onokala & Olajide, 2020; Akinshipe *et al*., 2024). Traditional approaches to addressing these issues have proven inadequate (Omer *et al*., 2023). Conventional project management practices that rely heavily on manual processes and paper-based documentation are susceptible to manipulation, delays, and errors (Onokala & Olajide, 2020). Additionally, fragmented data management systems exacerbate information silos that hinder effective communication and collaboration among project stakeholders (Kumar, 2023). In the absence of robust mechanisms for accountability and transparency, instances of fraud, mismanagement, and disputes persist, eroding trust and stifling industry progress (Kumar, 2023).

Digital technologies encompass a wide array of electronic tools, systems, devices, and resources that generate, store, or process data (Teisserenc & Sepasgozar, 2021a). These technologies include hardware such as computers and smartphones as well as software like applications and databases. The core functionality of digital technologies lies in their ability to convert information into digital formats that can be easily processed and analyzed (Badi *et al*., 2021; Sadeghi *et al*., 2022). This digital transformation facilitates faster communication and enhances data accuracy

while enabling automation across various processes. Moreover, digital technologies play a crucial role in advancing data analytics and artificial intelligence (AI) (Weber-Lewerenz, 2021), empowering businesses to make data-driven decisions that optimize operations.

2. Literature Review

2.1 Meaning of Digital Technologies

Digital technologies are integral to creating a cohesive and interconnected digital ecosystem, allowing various systems and devices to connect and integrate (Teisserenc & Sepasgozar, 2021). A prime example of this integration is the Internet of Things (IoT), where everyday objects are embedded with sensors and software to communicate and exchange data over the internet. This interconnectedness facilitates real-time monitoring, remote control, and predictive maintenance, thereby revolutionizing industries such as manufacturing, healthcare, and transportation (Teisserenc & Sepasgozar, 2021). In the context of the Nigerian construction industry, embracing these digital technologies can significantly enhance operational efficiency and project management.

Additionally, digital technologies like cloud computing provide scalable and flexible resources for data storage and processing. This capability enables organizations to manage vast amounts of data without extensive on-premises infrastructure. In Nigeria's construction sector, where data management is often fragmented, cloud computing can centralize information sharing among stakeholders, thereby improving communication and collaboration.

2.2 Adoption of Digital Technology in Nigerian Construction Sector

The adoption of Artificial Intelligence (AI) within the construction industry has proven to improve processes, enhance competitiveness, and boost overall performance. For instance, the benefits of implementing Building Information Modeling (BIM) and 3D concrete printing technology in addressing Nigeria's housing deficit. Using a mixed research approach that included 55 semi-structured questionnaires and 17 interviews, the study revealed that while BIM-driven 3D concrete printing can expedite mass housing projects, its usage among construction professionals in Nigeria remains in its infancy compared to developed countries.

Similarly, Bakori (2023) assessed the adoption of Fourth Industrial Revolution technologies in the construction sector through questionnaires administered to professionals in Abuja. The findings indicated that high costs of digital technologies, data security risks, and a lack of methodical approaches for implementation are significant barriers to technology adoption. Olaniyan (2019) further investigated perceptions among construction project managers regarding challenges to technology adoption through semi-structured interviews with ten participants. The thematic analysis identified five key themes: technology adoption, culture, organizational performance, innovative technology, and inter-organizational collaborations. These findings suggest that addressing these barriers is crucial for fostering technological advancement in Nigeria's construction industry.

2.3 Overview of Trust and Transparency in Organizations

Trust and transparency are foundational concepts critical to the success and sustainability of organizations (Kang & Hustvedt, 2014). Trust is defined as reliance on the integrity, ability, and character of individuals or organizations as a whole. It fosters a positive organizational culture by encouraging collaboration, risk-taking, and higher levels of employee commitment (Gomez-Trujillo *et al*., 2021; Stupak *et al*., 2021). Transparency involves openly sharing information about decisions and processes with stakeholders, which reduces ambiguity and fosters accountability (Kang & Hustvedt, 2014).

However, achieving trust and transparency presents challenges. Organizations must balance openness with confidentiality needs (Jiang & Huo, 2018). Excessive transparency can lead to information overload or unintended disclosure of sensitive data, while insufficient transparency can breed suspicion (Stupak *et al*., 2021). Effective communication strategies are essential for navigating this balance.

Leadership plays a crucial role in cultivating trust and transparency. Leaders must model desired behaviors by demonstrating honesty and integrity while establishing policies that promote transparency through regular updates on performance and open discussions (Gomez-Trujillo *et al*., 2021; Kang & Hustvedt, 2014). Understanding that trust and transparency are interlinked concepts reinforces their importance for organizational success (Parris *et al*., 2016). They enhance collaboration and ethical behavior while contributing to a positive organizational climate.

2.4 The Drivers of Digital Technologies for Trust and Transparency in Organizations

The adoption of digital technologies significantly impacts trust and transparency within construction organizations by fostering better communication, accountability, and efficiency (Li *et al*., 2022). Key determinants influencing successful integration include leadership commitment, technological infrastructure, employee training and engagement, data management practices, security measures, regulatory compliance, and standards (Gomez-Trujillo *et al*., 2021).

Leadership commitment is paramount for driving digital technology adoption aimed at improving trust and transparency (Gierlich-Joas *et al*., 2020). Leaders must articulate a clear vision that integrates digital tools into organizational culture while promoting openness and ethical behavior. By demonstrating commitment through transparent communication practices, leaders can set an example for their organizations.

Effective data management practices are also critical for maintaining trust within construction organizations. Implementing secure protocols for data collection and sharing protects sensitive information (Baldin, 2023). Technologies such as blockchain can enhance data security by providing immutable transaction records that stakeholders can audit. Ensuring data integrity builds stakeholder confidence by assuring them that information is accurate and secure.

3. Research Methodology

3.1 Research Methods

This study employs a quantitative research design utilizing self-administered questionnaires as the primary data collection instrument. The choice of a quantitative approach is driven by the need to capture broad patterns and statistical relationships regarding the adoption of digital technologies, trust, and transparency within the Nigerian construction sector. Quantitative methods are particularly effective for identifying trends and measuring variables across a large population, which is essential for generalizing findings in this context. However, to enhance the depth of understanding regarding trust and transparency—concepts that often benefit from qualitative insights—future research could integrate qualitative methods, such as interviews or focus groups, to explore participants' perspectives and experiences more comprehensively.

3.2 Study Population

The targeted population for this study consists of professionals operating within construction organizations in Abuja, Nigeria. This population will be drawn from databases of recognized professional institutions, including the Nigerian Institute of Architects (NIA), Nigeria Institute of Quantity Surveyors (NIQS), Nigerian Society of Engineers (NSE), and Nigerian Institute of Builders (NIOB). A total sample population of 4,722 was identified based on records from the Federal Capital Development Authority (FCDA, 2022). See Table I for a summary of the study population.

Table 1: Population Distribution

S/N	Sampled Population	Frequency	Percentage
1	Architects (NIA)	1680	24.2
2	Builders (NIOB)	1723	25
3	Quantity Surveyors (NIQS)	1319	19.2
	Total	**4722**	**100**

Source: Author's Computation adapted from Federal capital development Authority (FCDA,2022)

3.3 Sample Size/Frame

In order to arrive at a sample size that will serve as a good representative for the study population; the Salant and Dillman (2007) sample size formular was adopted. The formular is presented below.

Where:

Ns=completed sample size needed (notation often used is n)

Np=size of population (notation often used is N)

p=proportion expected to answer a certain way (50% or 0.5 is most conservative)

B=acceptable level of sampling error (0.05=±5%;0.03=±3%)

C=Z statistic associated with confidence interval (1.645=90% confidence level;1.960=95% confidence level;2.576=99% confidence level).

Therefore, substituting our sample frame into the formula at 95% confidence level, will give the following:

NS= (603184-108050-030(0-05)

Ns=364

3.4 Sample Techniques

To obtain a representative sample from the diverse population, a stratified random sampling technique was employed to allocate the proportion of the total sample size to various population elements. This ensures that each subgroup within the population is properly represented in the sample, offering better overall population coverage.

3.5 Methods of Data Analysis

Since the data will primarily be mixed, both descriptive, inferential statistical and content analysis will be adopted. Descriptive statistics, including percentages, charts, Likert scale, and mean scores, will be employed to describe the determinants, challenges, and strategies for mitigating challenges in adopting digital technologies to enhance trust and transparency in the construction sector. Inferential statistical methods, such as Chi-square and Relative Importance Index (RII), will also be utilized.

4. Results and Discussion

4.1 The Percentage of the Respondents in the Questionnaire Study

Out of the 364 questionnaires distributed to the selected sample, 291 were returned and used for the analysis, representing a percentage response rate of 79.94%. A study by Mugenda and Mugenda (2003) revealed that a response rate of70% is considered adequate for analysis in a Social Science study. Therefore, a response of 79.94% from the study participants can be considered as adequate in this study.

4.2 Demographic Characteristic of the Study Respondents

In order to gather demographic information from the participants that were selected for the study, data regarding level of education, profession, length of service, and average number of executed projects by participants over the years were collected. These are summarized in Table 2.

Table 2: Demographic information of the Participants of the Study

Variables	Characteristics	Frequency	Percentage	Cumulative
Work experience	10-15	65	22.34	22.34
	15-20	87	29.90	52.24
	20-25	84	28.87	81.11
	>25	55	18.90	100
Level of Education	MSc	33	11.34	11.34
	BSc	101	34.71	46.05
	HND	106	36.43	82.48
	ND	51	17.53	100
Work Designation	Project managers	37	12.71	12.71
	Builders	58	19.93	32.64
	Architects	43	14.78	47.42
	Quantity	47	16.15	63.57
	Civil/Structural Engineers	41	14.09	77.66
	Contractors/sub-contractors	65	22.34	100.00

Based on the information presented in Table 2 all the participants attained tertiary education (MSc, B.sc, HND a nd ND). This was followed by participants with a Higher National Diploma (HND). In terms of working experien ce over the years, the results obtained revealed that respondents' experience spans across different ranges of ye ars (5-10, 10-15, 15-20, above 20 years) indicating a diverse and extensive pool of knowledge. Therefore, it can be emphasized that all the participants of the study had worked for an adequate period of time, thus gaining the necessary experience required to correctly fill the questionnaires.

4.3 Drivers for Adoption of Digital Technologies for Trust and Transparency in Nigerian Construction Industry

Table 3: The drivers for adoption of digital technologies for trust and transparency in Nigeria construction firms

The various drivers	SD	MIS	Ranking	Remarks
Clear goal, objectives and scope of work/projects	0.942	4.91	1st	Accept
Strong leadership support	0.821	4.87	2nd	Accept
Strong stakeholders support and engagement	0.901	4.85	3rd	Accept
Readiness to change by organization management	0.831	4.76	4th	Accept

Digital literacy	1.142	4.65	5th	Accept
Reliable infrastructure and connectivity	1.018	4.61	6th	Accept
Clear data management policies and procedures	1,113	4.55	7th	Accept
Adequate cyber security	0.942	4.41	8th	Accept
Continuous monitoring and evaluation	0.821	4.37	9th	Accept
Collaboration and partnership among stakeholders	0.901	4.25	10th	Accept
Transparency and clear communication among stakeholders	0.831	4.19	11th	Accept
Organization trust and transparency culture	1,142	4.05	12th	Accept
Regulatory compliance to standard	1.018	3.91.	13th	Accept
Cost saving, efficiency and organization competitive advantage	1,113	3.83	14th	Accept
Customers satisfaction	0.901	3.51	15th	Accept
Environmental sustainability	0.831	3.21	16th	Accept
Government support and initiative	0.901	3,15	17th	Accept
Clients demands for trust and transparency in projects	0.831	2.91	18th	Accept

Based on the information presented in Table 3, it can be observed that the participants of the questionnaire study strongly agreed that clear project goals/objectives/scope of work, strong leadership support, strong stakeholders support and engagement, readiness to change by organization management, digital literacy, reliable infrastructure/connectivity and clear data management policies and procedures are the most significant drivers for adoption of digital technologies for trust and transparency in Nigerian construction firms (MIS above 4.5). This is synonymous with the findings of Gierlich-Joas *et al*. (2020) and Gomez-Trujillo *et al*. (2021). Gierlich-Joas *et al*. (2020) and Gomez-Trujillo *et al*. (2021) are of the views that leadership support and commitment are paramount in driving the adoption of digital technologies aimed at improving trust and transparency in organizations. This implies that for any organization to adopt digital technologies for trust and transparency, the leaders of such organization must have a clear strategic vision that integrates digital tools into the organizational culture and operations. This involves not only investing in the necessary technologies but also promoting a culture of openness and ethical behaviour. Hence, leaders must actively demonstrate their commitment to transparency through regular, honest communication and by setting an example for the rest of the organization (Gomez-Trujillo *et al*., 2021). Similarly, Mubarak & Petraite (2020) pointed that for organizations to integrate digital technologies into trust and transparency, organizations must define specific goals for adopting digital technologies. Baldin (2023) emphasized that effective staff training, engagement of all stakeholders such as clients, contractors/suppliers and data management practices are critical for maintaining trust and transparency in construction organizations.

Table 4: Influence of Drivers on Trust and Transparency in the Nigerian Construction Industry

S/N	Driver	Influence on Trust	Influence on Transparency
1	Clear Project Goals/Objectives	Establishes a shared understanding among stakeholders, reducing ambiguity and fostering trust.	Provides a framework for accountability, as all parties can refer back to agreed-upon objectives.
2	Strong Leadership Support	Leaders who advocate for transparency build trust by modeling ethical behavior and decision-making.	Encourages open communication, as leaders set the tone for sharing information and updates.
3	Stakeholder Engagement	Involving stakeholders in decision-making processes enhances their sense of ownership, leading to greater trust.	Promotes openness by ensuring that stakeholders are informed and included in relevant discussions.
4	Readiness to Change	Organizations willing to adapt foster trust among employees and stakeholders by demonstrating commitment to improvement.	Facilitates transparency as organizations openly communicate changes and their implications.

5	Digital Literacy	Increases confidence among employees and stakeholders in using digital tools, enhancing trust in the technology itself.	Ensures that all parties understand how data is managed and shared, promoting clarity and openness.
6	Reliable Infrastructure/Connectivity	Reliable systems build trust as stakeholders can depend on consistent access to information.	Enhances transparency by ensuring that data is accessible and up-to-date for all relevant parties.
7	Clear Data Management Policies	Establishing clear protocols for data handling fosters trust by assuring stakeholders that their information is secure and used responsibly.	Promotes transparency by outlining how data will be collected, stored, and shared, reducing uncertainty.

5. Conclusion and Recommendations

5.1 Conclusion

The Nigerian construction industry plays a pivotal role in the nation's economy, contributing significantly to GDP growth, job creation, and infrastructure development. However, it lags behind its peers in other developing nations regarding the adoption of modern technologies, leading to challenges such as trust deficits and transparency shortcomings that hinder project delivery and stakeholder confidence. Traditional project management practices are often susceptible to manipulation and errors due to reliance on manual processes and fragmented data management systems. Digital technologies, including tools for data processing and communication, can enhance operational efficiency and project management by fostering better communication, accountability, and efficiency. Key drivers for the adoption of these technologies include clear project goals, strong leadership support, stakeholder engagement, readiness to change, digital literacy, reliable infrastructure, and clear data management policies. The findings indicate a strong agreement among participants that these drivers are essential for enhancing trust and transparency in Nigerian construction firms. This study highlights the importance of integrating digital technologies into organizational practices to overcome existing barriers and improve overall industry performance.

5.2 Recommendations

The study recommends that stakeholders should pay attention to the identified drivers that enhance the effectiveness of digital technologies for trust and transparency in construction projects. Also, Construction firms should establish leadership training programs focused on integrating digital tools to foster transparency. This will lead to enhanced communication/collaboration, improved projects outcomes and quality in the construction sector.

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Navigating Urban Resilience in the Context of Global Economic Shifts: A Review of Literature

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Abstract

Research on urban vulnerability has expanded significantly in recent years, yet it remains constrained by interdisciplinary differences in definitions and approaches. This paper examines the framing of urban resilience within the context of global economic shifts, particularly in emerging economies. It explores how economic transformations impact the built environment and urban infrastructure, influencing economic and environmental challenges. By analyzing various approaches to urban vulnerability, this paper highlights the opportunities and challenges in integrating these perspectives into a cohesive understanding of urban resilience. It argues that a synthesis of different research lineages can provide valuable insights into the key dimensions and determinants of urban resilience, but also identifies the persistent challenges in achieving this synthesis. It emphasizes the need for concepts and tools that cut across disciplines how urban resilience is characterized, particularly economic thresholds, tipping points, and cascading impacts. The findings offer policy recommendations for enhancing urban resilience through adaptive planning and development strategies, particularly in the face of global economic uncertainty.

Keywords: Adaptive Urban Planning, Built Environment, Emerging Economies, Global Economic Revolution, Sustainable Development, Urban Resilience.

1. Introduction

Urban centers are pivotal to both local and international stability, but they face increasing threats from natural hazards such as floods and heatwaves, intensified by climate change (IPCC, 2023). Economic pressures, including financial crises and recessions, exacerbate these vulnerabilities, particularly in emerging economies (World Bank, 2020). These compounded risks underscore the importance of urban resilience, the ability of cities to withstand and recover from shocks

Economic instability poses a significant challenge to urban resilience. Economic recessions can lead to reduced public investment in essential infrastructure, impairing a city's ability to effectively respond to disasters. This issue is particularly critical in rapidly growing economies, where vulnerable economic systems tend to magnify the effects of such shocks (Dodman *et al.,* 2017; Garschagen and Romero-Lankao, 2015). Resilient infrastructure can mitigate natural disaster impacts, reduce economic losses, and ensure continuity of essential services (Rockefeller Foundation and ARUP, 2015). Conversely, poorly designed infrastructure can exacerbate vulnerabilities, prolong recovery, and increase costs (Meerow *et al*., 2016). Rapid urbanization in emerging economies often leads to inadequate infrastructure and informal settlements, further heightening risks (Seto *et al.,* 2012).

While research on urban resilience is growing, it remains fragmented, with diverse perspectives sometimes resulting in contradictory recommendations (Meerow *et al.,* 2016; Garschagen & Romero-Lankao, 2015). Addressing these challenges requires an integrated understanding of how global economic transformations affect resilience, especially in the built environment of emerging economies (Meerow *et al.,* 2016).

Urban centers are the epicentres of global population, economic activity, and infrastructure, making them pivotal to both local and international stability. However, these densely populated areas are increasingly vulnerable to a range of threats, including natural hazards like floods, heat waves, and droughts, which climate change is expected to intensify. In addition to environmental risks, urban areas are also subject to significant economic pressures, such as financial crises, trade disruptions, and economic recessions, particularly in emerging economies. These compounded risks highlight the critical importance of urban resilience, the capacity of cities to withstand, adapt to, and recover from both environmental and economic shocks (IPCC, 2023). Economic shocks can have far-reaching consequences for cities, exacerbating existing vulnerabilities and triggering cascading effects across social, economic, and physical systems. For example, an economic downturn can lead to reduced public funding for critical infrastructure, which in turn can weaken a city's ability to respond to environmental disasters (Garschagen

and Romero-Lankao, 2015). In emerging economies, where economic systems are often more fragile and urbanization is rapidly accelerating, the impact of economic instability can be especially severe. Ensuring that cities are resilient in the face of such instability is not only crucial for the well-being of urban residents but also for the broader economic and social stability of entire regions (Leitner, *et al*., (2018).

Meerow *et al*., (2016) assert that Central to the concept of urban resilience is the role of the built environment—the physical structures and infrastructures that make up a city, including buildings, roads, bridges, public spaces, and utilities. The built environment serves as the backbone of urban life, supporting the daily activities of millions of people and businesses. A well-planned and resilient built environment can mitigate the impacts of natural disasters, reduce economic losses, and ensure the continuity of essential services during and after a crisis. For example, resilient infrastructure can help prevent flooding in vulnerable areas, provide safe and reliable transportation routes, and maintain access to clean water and electricity even in the face of severe weather events. Conversely, poorly designed or inadequately maintained infrastructure can exacerbate vulnerabilities, leading to greater damage, prolonged recovery times, and increased human and economic costs.

In emerging economies, the challenges related to the built environment are particularly pronounced. Rapid urbanization often outpaces the development of adequate infrastructure, resulting in informal settlements, overcrowded housing, and insufficient public services. These conditions not only heighten the risk of disasters but also complicate recovery efforts, making it more difficult for cities to bounce back from crises. Therefore, understanding how the built environment contributes to or undermines urban resilience is crucial for developing strategies that can enhance the capacity of cities to withstand and adapt to both environmental and economic shocks (UN-Habitat, 2022).

Despite the growing body of research on urban vulnerability and resilience, the field remains fragmented, with various disciplines offering different and sometimes conflicting perspectives. Some scholars argue that this diversity of approaches is necessary to capture the full complexity of urban systems, suggesting that existing frameworks are complementary and can together provide a more holistic understanding of urban resilience. Others contend that these divergent perspectives lead to incompatible narratives and contradictory policy recommendations, which can hinder effective decision-making and action (Meerow *et al.,* 2016).

This paper seeks to address these challenges by exploring how global economic transformations impact urban resilience in emerging economies, with a particular focus on the role of the built environment. It examines how different conceptual approaches to urban vulnerability contribute to our understanding of resilience and assesses the limitations of these approaches in the context of economic instability. By synthesizing these diverse perspectives, the paper aims to provide a more cohesive understanding of the key dimensions and determinants of urban resilience, offering insights into how cities can better prepare for and respond to the complex challenges posed by both climate change and economic transformation.

2. Literature Review

2.1 Current Perspectives on Urban Vulnerability and Resilience

Studies on urban vulnerability often describe it as the potential for harm, which encompasses the degree to which a system such as a city, its population, infrastructure, or economic sectors is susceptible to and struggles to cope with the adverse effects of various hazards or stresses, including climate change and economic instability (Garschagen and Romero-Lankao, 2015). This concept of vulnerability is inherently complex and dynamic. It extends beyond mere susceptibility to harm and incorporates a range of factors, including sensitivity to stressors and the capacity to adapt to and recover from them (IPCC, 2023). Vulnerability cannot be defined solely by the nature of the hazard or the intrinsic properties of the affected system. Rather, it is the result of an interplay between these factors and involves multiple dimensions: impacts, exposure, sensitivity, adaptive capacity, and actual responses (Dodman *et al*., 2017; Satterthwaite *et al*., 2007). Understanding urban vulnerability requires examining how these dimensions interact within the context of both environmental and economic pressures (World Bank, 2020; UN-Habitat, 2022). Current research on urban vulnerability often aligns with broader environmental change contexts, such as the study of natural hazards, political economy, and ecological resilience (Meerow *et al*., 2016; Rockefeller Foundation and ARUP, 2015). However, emerging perspectives highlight the need to integrate considerations of economic instability alongside environmental risks to provide a more comprehensive understanding of urban resilience (Seto *et al*., 2012; Garschagen and Romero-Lankao, 2015). This expanded focus recognizes that economic disruptions, such as financial crises and trade disruptions, can exacerbate vulnerabilities and complicate the capacity of cities to respond to and recover from environmental hazards (Dodman *et al*., 2017; IPCC, 2023) Thus, while traditional research paradigms address various aspects of vulnerability, there is a growing need to synthesize these approaches to better capture the interplay between economic and environmental factors. By incorporating these dimensions, researchers and policymakers can develop more robust frameworks for

understanding and enhancing urban resilience in the face of multifaceted challenges (Garschagen and Romero-Lankao, 2015; IPCC, 2023).

2.2 Urban Vulnerability as Impact

Recent studies continue to explore urban vulnerability to climate change through the lens of exposure, sensitivity, and adaptive capacity. These dimensions are often highlighted in scientific assessments, including frameworks used by the IPCC and related studies (Sarkodie, *et al*. (2022). For instance, (Marcotullio, P. J. *et al*. (2023) sated that vulnerability is conceptualized as a combination of exposure (the presence of populations or infrastructure in areas prone to hazards), sensitivity (susceptibility due to physical or social factors), and adaptive capacity (the ability to respond to or recover from climate impacts). His research underscores that vulnerability is shaped by socio-economic structures, institutional responses, and disparities in access to resources, which can exacerbate the impacts of climate risks such as extreme heat or flooding.

To address this, contextual approaches highlight the role of political, economic, and social frameworks in conditioning how urban areas experience and respond to climate events. These approaches emphasize the need for multidimensional vulnerability assessments that integrate both structural and systemic factors to inform equitable adaptation measures (Marcotullio, P. J. *et al*. (2023). This perspective encompasses two main research approaches:

2.2.1 Parameter-Based Impact Analysis

This approach examines how variations in climate parameters, such as temperature, air pollution, and precipitation, correlate with impacts like fluctuations in mortality and morbidity. It also considers how demographic factors such as age, gender, and socioeconomic status affect the relationship between hazards and health outcomes (IPCC, 2023). Additionally, it investigates geographical features of urban areas, such as low-elevation coastal zones, water scarcity, and steep slopes, which contribute to heightened vulnerability among city residents, especially those from disadvantaged communities (Hallegatte *et al*., 2013).

n 2019, the buildings and construction sector contributed to 38% of global energy-related CO2 emissions and accounted for 35% of energy consumption worldwide. Of these emissions, 26% originated from the production of building materials, representing 10% of total CO2 emissions. Additionally, energy use in buildings contributed 14% of sector-related emissions, corresponding to 5% of total global energy consumption (Ramon and Allacker, (2023).

2.2.2 Top-Down Impact Assessments

This approach involves applying scaled-down versions of global climate scenarios to urban settings to model future impacts, such as increased temperatures and sea-level rise. It estimates the potential effects of climate hazards, including urban heat island effects, storm surges, and heat waves, under various climate change scenarios (Rockefeller Foundation and ARUP, 2015). Some studies also explore adaptation options under different socioeconomic conditions to assess how these impacts might be mitigated (Carter *et al*., 2015). The "urban vulnerability as impact" perspective focuses on understanding urban exposure and sensitivity to changes in climate hazards. By evaluating the nature of these hazards, such as their intensity, frequency, and duration impact assessments address key research and policy questions. These include: What are the likely avoidable or unavoidable impacts of climate hazards on urban populations, infrastructures, and activities, considering policy responses like mitigation efforts and climate-proofing measures (IPCC, 2023; UN-Habitat, 2022) However, this approach does not fully capture all dimensions of urban vulnerability. It overlooks critical aspects such as how and why specific urban centres or populations are differentially affected, the receptiveness and motivation of local stakeholders and populations towards adaptation measures, and the availability of necessary skills, awareness, and resources for effective adaptation" (Yao *et al*., 2024). Additionally, it does not address how social, economic, political, and environmental factors constrain potential adaptation choices (Dodman *et al*., 2017; Garschagen and Romero-Lankao, 2015).

In essence, while this perspective provides valuable insights into the impacts of climate hazards on urban areas, it needs to be complemented by a more comprehensive understanding of the socio-economic and contextual factors that influence vulnerability and resilience (IPCC, 2022).

2.3 Inherent Urban Vulnerability

Research on inherent urban vulnerability, informed by livelihoods, political economy, and political ecology perspectives, provides a nuanced understanding of why certain cities or populations are more susceptible to climate change and other stressors, as well as their varying capacities to cope and adapt. This body of research addresses several key dimensions and questions (Dodman *et al*., 2012). The livelihoods approach emphasizes the role of asset building at individual, family, or community levels in mitigating hazards. Strategies such as self-help housing and localized disaster preparedness are pivotal in enhancing resilience. However, this approach faces challenges in

scaling such actions to the broader city level. For instance, while individual actions like relocating belongings to higher floors during heavy rainfall can be beneficial, they may not significantly alter overall urban vulnerability. These limitations underscore the need for broader, systemic interventions to address urban-scale vulnerabilities (Dodman *et al*., 2012).

State-centered interventions highlight the crucial role of government-led initiatives in building adaptive capacity. These initiatives often focus on economic growth, poverty reduction, and infrastructural development. This approach is essential for addressing structural determinants of vulnerability, such as inequities in resource distribution and access (Davino, *et al*., 2021). Effective state intervention can enhance urban resilience by addressing underlying socioeconomic disparities and improving infrastructural robustness Research on inherent urban vulnerability frequently concentrates on middle- and low-income countries, where development and governance failures exacerbate vulnerabilities. These regions often experience heightened risks due to inadequate infrastructure, limited resources, and ineffective governance structures. The focus on these contexts reveals how systemic issues contribute to urban vulnerabilities and underscores the need for targeted interventions to address these specific challenges (Karimi, *et al*., 2018).

Several key determinants shape inherent urban vulnerability. The interaction of hazards and socioeconomic factors examines how natural hazards intersect with social, economic, and political factors to create vulnerable urban situations. Historical patterns of social marginalization and domination contribute to underlying vulnerabilities. Additionally, the extent to which urban populations can influence choices, options, and policies—referred to as control and choice affects their vulnerability and resilience. Differential access to vital resources, including income, water, sanitation, and health services, plays a critical role in shaping vulnerability (Satterthwaite, 2013).

3. Methodology

3.1 Research Method

For this research, an expository qualitative research approach was employed in order gain brother knowledge of the topic. Expository research typically involves explaining, informing, or describing a topic in a clear and straightforward manner, often presenting facts and evidence to inform the reader. It does not aim to argue or persuade but rather to explain something in a detailed, unbiased way (O'Neill, (2019).

3.2 Sampling Technique

A purposive sampling technique is to be adopted for this research for the following;

a. **Focus on Relevance:** Purposive sampling allows you to select articles, reports, and studies that directly address the themes of urban vulnerability, exposure, sensitivity, resilience, or climate change.
b. **Efficient Use of Resources:** Instead of reviewing all available literature, purposive sampling focuses on high-quality, peer-reviewed sources and reputable databases.
c. **Alignment with Research Goals:** It ensures that the literature selected aligns closely with the study's objectives, such as identifying socio-economic or contextual factors influencing vulnerability.

3.3 Data collection

Data for the study is collected from all relevant literature, articles, reports and studies relevant to the objectives of this research. A total of five (5) articles and two (2) reports will be reviewed for the purpose of this study

S/N	Authors	Publication
1	Cote, M., & Nightingale, A. J. (2012).	Resilience thinking meets social theory: Situating social change in socio-ecological systems (SES) research. *Progress in human geography*, *36*(4), 475-489.
2	Davino, C., Gherghi, M., Sorana, S., & Vistocco, D. (2021).	Measuring social vulnerability in an urban space through multivariate methods and models. *Social indicators research*, *157*(3), 1179-1201.
3	Dodman, D., Leck, H., Rusca, M., & Colenbrander, S. (2017).	African urbanisation and urbanism: Implications for risk accumulation and reduction. *International journal of disaster risk reduction*, *26*, 7-15.
4	Karimi, M., Nazari, R., Dutova, D., Khanbilvardi, R., & Ghandehari, M. (2018).	A conceptual framework for environmental risk and social vulnerability assessment in complex urban settings. *Urban climate*, *26*, 161-173.

5	Ramon, D., & Allacker, K. (2023).	Optimizing building solutions in a changing climate: parameter-based analysis of embodied and operational environmental impacts. *Environmental Research: Infrastructure and Sustainability*, *3*(4), 045010.
6	IPCC, 2022:	The Intergovernmental Panel on Climate Change (IPCC) (Report)
7	UNDP, (2020)	The UNDP's review of urban resilience emphasizes that risks often cascade through urban systems due to socio-economic disparities and inadequate infrastructure (Report)

3.4 Data analysis

The PRISMA review framework (which is one of the most preferred Systematic Reviews and Meta-Analysis) will be used to organize the extracted data

Organize the extracted data in a spreadsheet or software (e.g., Excel, NVivo) with columns for:

- Author(s) and publication year
- Study location and context
- Key themes (e.g., exposure, sensitivity, adaptive capacity)
- Methodology used
- Findings and relevance to your study.

4. Findings and Discussion

4.1 Presentation of Findings

Table 1: list of reviewed literature and the findings

S/N	Author(s)/Year	Paper type	Themes	Findings
1	Cote, M., & Nightingale, A. J. (2012).	Article	• Social Theory Integration • Power and Inequality • Human Agency • Critique of Apolitical Resilience Models	• Critiques traditional resilience thinking by incorporating social theory into socio-ecological systems analysis. • Emphasizes the need for a more nuanced understanding of resilience, considering social change, power dynamics, and inequalities that influence a community's adaptive capacity to environmental challenges
2	Dodman, D., Leck, H., Rusca, M., & Colenbrander, S. (2017).	Article	• Rapid Urbanization in Africa • Urban Vulnerability and Risk Accumulation • Inclusive and Participatory Approaches • Climate Change and Adaptation	• Underscore the importance of addressing both the social and environmental dimensions of urbanization in Africa to reduce vulnerability and improve urban resilience in the face of climate change.
3	Davino, C., Gherghi, M., Sorana, S., & Vistocco, D. (2021).	Article	• Multivariate Analysis for Vulnerability Assessment • Spatial Distribution of Vulnerability • Heterogeneity of Urban Vulnerability	• Multivariate models can provide a more nuanced and accurate understanding of social vulnerability, enabling better-targeted urban planning and policy-making.
4		Article	• Environmental and Social Vulnerability:	• Highlights the complex interactions between

	Karimi, M., Nazari, R., Dutova, D., Khanbilvardi, R., & Ghandehari, M. (2018).		• Urban Heat and Climate Risks • Urban Planning and Adaptation • Social Inequality and Environmental Justic	environmental factors, social vulnerability, and urban heat risks, offering a framework for assessing the vulnerability of urban communities to heat and other related environmental stresses.
5	Ramon, D., & Allacker, K. (2023).	Articles	• Energy Efficiency and Sustainability • Life Cycle Assessment (LCA) • Building Design Optimization	• Highlights the importance of assessing both operational and embodied energy in buildings and the role of data-driven tools in optimizing energy consumption across building systems. • Emphasizes the use of energy flexibility through smart systems, showing how buildings can become energy-efficient by balancing energy supply and demand.
6	IPCC, (2022).	Report	• Widespread and Severe Impacts • Irreversible Risks with Higher Temperatures • Inequality and Vulnerability • Urgency for Action	• Highlights the urgent need for global action to reduce greenhouse gas emissions and addresses the risks posed by climate change across different sectors and regions.
7	UNDP, (2020)	Report	• Interconnected nature of urban risks, • Exacerbating vulnerabilities	• Addresses how urban risks, such as natural disasters and climate impacts, can cascade through interconnected systems, particularly due to disparities in socio-economic conditions and the inadequacies in urban infrastructure. • The goal is to highlight the need for integrated, equitable approaches to improving resilience in cities.

4.2 Reoccurring Themes

The recurring themes across these studies and publications highlight the interconnected nature of social and environmental vulnerabilities within urban settings, especially in the context of climate change and rapid urbanization. Key themes that emerge include:

a. **Social Inequality and Power Dynamics:** The role of social theory, power, and inequality is emphasized in understanding urban vulnerability and resilience. Several studies critique the apolitical nature of traditional resilience models, advocating for approaches that consider human agency and the effects of social disparities (Cote & Nightingale, 2012; Dodman *et al*., 2017; UNDP, 2020).

b. **Urban Vulnerability and Climate Risks:** Many articles stress the heterogeneity of urban vulnerability due to factors such as rapid urbanization (especially in African cities), which amplifies climate risks like urban heat islands and environmental degradation. The need for inclusive and participatory approaches in urban planning is also common across studies (Davino *et al*., 2021; IPCC, 2022).

c. **Climate Change Adaptation and Resilience:** Studies underline the urgency of climate change adaptation, highlighting irreversible risks and the need for comprehensive action to prevent severe impacts. They also emphasize multivariate analysis for better understanding of social and environmental vulnerabilities in urban areas (Karimi *et al*., 2018; UNDP, 2020).

d. **Energy Efficiency and Sustainability:** The integration of energy efficiency and sustainability into urban planning and building design optimization is recurrent. This includes the use of Life Cycle Assessments (LCA) to reduce emissions and ensure energy use is aligned with long-term resilience goals (Davino *et al*., 2021).

e. **Systems and Interconnectedness:** A consistent theme is the interconnected nature of urban risks, where environmental stressors exacerbate socio-economic inequalities, creating cascading effects that affect vulnerable communities. This calls for integrated, cross-sectoral approaches to build resilience (IPCC, 2022; Dodman *et al*., 2017).

Essentially, the themes across these studies underscore the necessity of integrating social and environmental perspectives into urban resilience strategies, prioritizing inclusivity, and applying data-driven tools for effective urban planning and risk mitigation.

5. Conclusion and Recommendations

The findings emphasize the need to move beyond traditional resilience frameworks by incorporating social theory into socio-ecological systems analysis. A nuanced understanding of resilience, one that accounts for social dynamics such as power, inequalities, and social change, is crucial for improving urban adaptive capacities to climate challenges. In African urbanization contexts, integrating both social and environmental considerations is vital for reducing vulnerability and building resilience against climate risks. The findings further highlight the importance of multivariate models for better understanding social vulnerabilities and urban heat risks. Additionally, the role of energy efficiency in urban infrastructure, especially through smart systems, is pivotal in mitigating climate change impacts.

The interconnectedness of urban risks, such as natural disasters and climate change, underscores the urgent need for comprehensive, integrated, and equitable approaches. Socio-economic disparities and inadequate infrastructure magnify these risks, creating cascading effects across urban systems. Therefore, policies must adopt a holistic, inclusive, and data-driven approach to urban planning and resilience-building.

7. Recommendations

a. **Integrate Social and Environmental Factors**: Future resilience strategies must consider both social inequalities and environmental impacts, particularly in vulnerable urban areas such as those in Africa (Cote & Nightingale, 2012; Dodman *et al*., 2017).

b. **Adopt Multivariate Models**: Use advanced data-driven tools and multivariate models to accurately assess and address social vulnerabilities in urban settings, facilitating targeted urban planning and policies (Davino *et al*., 2021).

c. **Enhance Urban Infrastructure**: Address infrastructural inadequacies and strengthen urban systems to withstand cascading risks from climate change impacts (IPCC, 2022).

d. **Promote Energy Efficiency**: Encourage the adoption of smart energy systems and optimize building energy use to reduce environmental and operational risks, fostering greater urban resilience (Karimi *et al*., 2018).

e. **Global Action on Climate Change**: Urgent, collaborative global efforts are needed to reduce greenhouse gas emissions and mitigate climate-related risks, ensuring that urban resilience strategies are aligned with international sustainability goals as stated by (UNDP, 2020).

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Challenges in Adopting Industry 4.0 for Total Quality Management in Nigeria's Construction Industry

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Abstract

Despite the potential benefits of Industry 4.0 technologies, including enhanced productivity and quality, the transition to these technologies in Nigeria's construction industry is significantly hindered by various barriers. This study aims to identify and analyze the challenges faced by construction firms in adopting Industry 4.0 technologies within Total Quality Management (TQM) frameworks. Utilizing a quantitative research approach, data was collected through questionnaires distributed to registered construction firms within the Federal Capital Development Authority in Abuja, Nigeria. Key findings reveal that 80% of respondents cited inadequate digital infrastructure as a primary barrier, while 70% identified high initial investment costs and 65% noted a lack of technological readiness among the workforce. Additional challenges include cultural resistance to change, insufficient leadership support, and concerns regarding cybersecurity and data privacy. The implications of these findings suggest that addressing these barriers through targeted strategies—such as enhancing digital infrastructure, investing in workforce training, and fostering leadership commitment—can significantly improve productivity and quality outcomes in the sector. Ultimately, this research underscores the necessity for coordinated efforts to facilitate the successful integration of Industry 4.0 technologies into TQM practices, positioning Nigeria's construction industry for sustained growth and competitiveness on a global scale.

Keywords: Industrial 4.0, Total Quality Management, Construction Industry, Big Data analytics, Robotics.

1. Introduction

The Nigerian construction industry is a vital component of the nation's economic landscape, significantly contributing to the GDP and providing employment for a large segment of the population (Olaniran *et al*., 2020). However, this sector faces critical challenges that impede its growth and efficiency, including project delays, cost overruns, and quality deficiencies (Oyedele *et al*., 2018). Particularly in Nigeria, the fragmented nature of the construction supply chain complicates quality management, as multiple stakeholders—such as contractors, subcontractors, suppliers, and regulatory bodies—often struggle with coordination and communication (Chan *et al*., 2019). This lack of collaboration can lead to misinterpretations of project specifications and ultimately result in compromised quality standards (Kotnour *et al*., 2015).

Despite the pressing need for effective quality management practices, the industry has not fully embraced innovative solutions that could enhance operational performance. The integration of Industry 4.0 technologies presents a promising avenue for addressing these challenges. However, the current literature reveals a significant gap regarding the intersection of Industry 4.0 and Total Quality Management (TQM) specifically within Nigeria's construction sector. While numerous studies have explored TQM and Industry 4.0 independently, there is a lack of research focusing on how these frameworks can be synergistically applied to improve quality outcomes in developing countries like Nigeria.

This study aims to fill this research gap by examining the barriers to adopting Industry 4.0 technologies in TQM practices within Nigeria's construction industry. By focusing on Nigeria-specific issues, this research will provide empirical insights into how leveraging Industry 4.0 can enhance TQM efforts and ultimately improve project outcomes. The significance of this study lies not only in its potential contributions to academic discourse but also in its practical implications for industry stakeholders seeking to navigate the complexities of modern construction challenges. By exploring this intersection, the research will offer actionable recommendations that can facilitate the successful integration of advanced technologies into quality management practices, thereby enhancing the competitiveness and sustainability of Nigeria's construction industry in the global market.

2. Literature Review

2.1 Overview of Total Quality Management in Organizations

Total Quality Management (TQM) is a comprehensive approach to improving the quality of products and services in organizations. It encompasses all employees, from the CEO to the front-line workers, aiming to embed a quality-conscious culture throughout the organization. TQM emphasizes the importance of supplier quality management that build strong relationships with suppliers and involving them in the quality improvement process that can lead to better quality inputs and more reliable supply chains (Crosby, 1979). By collaborating with suppliers, organizations can ensure that quality standards are upheld throughout the supply chain, resulting in higher overall product quality.

The concept of TQM emerged in the mid-20th century, drawing on earlier ideas from quality control and management pioneers like W. Edwards Deming, Joseph M. Juran, and Philip B. Crosby (Goetsch & Davis, 2014). These thought leaders emphasized that quality should not be the responsibility of a single department but should be a core organizational value.

At its core, TQM focuses on long-term success through customer satisfaction. This principle is evident in Deming's 14 Points for Management, which advocate for constancy of purpose, continuous improvement, and a system of profound knowledge (Deming, 1986). Deming argued that by fostering a culture where quality is paramount, organizations can achieve both higher efficiency and greater customer loyalty. This holistic approach involves not just meeting customer expectations but exceeding them, thereby fostering a sense of trust and reliability in the brand (Oakland, 2014).

One of the fundamental aspects of TQM is its emphasis on continuous improvement, or Kaizen, a Japanese term meaning "change for the better" (Imai, 1986). Continuous improvement involves everyone in the organization working together to make incremental changes to processes, products, and services. This iterative process helps to identify and eliminate inefficiencies, reduce waste, and enhance product quality. For instance, Toyota's implementation of the Kaizen philosophy has been instrumental in establishing its reputation for high-quality and reliable vehicles (Liker, 2004).

2.2 Total quality Management practices in Nigerian Construction Industry

Total Quality Management (TQM) is essential for enhancing the quality of products and services in the Nigerian construction industry, which faces significant challenges such as project delays, cost overruns, and substandard work quality. The effective implementation of TQM can improve the performance and competitiveness of construction firms by fostering a culture of continuous improvement and customer focus. However, the sector struggles with issues like inadequate project management, poor planning, and a lack of adherence to quality standards, compounded by economic instability and a shortage of skilled labor (Ogunbiyi *et al*., 2014).

To address these challenges, TQM practices must be tailored to the unique context of Nigeria's construction industry. For instance, enhancing collaboration among stakeholders—contractors, subcontractors, and suppliers—can improve communication and reduce misunderstandings that lead to delays and increased costs. Moreover, integrating Industry 4.0 technologies, such as IoT and AI, into TQM frameworks presents an opportunity to revolutionize traditional processes by enabling real-time data analysis and automation. However, barriers like inadequate digital infrastructure and low technological literacy must be overcome to fully leverage these advancements in quality management practices.

2.3 Principles of Total quality Management Practices in Organizations

Total Quality Management (TQM) is a comprehensive management approach that focuses on long-term success through customer satisfaction and continuous improvement of all organizational processes. The principles of TQM are fundamental guidelines that shape how organizations implement quality management practices to enhance efficiency, productivity, and competitiveness.

One core principle of TQM is customer focus. According to Evans and Lindsay (2014), customer focus means understanding and meeting the needs of customers, both internal and external. This principle asserts that the customer's requirements should dictate the quality standards of an organization. To achieve this, organizations must engage in continuous feedback mechanisms, ensuring that products and services not only meet but exceed customer expectations. Companies like Toyota and Apple have set benchmarks in this area by relentlessly focusing on customer satisfaction, which has translated into high customer loyalty and repeat business (Evans & Lindsay, 2014).

Another essential principle is continuous improvement, often encapsulated in the Japanese term "Kaizen." This principle is about making incremental changes that improve the organization’s processes, products, or services. Continuous improvement involves every employee, from top management to frontline workers, creating a culture where everyone is encouraged to suggest and implement improvements. This approach has been widely adopted in

various industries; for instance, the manufacturing sector uses tools such as Six Sigma and Lean methodologies to streamline processes, reduce waste, and improve quality (Liker, 2004). These methodologies have been particularly effective in organizations like General Electric and Motorola, where continuous improvement has led to significant cost savings and quality enhancements.

2.4 Industrial 4.0 Technologies

Industry 4.0, often referred to as the Fourth Industrial Revolution, signifies a transformative shift in industrial processes through the integration of advanced digital technologies. Key technologies within this paradigm include the Internet of Things (IoT), Artificial Intelligence (AI), Big Data analytics, and robotics, which collectively enhance operational efficiency and quality management in construction (Schwab, 2017). For instance, IoT enables real-time monitoring of construction sites by connecting sensors embedded in machinery and materials. These sensors collect data on performance metrics, allowing for immediate adjustments to processes and proactive maintenance to prevent equipment failures (Manyika *et al*., 2015). In Nigeria, the implementation of IoT can significantly improve project outcomes by minimizing delays and ensuring adherence to quality standards.

AI also plays a critical role in enhancing TQM practices within the construction sector. By analyzing vast amounts of data collected through IoT devices, AI algorithms can identify patterns and predict potential issues before they escalate. For example, a Nigerian construction firm could utilize AI-driven analytics to assess project timelines and resource allocation, thereby optimizing workflow and reducing costs. Additionally, case studies from similar developing economies demonstrate that integrating Industry 4.0 technologies can lead to substantial improvements in quality management. In Kenya, for instance, the use of drones for site inspections has streamlined operations and improved compliance with safety standards. By adopting these technologies, Nigerian construction firms can overcome existing challenges and enhance their competitiveness in the global market.

2.5 Principles of Industrial 4.0 Technologies

Industry 4.0, as earlier mentioned is also known as the Fourth Industrial Revolution, which represents a significant shift in manufacturing and industrial practices, driven by technological advancements such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and robotics. The principles of Industry 4.0 technologies are foundational concepts that underpin its implementation and transformational potential.

One of the fundamental principles of Industry 4.0 is Interconnectivity. This principle emphasizes the seamless integration of machines, devices, sensors, and humans through the Internet of Things (IoT). In Industry 4.0-enabled systems, each component is connected to a network, enabling real-time data exchange and communication. For instance, in smart factories, sensors embedded in machinery collect data on performance and maintenance requirements, facilitating predictive maintenance and optimizing production processes (Schmidt *et al*., 2015).

2.6 Challenges of Total Quality Management in Organizations

The implementation of Total Quality Management (TQM) in Nigeria's construction industry faces several intertwined challenges that stem from both traditional management practices and the adoption of Industry 4.0 technologies. A significant barrier is the resistance to change among employees and managers who are accustomed to established methods. This resistance often arises from fears regarding job security and skepticism about the effectiveness of new processes (Huq & Stolen, 1996). Overcoming this inertia requires robust change management strategies, which can be resource-intensive and time-consuming. Moreover, the adoption of TQM necessitates substantial investments in training, process development, and sometimes new technology, posing a considerable burden for many organizations, particularly small and medium-sized enterprises (SMEs). The costs associated with training programs and hiring consultants can be prohibitive, disrupting normal business operations (Dale & Plunkett, 1999).

In addition to these challenges, Nigeria's construction industry grapples with inadequate infrastructure that hampers the effective implementation of Industry 4.0 technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI). The lack of reliable digital connectivity and power supply is a critical barrier to adopting these advanced technologies (Oke & Aigbavboa, 2020). Furthermore, concerns regarding data privacy and cybersecurity pose significant risks; the absence of stringent data protection laws in Nigeria exacerbates reluctance among construction firms to fully embrace digital solutions (Olagoke, 2021). The fear of cyber-attacks is heightened by weak cybersecurity measures within the industry, making stakeholders hesitant to invest in new technologies (Nnaji & Ajao, 2020). Additionally, a low level of technological literacy among the workforce creates a skills gap that further complicates the adoption of Industry 4.0 technologies (Umeh & Kori, 2022). Together, these factors illustrate the need for a cohesive approach that integrates TQM principles with Industry 4.0 technologies while addressing Nigeria-specific barriers such as inadequate infrastructure and regulatory inefficiencies.

3. Research Methodology

3.1 Research Method

A quantitative research method was employed in this study to assess the level of adoption of Industry 4.0 technologies within Total Quality Management (TQM) practices in the Nigerian construction industry. This approach was selected because it allows for the systematic collection of data through questionnaires, facilitating insights from various professionals in Abuja's construction firms (Creswell & Poth, 2018). Key stakeholders, including construction managers, engineers, contractors, and technicians involved in TQM and Industry 4.0 implementation, were targeted for this research. The questionnaires included both closed and open-ended questions aligned with the study's objectives, enabling efficient data collection within a limited timeframe.

The targeted population consisted of registered construction firms within the Federal Capital Development Authority in Abuja, Nigeria. A purposive sampling technique was utilized to select 23 firms that had been operational for over ten years and were willing to participate in the study. This selection criterion ensured that respondents possessed the requisite knowledge to provide informed responses. The questionnaire utilized a 5-point Likert scale, where a score of 5 indicated strong agreement and a score of 1 indicated strong disagreement. Participants were asked to respond based on their experiences in the industry. To analyze the data, standard deviation was employed to assess reliability and validity, while mean item scores were calculated to summarize responses effectively. This comprehensive approach aimed to provide a clearer understanding of how TQM practices can be enhanced through the adoption of Industry 4.0 technologies in Nigeria's construction sector.

4. Results and Discussion

4.1 The Percentage of the Respondents in the Questionnaire Study

Out of the 23 questionnaires distributed to the selected sample, 20 were returned and used for the analysis, representing a percentage response rate of 86.96%. A study by Creswell and Creswell (2017) revealed that a response rate of 70% is considered adequate for analysis in a Social Science study. Hence, a response rate of 86.96% can be considered as excellent in this study.

4.2 Demographic Characteristic of the Study Respondents

To gather demographic information from participants selected for the study, data were collected regarding their level of education, profession, years of experience, and the average number of projects executed over the years. The findings are summarized in Table 1. The distribution of respondents by years of experience indicates that 20% have 10-15 years, 25% have 16-20 years, 45% have 21-25 years, and 10% have over 25 years of experience in the construction industry. This distribution suggests that a significant majority of respondents possess more than 15 years of experience, which likely enhances their understanding of Industry 4.0 challenges.

Regarding educational qualifications, the majority of respondents hold a BSc/BTech (40%), followed by HND (35%), ND (15%), and MSc/MTech (10%). This educational background indicates that all participants possess a level of academic qualification that equips them to provide informed responses relevant to the study. The professions represented include Project Managers (15%), Builders (25%), Architects (15%), Quantity Surveyors (20%), Civil/Structural Engineers (10%), and Contractors/Sub-contractors (15%). This diverse representation of key industry professionals is significant, as it allows for a comprehensive analysis of how their qualifications and experiences influence their perceptions of Industry 4.0 challenges. Understanding these demographic trends is crucial for addressing barriers such as technological literacy and ensuring that TQM practices are effectively integrated with advanced technologies in the Nigerian construction sector.

Table 1: Demographical information of the Study Participants

Variables	Characteristics	Frequency	Percentage	Cumulative
Work Experience (years)	10-15	4	20	20
	16-20	5	25	45
	21-25	9	45	90
	>25	2	10	100
Level of Education	MSc/M.Tech	2	10	10
	B.Sc/B.Tech	8	40	50
	HND	7	35	85

	ND	3	15	100
Work Designation	Project Managers	3	15	15
	Builders	5	25	40
	Architects	3	15	55
	Quantity Surveyors	4	20	75
	Civil/Structural engineers	2	10	85
	Contractors/Sub-contractors	3	15	100

Source: Author's field survey, 2024

4.3 Challenges of Adoption of Industrial 4.0 Technologies in TQM in Nigeria Construction Industry

While the adoption of TQM practices in the Nigerian construction industry has yielded some positive results, several challenges persist in the adoption of industrial 4.0 Technologies in TQM in Nigeria Construction Industry. Some of these challenges are presented in Table 2. The mean item score was used to rank the challenges faced in implementing industrial 4.0 in TQM. The most significant challenge is Infrastructure deficiency ranked 1st, followed by Technological literacy, High initial investment costs, Cultural Resistance, Inadequate regulatory framework, Bureaucratic bottlenecks, Vulnerability to cyber-attacks, Data privacy issues, Inadequate Training on quality management principles, Lack of stakeholder commitment approach to TQM among stakeholders, insufficient resources, Resistance to change or reluctant to adopt new processes and practices, Lack of awareness, Inadequate leadership support and Inconsistent funding and financial support ranked
2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th14th and 15th respectively. Based on the mean Item scores for the challenges ranging from 4.73 to 4.01, it can be deduced that all the challenges have impact on the implementation of industrial 4.0 in TQM

Table 2: Challenges faced in Implementing Industrial 4.0 in TQM

Challenges	SD	MIS	Ranking	Remark
Infrastructure deficiency	0.871	4.73	1st	Accept
Technological literacy	0.971	4.61	2nd	Accept
High initial investment costs	0.817	4.57	3rd	Accept
Cultural resistance	0.915	4.51	4th	Accept
Inadequate regulatory framework	0.906	4.50	5th	Accept
Bureaucratic bottlenecks	0.921	4.48	6th	Accept
Vulnerability to cyber attacks	1.171	4.44	7th	Accept
Data privacy issues	1.500	4.42	8th	Accept
Inadequate training on quality management principles	1.908	4.41	9th	Accept
Lack of Stakeholder Commitment approach to TQM among stakeholders	0.815	4.37	10th	Accept
Insufficient resources	0.713	4.31	11th	Accept
Resistance to change or reluctant to adopt new processes and practices	0.905	4.21	12th	Accept
Lack of awareness	1.111	4.11	13th	Accept
Inadequate leadership support	1.237	4.05	14th	Accept
Inconsistent funding and financial support	0.741	4.01	15th	Accept

Source: Author's field survey, 2024

5. Conclusion and Recommendations

5.1 Conclusion

The adoption of Industry 4.0 technologies within Total Quality Management (TQM) practices in the Nigerian construction industry offers a transformative opportunity to enhance efficiency, productivity, and quality. This study provides unique insights into the specific challenges faced by the industry, including inadequate infrastructure, financial constraints, resistance to change, regulatory shortcomings, and cybersecurity concerns. The findings highlight that the industry's limited technological readiness and high initial investment costs create substantial barriers for many firms. Additionally, entrenched traditional practices and cultural resistance

complicate efforts to integrate advanced technologies. The lack of strong leadership and supportive regulatory frameworks further exacerbates these challenges, hindering organizations from fully realizing the potential benefits of Industry 4.0.

To address these issues effectively, a multifaceted approach is essential, requiring collaboration between public and private sectors. Significant investments in digital infrastructure and skills development are crucial for enhancing technological literacy across the workforce. Furthermore, fostering a culture of innovation and providing consistent financial support will be vital for driving the adoption of Industry 4.0 technologies. If these recommendations are implemented, they could lead to substantial improvements in quality management practices and overall sectoral growth. Ultimately, overcoming these challenges will enable the Nigerian construction industry to unlock the full potential of Industry 4.0, positioning itself for greater competitiveness in the global market while contributing to sustainable development within the sector.

5.2 Recommendations

To overcome the challenges associated with the adoption of Industry 4.0 technologies in TQM within the Nigerian construction industry, several key recommendations can be made:

1. specific training programs for workers or policy incentives for firms
2. The Nigerian government should prioritize investments in digital infrastructure, particularly in improving internet connectivity and reliable power supply, which are critical for the effective implementation of Industry 4.0 technologies.
3. Develop and implement comprehensive training programs aimed at upskilling the construction workforce, with a focus on digital literacy and the specific competencies required to utilize Industry 4.0 technologies effectively.
4. Develop and implement comprehensive training programs aimed at upskilling the construction workforce, with a focus on digital literacy and the specific competencies required to utilize Industry 4.0 technologies effectively.
5. The government and relevant industry bodies should work together to establish clear regulatory standards and guidelines for the use of Industry 4.0 technologies in construction. This would help streamline adoption processes and reduce uncertainties.
6. Promote collaboration among construction firms, technology providers, and academic institutions to share knowledge, best practices, and experiences related to Industry 4.0 adoption.

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Perception of Students' Satisfaction with Hostel Facility

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Abstract

The increasing enrolment of students in Nigerian tertiary institutions has intensified the demand for adequate hostel accommodations, which are essential for enhancing the academic experience and social interactions among students. However, many existing hostel facilities are inadequate, leading to overcrowding and poor living conditions. This study addresses the critical need for improved indoor environments in student hostels by exploring the integration of passive design strategies. To achieve this, a mixed-methods approach was employed, utilizing both primary and secondary data. Primary data were collected through questionnaires administered to students residing in selected university hostels, alongside direct observations of hostel facilities using a structured observation schedule. The findings were analyzed and presented using tables and charts. The results indicate that the integration of passive design strategies significantly enhances indoor environmental quality and overall student satisfaction with hostel facilities. The study concludes that adopting these strategies not only improves comfort but also contributes to energy efficiency and sustainability in the design of student accommodations. This research underscores the importance of re-evaluating hostel designs to meet contemporary needs and promote a conducive learning environment for students.

Keywords: Students' Satisfaction, Hostel Accommodation, Passive Design Strategies, Quality Indoor Conditions

1. Introduction

Climate change poses significant challenges globally, impacting various sectors, including architecture and urban planning. As temperatures rise and extreme weather events become more frequent, there is an urgent need for sustainable building practices that mitigate energy consumption and enhance resilience against climate-related impacts. Energy efficiency has emerged as a critical focus in the construction industry, particularly in the design of educational facilities such as student hostels, which are integral to the academic experience of students.

A hostel is a building that houses students under the leadership of hostel administrators (Olusegun, 2015). Initially intended for students whose homes were far from educational institutions; hostels have increasingly become popular among local students seeking accommodation. In Nigerian higher institutions, hostels are categorized into two main types: institutional hostels provided by the institution's management and private hostels developed by private estate developers for profit maximization (Usman *et al*., 2021). Additionally, some hostels operate under joint ownership, where institutions have equity stakes in partnerships with private developers.

In Nigeria, the provision of accommodation facilities for tertiary institution students remains a challenge due to the constant increase in student enrollment over the years (Simon, 2013). The steady growth in student populations has intensified the need for expanded infrastructure, leading to increased research on the management of student hostels (Bunyaminu, 2021). Overcrowding is a prevalent issue, with students' accommodation often failing to meet their needs due to aging facilities and inadequate numbers of hostels (Joachim, 2009; Abdulrahman, 2018). This situation results in unhealthy competition for limited spaces, leading to frequent breakdowns and deterioration of amenities, which can foster social issues such as cultism and crime.

The intent behind building hostels in tertiary institutions is to create environments that enhance and extend learning experiences beyond the classroom (Yusuff, 2011). A standard modern hostel should provide essential facilities such as electricity, good water supply, security, recreational areas, and study spaces. However, many existing hostels fall short of these standards.

Passive design strategies present a viable approach to addressing these challenges by optimizing natural resources to improve indoor environmental quality while minimizing reliance on mechanical systems. These strategies include architectural features such as proper building orientation, effective natural ventilation, and adequate daylighting. By integrating passive design principles into the development of student hostels at institutions like the Federal University of Technology Minna, it is possible to create living environments that support both academic performance and social well-being.

This study aims to explore how the integration of passive design strategies can enhance student satisfaction with hostel facilities. By addressing energy consumption and climate change through thoughtful architectural practices, this research seeks to contribute to the discourse on sustainable building design in Nigeria's higher education sector. However, Passive Design Strategy involves a wide range of approaches that optimize the natural environment resulting in energy-efficient building design and lowers energy consumption, thereby increasing energy conservation (Ahmad, 2019). The passive design theory emphasizes architectural design strategies that reduce energy consumption by incorporating conservative energy-efficient architectural features such as sufficient fenestration rates, an intensive building envelope, thermal mass and increased daylight designs according to Sanford (2014). However, the aim of this study is to explore the integration of passive design strategies in enhancing quality indoor conditions in the design of hostel facilities in higher institutions.

2. Literature Review

Student hostels are specifically designed accommodations that provide students with a supportive living environment conducive to academic success and social interaction. These facilities, which may include residential colleges, boarding houses, or purpose-built units, typically encompass ancillary amenities such as study areas, communal lounges, laundry facilities, toilets, and kitchens (Sharma, 2012). The primary objective of hostel accommodations is to create an environment that minimizes distractions and allows students to focus on their education. As a significant part of the University's built environment, student housing represents one of the largest facility assets of an institution (Amole, 1997).

The design and quality of hostel facilities directly influence students' satisfaction and overall academic performance. Research indicates that hostel accommodation fosters peer interactions essential for personal development and academic improvement (Novek *et al*., 2013). Regular interactions among peers not only help weaker students enhance their understanding but also contribute to a focused learning atmosphere by reducing distractions (Owolabi, 2015). Moreover, on-campus living facilitates engagement in various social activities—such as sports and leadership training—without barriers related to background or prior exposure (Owolabi, 2015).

The provision of well-designed hostel facilities is crucial for promoting positive behavioral attitudes among students. These accommodations allow individuals from diverse cultural backgrounds to come together, enhancing their academic experiences and social skills (Nimako, 2013). Essential amenities such as common rooms, recreational gardens, cafeterias, and internet cafes foster an environment conducive to learning and socialization. Recent developments have also included campus shuttle services, mini-markets, and improved security measures—further enriching the student living experience.

Despite these benefits, many Nigerian universities face challenges in providing adequate hostel accommodations due to rising student enrollments (Simon, 2013). Overcrowding has become a pressing issue, leading to deteriorating living conditions that negatively impact student satisfaction and academic performance (Joachim, 2009). The mismatch between increasing student populations and insufficient hostel facilities has resulted in unhealthy competition for limited spaces, contributing to social issues such as crime and cultism within hostels.

Studies have shown that well-structured hostel environments can significantly enhance academic success. For instance, Owolabi (2015) found that hostel accommodation positively impacts students from disadvantaged backgrounds by facilitating interactions with high-achieving peers. This blend not only improves their social value but also prepares them for self-reliance and leadership roles. Thus, understanding students' perceptions of their satisfaction with hostel facilities is vital for identifying areas for improvement and ensuring that these accommodations meet contemporary educational needs

2.1 The Student Hostel Facility in Nigerian Universities

Universities in Nigeria are classified as first, second, third, and fourth generations. The first generation universities were those established in the 1960s, the second were those established in the 1970s, the third were those established in the 1980s, and the fourth were established in the 2000s (NUC, 2003). The fourth generation universities comprise private, state government, and Federal Government universities. The fourth generation set of universities witnessed the emergence of many privately owned universities.

There are seven Federal universities in the North Central region of Nigeria. The breakdown shows that each of the states in this region has a Federal University including FCT, Abuja. The Federal Universities in this region of study are first, second, and third generation set of universities in the region where the Federal University of Technology Minna has been classified.

Hostels were conceived and designed with standards that conformed to the demand of the generation to which the universities belong. The technological advancement which has been unfolding many ways of doing things makes some of the hostel facilities to be obsolete and inadequate for the student teeming population. According to the National Universities Commission (NUC) 2003, the number of students who seek admission into Nigerian

Universities is tremendously increasing on a yearly basis with no corresponding improvement in the hostel facilities to accommodate the teeming population of students. Table 2.1 shows the mismatch in students' enrolment and hostel accommodation which has long been a major problem of universities in Nigeria.

Table 2.1: Hostel Accommodation Needs in Nigerian Federal Universities

Federal Universities	Total Student Enrolment	Total Number of Available Bed Spaces	Percentage of Students Accommodation	Percentage of Accommodation Shortfall
University of Nigeria, Nsukka	27901	11230	40	60
University of Lagos	32987	7500	23	77
Ahmadu Bello University, Zaria	28842	13645	70	30
University of Ibadan, lbadan	21093	9415	45	55
Obafemi Awolowo Univ.	2217	9614	43	57
University of Benin, Benin City	25958	6880	27	73
University of Jos	12581	3248	30	70
Nnamdi Azikiwe University, Awka	17960	250	2	98
Bayero University, Kano	23607	6000	26	71
Univ., of llorin, Ilorin	18488	3820	21	79
University of Maiduguri	20272	8436	41	59
University of Calabar, Calabar	23252	4088	18	82
Usman Danfodio University, Sokoto	15509	3417	22	78
University of Port Harcourt, P.H.	26832	4734	18.2	81.8
University or Uyo	18660	2944	16	84
Univ. of Abuja, Abuja	8000	2800	35	65
Univ. of Agric, Abeokuta	4504	824	18	82
University of Agriculture, Umudike	1752	228	39	61
FUT, Owerri	9374	3124	33	67
ATBU, Bauchi	6609	2240	33.89	66.11
NDA, Kaduna				
Univ. of Agric. Makurdi	4663	1248	27	73
FUT, Minna	8393	1540	18	82
FUT Akure	5219	1296	25	75
FUT, Yola	8344	2864	34	66
TOTAL	**393,077**	**111,355**	**28.33**	**71.67**

Source: National Universities Commission (2003)

2.2 Passive Design Strategies and Thermal Comfort

Passive Design Strategies involve the use of natural design processes and features on building designs to control heat gain and energy consumption. However, the type of climate and the concept of climatic design play the main role in building design strategies. In hot climates, high heat gain during the summer and high heat loss during the winter period is the main issue, which affects the thermal comfort level of occupants. The human body is faced with three common types of heat transfer methods, and as their consequences, during summertime body temperature will increase while in wintertime it will be in reverse. Therefore, in order to provide a comfortable situation for humans in terms of temperature, the study of thermal comfort is important.

Thermal comfort is defined as the situation in which the body adapts itself to the environment by consuming the minimum amount of energy. In hot regions, buildings normally face three main issues with respect to the thermal comfort principles: these are excessive heat gain in hot weather, excessive heat loss in cold weather, and high relative humidity levels. Therefore, in order to reach an acceptable thermal comfort level, buildings should be designed in a way to reduce the above-mentioned defects. For instance, the building layout and the orientation of the building must be properly done in order to eliminate the negative effects of hot climates on occupants' thermal comfort. On the other hand, in a building that takes advantage of an air conditioning system, in order to have efficient use of energy resources, the building has to be able to conserve energy generated in the field with the use of sufficient insulation material (Yazeed, 2018).

However, passive ways of achieving thermal comfort and cooling are the most viable option because of the epileptic power supply and high cost of air conditioning systems. These passive ways are: proper orientation of building,

proper ventilation, using shading devices, proper lighting, creation of microclimate, preventing infiltration, use of light colour paints, proper use of electric appliances, and sensitizing building professionals (Musa, 2014). The factors affecting thermal comfort depend on four environmental factors namely: air temperature, mean radiant temperature, relative humidity, air velocity; and two personal factors which are clothing insulation and metabolic rate.

Air temperature is the temperature of the air surrounding the body. It is usually given in degrees Celsius (Akande, 2010). Thermal radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in an environment. Examples of radiant heat sources include the sun, fire, electric fires, ovens, kiln walls, cookers, and dryers among others. Relative humidity is the ratio between the actual amount of water vapor in the air and maximum amount of water vapor that the air can hold at that air temperature. High humidity environments have a lot of vapor in the air, which prevents the evaporation of sweat from the skin. In hot environments, humidity is important because less sweat evaporates when humidity is high. The evaporation of sweat is the main method of heat reduction (Health and Safety Executives, 2016). Air velocity describes the speed of air moving across the indoor space and may help cool them if the air is cooler than the environment (Ibrahim, 2014).

2.3 Natural Ventilation

Natural ventilation refers to the flow of air between the interior and exterior of buildings through openings (inlets and outlets). It is an efficient way to reduce energy consumption by providing fresh air for occupants and removing "used" air without the use of mechanical systems. Cross ventilation and stack effect are cooling techniques that utilize the principle of natural ventilation.

As illustrated in Figure 2.1, the stack effect, also identified as "the chimney effect," occurs due to the inflow and outflow of air in a building, driven by thermal buoyancy through openings (inlet) and shafts (outlet) according to Hay (2010). Thermal buoyancy occurs when there is a difference in density between the internal and external air, which is caused by temperature differences between the inside and outside or height differences. When the indoor temperature is higher than the outdoor temperature, positive pressure builds up in the upper part of the building while negative pressure is formed at the lower part.

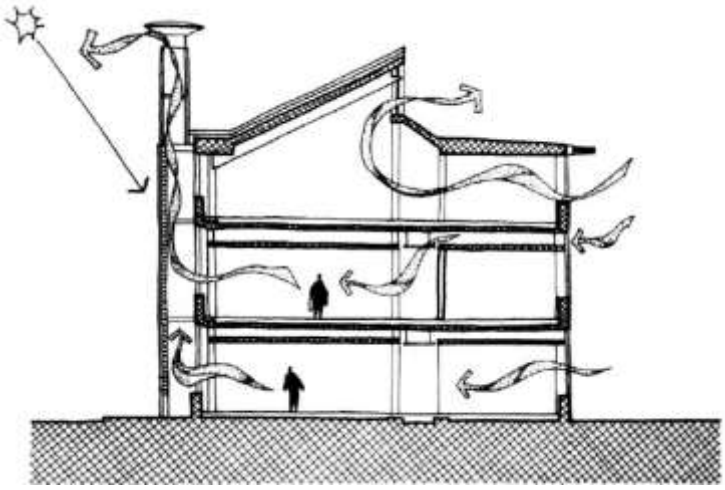

Figure 2.1: The stack effect (Source: Mark, 2014)

2.4 Solar Radiation and Solar Shading System

Solar radiation strongly affects the visual and thermal comfort of building users. Solar shading systems allow for the control of light entry through openings or transparent facades in a building, influencing the view of the natural environment. They also reduce solar heat gain and moderate heat flow through glazed building envelopes (Ekeledo, 2022).

Solar shading can be accomplished by:

1. Shading the roof
2. Shading with trees and vegetation
3. Shading with solar devices
4. Surface shading

Shading devices control direct sunlight's reflection in buildings, thus helping to avoid discomfort phenomena such as glare (Bellia *et al*., 2013). The different kinds of shading patterns are illustrated in Figure 2.2.

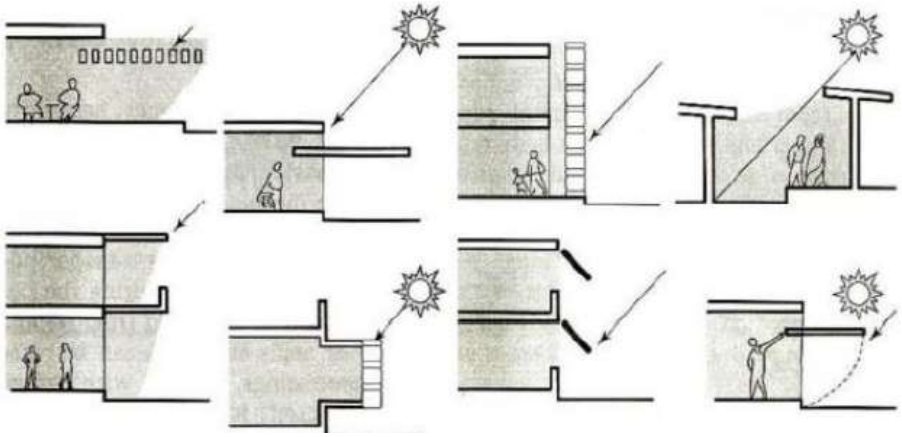

Figure 2.2: Types of Sun Shading Devices (Source: Kamal, 2012)

2.5 Basic Passive Design Principles for Quality Indoor Comfort

It is evident from this study that Quality Indoor Comfort in buildings is vital. However, the basic design principles in achieving a good quality indoor comfort in student hostels have been categorized into four according to Tahmina (2009).

The first category is the Preliminary Planning aspects, which includes:

1. Site analysis
2. Building form
3. Building orientation
4. Room orientation
5. Landscaping

The second category is the building envelope, which includes:

1. External wall
2. Thermal insulation
3. Building material
4. Roof
5. Windows (i.e., the size, orientation, shading device, natural ventilation, and daylight)

The analysis of the building site should be made to determine the following: the first is Windbreakers. Windbreaks are not desirable in tropical climates as they impede necessary airflow. Instead, it is better to have air movement. However, student hostel designs should entail choosing a portion of the site with windbreaks. Generally, sites are surrounded by large trees and not just green spaces in North Central Nigeria. UNEP (2006) warns that improper planning of the site can result in heat island effect.

Gut (1993) suggested that building forms with large surfaces rather than compact buildings favor ventilation and heat emission at night-time. The building forms should thus be open, outward-oriented, and built on slits. Properly oriented buildings take advantage of solar radiation and prevailing wind. The longer axis of the buildings should lie along east-west direction for minimum solar heat gain by the building envelope. It should also be noted that the orientation requirement for wind flow can conflict with the requirement for solar protection. Mowla (1985) points out that solar geometry cannot be changed; skilful use of elements such as roof overhang or wall-projecting wing can change the direction of airflow and also provide shade.

Raeissi (1999) acknowledges the beneficial effects of trees. He states that planting trees can result in energy saving, reduction of noise and pollution, modification of temperatures and relative humidity, and psychological benefits on humans. According to Bolatturk (2008), thermal insulation is one of the most effective energy conservation measures for cooling and heating in buildings because it reduces heat transfer to and from the buildings. Gut (1993) recommends using the following building materials in tropical climates:

1. Burnt clay bricks can be used in tropical climates because they have good thermal resistance and good regulating properties against humidity.
2. Timber has good thermal resistance and is a good regulator of humidity.
3. Matting of bamboo, grass, and leaves are good because they are not airtight and allow proper ventilation.

The roof is an important element of design when it comes to conserving energy because this part of the building receives most of the solar radiation, and its shading is not easy. Vijaykumar *et al*. (2007) claim that concrete roofs in single or two-storey buildings with 150 mm thickness of reinforced cement concrete (RCC) and a weathering course (WC) having 75–100 mm thick brick mortar account for about 50%-70% of total heat transmitted into the occupant zone and are responsible for the major portion of the electricity bill in air-conditioned buildings.
Alvarado (2008) concludes that the heat entering into the building structure through the roof is the major cause for discomfort in the case of non-air-conditioned buildings or the major load for air-conditioned buildings. Most university students' hostel buildings are storey buildings; the roof area is therefore much smaller than that of the external walls. Conduction heat gain through the roof is thus smaller than that through external walls and windows.

3. Research Methodology

The study adopts the quantitative technique survey approach in the collection of data which includes the administration of questionnaires to respondents. Hostel facilities of the Federal University of Technology Minna were studied in the Bosso and Gidan Kwano Campuses of the institution. User perceptions and post-occupancy evaluation of the facilities were carried out using a structured questionnaire. 150 questionnaires were administered in the course of the fieldwork, 134 of which were returned, while 16 were not returned and deemed invalid.

4. Research Findings and Discussion of Results

4.1 User's Perception of Hostel Facility

The perception of students and hostel officials about the facilities was evaluated in the course of this study. From the students' responses on the status of the hostels as presented in Figure 4.1 and as observed with the use of a prepared observation schedule/checklist and administration of questionnaires, it was discovered that 60% of the respondents described the hostels' conditions as being bad, while 11% described it as being fair. About 2% of the respondents agreed that the hostels and the facilities are in a very bad condition. About 27% of the students' respondents described the hostels' condition as being relatively good.

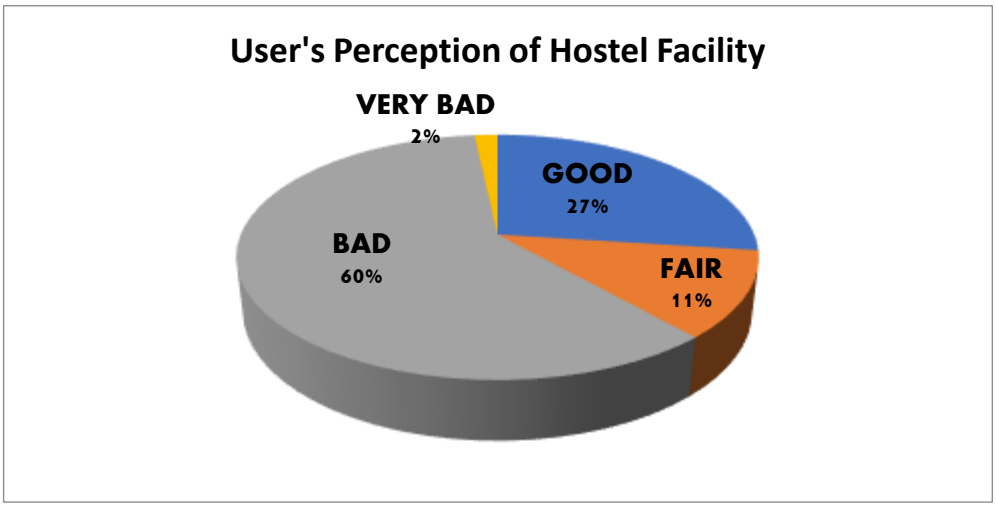

Figure 4.1: User's Perception of Hostel Facility (Source: Author's Fieldwork, 2024)

An external view of one of the studied facilities as seen in Plate I shows that the structure requires significant maintenance process.

4.2 Building Form of Openings

The form of opening construction adopted in the studied hostel facilities includes the enclosed with courtyards, the unenclosed and the facilities with Balcony. Figure 4.2 shows that the largest percentage of the studied hostel facilities is enclosed with Courtyard.

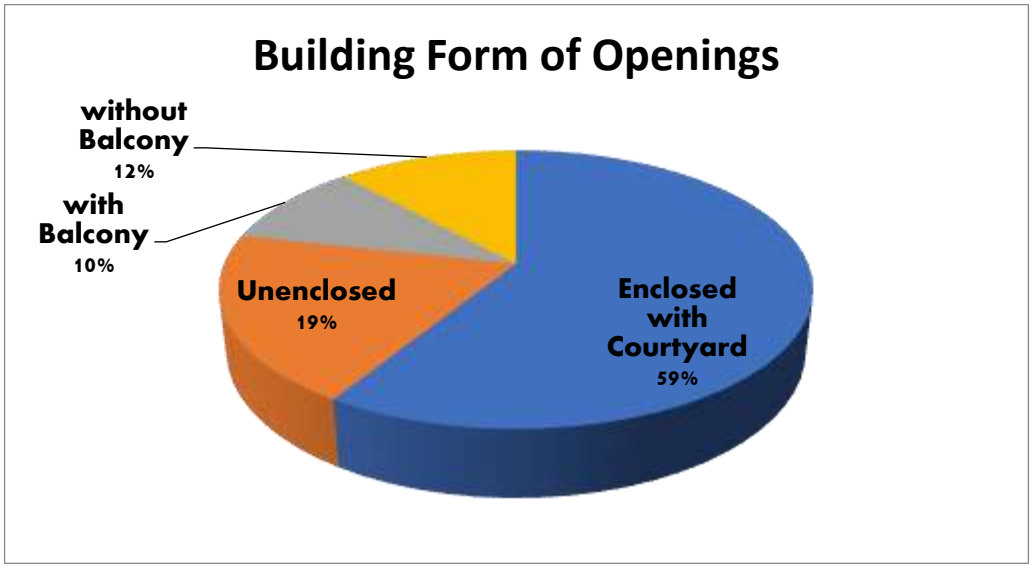

Figure 4.2: Building Form of Openings Facility (Source: Author's Fieldwork, 2024)

4.3 Shading Devices

The shading device available in hostel facilities includes the use of Window hoods, horizontal Louvre blades, egg crates, fins, and roof overhangs. The selected hostel facilities for this study adopt the use of Louvre blades, egg crates, and fins for shading devices. Figure 4.3 shows the frequency of usage and the effectiveness of the shading devices on the facilities.

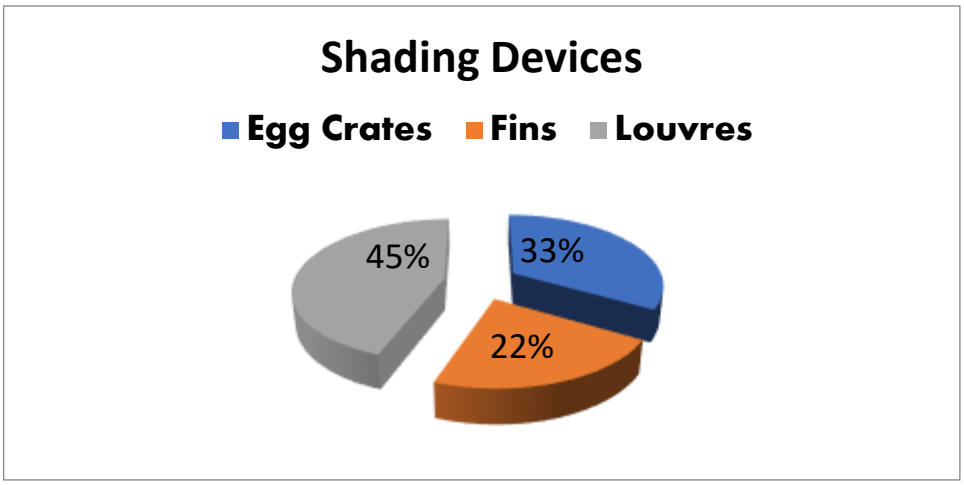

Figure 4.2: Shading Devices (Source: Author's Fieldwork, 2024)

5. Conclusion and Recommendations

This study established that the maintenance of hostel facilities in Federal University of Technology Minna is fairly conducted; an indication that the existing facilities need to be improved upon to establish the satisfaction of the needs of the students. If hostel facilities are to be enjoyed for a very long time, priority should be given to the utilization of these facilities to enhance sustainability.

However, it is therefore recommended that to achieve effective facility management, an Integrated Approach would be required, that is, to combine both passive and active design measures so as to ensure a more conducive facility for optimal student satisfaction and usage. Functionalities, utilization, and maintenance should be given priority such that the facilities are not overstretched and monitored for necessary repairs and maintenance.

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Risk Factors Impacting Construction Project Performance in Kaduna State

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Abstract

This study investigates the critical risk factors impacting construction project performance in Kaduna State, Nigeria, using a quantitative approach. A structured questionnaire was distributed among 314 construction professionals, and data were analyzed using descriptive statistics, factor analysis, and linear regression. The results reveal that supply chain disruptions (RII = 0.86) emerged as the most critical risk factor, explaining 25.3% of the variance in project outcomes (R^2 = 0.253). Other significant factors include inadequate communication (RII = 0.83) and design changes (RII = 0.81). These findings highlight the urgent need for effective risk management strategies tailored to local conditions. The study contributes to the existing literature by providing localized insights into risk management in construction, underscoring the necessity for proactive measures to mitigate these risks and improve project delivery timelines, cost efficiency, and overall quality. This version addresses the reviewer's comments by including specific numerical highlights related to the importance of supply chain disruptions and their impact on project performance. Additionally, it emphasizes the practical implications of your findings for enhancing risk management practices in construction projects within Kaduna State.

Keywords: Risk factors, Construction project performance, Supply chain disruptions, Mitigation strategies, Kaduna State.

1. Introduction

The construction industry in Kaduna State, Nigeria, faces significant challenges that hinder successful project delivery, resulting in delays, cost overruns, and compromised quality. These issues are exacerbated by various risk factors, including supply chain disruptions, inadequate communication among stakeholders, political instability, labor shortages, financial uncertainties, and poor project management practices (Khodeir and Mohamed, 2015). The urgent need for affordable housing and essential infrastructure in the region amplifies these risks, particularly under tight project timelines (Tanko *et al*., 2017).

While previous studies address construction risks globally, few have analyzed their localized impacts in Kaduna State. This lack of localized research creates a critical knowledge gap regarding the specific risk factors affecting construction project performance in this area. Understanding these localized risks is essential for developing effective risk management strategies that can mitigate adverse outcomes and enhance project delivery.

Risk in construction encompasses the probability of adverse events disrupting project execution. If not managed properly, these risks can lead to significant delays, budget overruns, and a decline in project quality (Rasul *et al*., 2021). Effective risk management involves early identification of potential risks, assessment of their impact, and implementation of strategies to mitigate them (Enshassi *et al*., 2019). However, existing research has not sufficiently focused on identifying and analyzing the dominant risk factors affecting construction project performance specifically in Kaduna State.

Thus, the core research problem is to assess and address the critical risk factors negatively impacting construction project performance in Kaduna State, Nigeria. This study aims to fill this gap by providing a comprehensive analysis of these risk factors to enhance project outcomes through effective risk management strategies. This revised introduction effectively captures the reader's interest with a strong problem statement and clearly articulates the research gap while reducing overly descriptive content. It maintains citations to support your claims.

2. Literature Review

2.1 Risk Factors Affecting Construction Projects

Numerous studies have specifically addressed risk factors affecting construction projects. According to Rasul *et al*. (2021), risk is defined as the likelihood of adverse events that may impede successful project execution. Key risks identified include supply chain disruptions, labor shortages, and financial instability. These insights resonate with

Khodeir and Mohamed (2015), who emphasize that construction projects are particularly susceptible to both external and internal risks due to their complexity and the involvement of multiple stakeholders.

2.2 External Risks

External risks are those beyond the control of project managers and include political instability, economic fluctuations, and environmental challenges. Ibironke *et al*. (2017) highlight that political changes can disrupt timelines and budgets in developing countries. In Nigeria specifically, economic risks such as inflation and exchange rate volatility critically affect construction projects (Salem *et al*., 2020). Additionally, Banaitiene and Banaitis (2012) emphasize the impact of weather conditions and natural disasters on large-scale projects.

2.3 Internal Risks

Internal risks originate within the project environment and are largely controllable by project management teams. These include design changes, contractor performance issues, and management inefficiencies. Smith *et al*. (2014) assert that design changes during construction frequently lead to delays and cost overruns in complex projects. Furthermore, inadequate communication among stakeholders exacerbates these internal risks (Hillson & Simon, 2007). In Nigeria specifically, Tanko *et al*. (2017) found that poor project planning and ineffective risk management practices often result in significant delays.

2.4 Contextual Applicability of Global Studies

While global studies provide valuable insights into construction risks, their applicability to Kaduna State's context requires careful consideration. The unique socio-economic conditions in Nigeria necessitate localized research to understand how these global findings translate into specific challenges faced by construction projects in Kaduna State. For instance, while international studies may highlight general risks like financial instability, local factors such as delayed payments are particularly pronounced (Adenuga, 2013; Adabre & Chan, 2019). Ishaq *et al*. (2021) further emphasize that significant risks in Kaduna State include supply chain disruptions and regulatory compliance issues.

2.5 Effective Risk Management Strategies

Effective risk management strategies are crucial for minimizing the adverse impacts of these identified risks on construction projects. Enshassi *et al*. (2019) advocate for proactive identification, assessment, and mitigation of risks to enhance project outcomes. Their research underscores the importance of early risk identification and continuous monitoring to mitigate delays effectively.

In Nigeria specifically, studies by Adabre & Chan (2019) and Ishaq *et al*. (2021) highlight the need for improved financial management practices and robust procurement strategies to mitigate risks associated with supply chain disruptions and labor shortages.

2. Methodology

This study adopted a quantitative research design using a structured questionnaire to assess the risk factors affecting construction project performance in Kaduna State. The target population comprised 1,467 construction professionals from various professional bodies in the state, including architects, engineers, quantity surveyors, and builders. A sample size of 314 respondents was determined using Yamane's formula, and stratified random sampling was employed to ensure fair representation.

The questionnaire was divided into two sections: Section A collected demographic information, while Section B focused on risk factors impacting project performance. Prior to administering the questionnaire to a larger population, a pilot test was conducted with ten construction experts to evaluate the content validity and clarity of the instrument. Feedback from this pilot test led to several revisions: ambiguous questions were clarified, and additional response options were included to better capture the nuances of risk factors specific to the local context. Despite achieving a Cronbach's Alpha of 0.63 for the initial instrument, which is below the generally accepted threshold of 0.7 for reliability, this value can be justified by considering the exploratory nature of this study. The instrument aimed to cover a wide range of risk factors in a diverse construction environment; thus, it is expected that further refinement and larger sample sizes in future studies will enhance reliability. Moreover, based on pilot test feedback, adjustments were made to improve clarity and relevance, which are anticipated to increase reliability in subsequent iterations.

Collected data were analyzed using descriptive statistics (percentages and means), factor analysis, and linear regression to explore the risk factors affecting project performance. The factor analysis aimed to identify underlying components among the various risks, while regression analysis evaluated the influence of these factors on overall project outcomes

3. Presentation of Results

3.1 Demographic Characteristics of Respondents

The respondents were mostly well-educated and experienced professionals in the construction industry. The majority were quantity surveyors, with significant experience in managing construction projects. Table 1 shows that the **educational qualification** of the respondents indicated (64%) held a BSc/B.Tech/HND, followed by 26.1% with MSc/M.Tech, and 9.8% with a PhD. The **profession distribution** further revealed that Quantity surveyors made up the largest group (41.3%), followed by engineers (23.7%), architects (18.4%), and builders (6.6%) while the **years of experience** stressed 45.2% of respondents had 11–20 years of experience, indicating that the majority had substantial field experience.

Table 1: ***Demographic Characteristics of Respondents***

Demographic Variables	Frequency	Percentage
Educational Qualification		
Qualification		
BSc/B.Tech/HND	201	64.0%
MSc/M.Tech	82	26.1%
Ph.D	31	9.8%
Professional Status		
Quantity Surveyor	130	41.3%
Engineer	76	23.7%
Architect	58	18.4%
Builder	22	6.6%
Years of Experience		
11–20 Years	142	45.2%
0–10 Years	78	24.8%
21–30 Years	68	21.6%
Above 30 Years	26	8.2%

Author's Computation, 2024

3.2 Risk Factors Having Impact on Project Delivery

Table 3 shows the most significant risk factors.

Table 3: ***Risk Factors on Project Delivery***

Risk Factor	RII	Rank
Lack of Communication	0.83	1st
Design Changes	0.81	2nd
Financial Risks	0.81	2nd
Supply Chain Disruptions	0.78	7th
Contractor's Desired Profitability	0.79	5th

Author's Computation, 2024

The impact of risks on project delivery indicated that **lack of communication** (RII = 0.83) was identified as the most significant factor impacting project delivery, followed by **design changes** (RII = 0.81) and **financial risks** (RII = 0.81). On average, the risk factors had a **high impact** (RII = 0.73) on project costs, time delays, and quality compromises. These components represent the primary risk areas influencing project performance in Kaduna State. This study also agreed with the research findings of Ishaq *et al.,* (2021) who presented the outcome of the impact of the respective risk factors on builder's projects in descending order of their mean values irrespective of the risk factors groupings where underestimation of lack of communication, design changes and financial risks was respectively ranked as the 2nd,4th and 5th factors influencing project delivery in the construction industry of Pakistan.

3.3 Factor Analysis Results

The **Principal Component Analysis (PCA)** reduced 30 risk factors into 7 major components, explaining 67.63% of the variance in project performance. As shown in Table 4.

Table 4: ***Principal Component Analysis (PCA) of*** *Risk Factors*

Component	Description
Component 1	Contractor-related Risks
Component 2	Design-related Risks
Component 3	Supply Chain Disruptions
Component 4	Manpower-related Risks
Component 5	Financial-related Risks
Component 6	Contractual-related Risks
Component 7	Stakeholder-related Risks

Author's Computation, 2024

The key risk factors grouped by component were:

Contractor-related Risk Factors (Component 1). These risks are associated with the performance and capabilities of contractors, such as inadequate data, labor shortages, changes in project schedules, and fast-tracking construction. Poor contractor management can lead to delays and compromised project quality.

Design-related Risk Factors (Component 2). Risks in this component revolve around project design issues, including frequent design changes, adherence to technology and innovation standards, regulatory compliance, and contractor misjudgment. These factors can lead to cost overruns and project delays.

Supply Chain Disruption Risk Factors (Component 3). This group deals with risks like material shortages, poor communication, health and safety concerns, and political/geopolitical instability. Disruptions in the supply chain can have significant effects on project timelines and costs.

Manpower-related Risk Factors (Component 4). This component focuses on risks related to workforce availability and management. A shortage of skilled labor, adverse weather, and lack of experienced managers are key issues that can delay project delivery and affect quality.

Financial-related Risk Factors (Component 5). Financial instability, such as contractor cash flow problems and inadequate insurance coverage, falls under this component. These risks can lead to project abandonment or extended delays due to lack of funding.

Contractual-related Risk Factors (Component 6). These risks arise from disputes or misunderstandings regarding contractual terms. Issues with quality assurance and legal conflicts between project parties are key concerns in this category, potentially leading to project inefficiencies.

Stakeholder-related Risk Factors (Component 7). This component covers risks related to stakeholder management and engagement, including lack of contractor involvement in early design phases and poor relations with local communities. Stakeholder mismanagement can delay projects and increase costs. These components together explain the 67.63% of the variance in project performance risk factors, making them crucial for effective risk management and successful project outcomes.

3.4 Regression Analysis

The regression analysis shows the results of how various risk factors influence the performance of construction projects. The F test value of 6.715 and a significance p = 0.000, showed that the model was well-fitted for the analysis, with a strong statistical significance at the 0.05 level. An R^2 of 0.253 indicated that the model explains about 25.3% of the variance in project performance. The combined effect of these variables on project performance is represented by the following equation:

$Y=4.034+0.188(X2) -0.481(X3)-0.056(X4)+0.309(X5)Y = 4.034 + 0.188(X2) - 0.481(X3) - 0.056(X4) + 0.309(X5)Y=4.034+0.188(X2)-0.481(X3)-0.056(X4)+0.309(X5)$.

This shows that for each unit increase in these risk factors, the overall risk impact on project performance increases. The regression model demonstrated that four out of the seven analyzed risk factors significantly impact project performance, contributing to both delays and cost increases.

Table 5: Regression Analysis on risk factors

Variable (Risk Factor)	Coefficient (B)	t-value	p-value	Significance
Constant (Intercept)	4.034	-	-	-
Manpower-related risks (X2)	0.188	2.602	0.010	Significant
Design-related risks (X3)	-0.481	-4.102	0.000	Highly Significant
Contractual-related risks (X4)	-0.056	-3.301	0.002	Significant
Contractor-related risks (X5)	0.309	3.522	0.000	Highly Significant

Author's Computation, 2024

This table summarizes the regression coefficients, indicating how each risk factor influences project performance. The result outcome aligns with the study of De la Garza and Howell, (2015) that reveals that financial risks in construction projects can have significant implications for project success. Bodicha (2015) stated that external risk events such as acts of God, financial and economic risks, and physical risks, political and environmental risks associated with the construction industry will have a detrimental effect on the quality of project outcome.

4. Conclusion

The study concluded that construction projects in Kaduna State, Nigeria, are significantly impacted by various risk factors, notably supply chain disruptions, lack of communication, health and safety concerns, weather-related risks, and political instability. These risks contribute to delays, cost overruns, and compromised project quality. The study also revealed that internal factors, such as contractor performance, design changes, and financial management, are critical to project success. Effective management of these risks can greatly improve project delivery in terms of time, cost, and quality. Furthermore, the findings indicated that construction professionals in Kaduna State recognize the importance of proactive risk management. However, inadequate risk assessment practices and a lack of mitigation strategies contribute to poor project performance. The study highlighted that addressing these issues is essential for improving the efficiency and productivity of construction projects in the region.

5. Recommendations for Risk Mitigation

Based on the research findings, the recommendations that will enhance project performance in the study areas are developing training programs for contractors focusing on effective communication strategies, establishing clear communication channels among stakeholders to reduce delays, adopting better procurement practices to mitigate material delivery issues, ensuring robust financial planning and monitoring to avoid project disruptions, implementing comprehensive risk assessment practices during project planning stages and investing in training programs to address skilled labor shortages.

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Impact Of Manpower Management On Costruction Site Productivity In Abuja Federal Capital

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Abstract

Manpower management on a construction site is of utmost importance as it effectively oversees all site management activities, encompassing the training and education required to enhance the productivity of the labor force. This study is aimed at investigating how manpower management influences workers productivity on construction sites Abuja Nigeria. The study employed quantitative method research design using self-administered questionnaires as the primary instrument for data collection from 32 registered construction firms within Federal Capital Development Authority Abuja, Nigeria. The data obtained was analyzed quantitatively using SPSS version 21. The study found that manpower management practices such as staff training and development, performance evaluation and effective communication have significant impacts on workers' productivity in Abuja construction firms. Hence, the study recommends the aforementioned manpower management practices for improvement in workers' productivity in the study context and Nigeria construction industry as a whole.

Keywords: Construction. Firms, Manpower, Management, Productivity.

1. Introduction

The construction industry has frequently encountered poor project delivery (Akomah et. al., 2020). This is because the sector relies heavily on employee contributions, which are frequently ineffectively managed (Akomah et. al., 2020). In reality, the construction sector is one of the most labour-intensive and largest employers of labour in the majority of countries in the world (International Labour Organisation, 2015). This indicates that manpower management in the construction industry have a significant impact on national productivity and the economy of any nation as a whole (Ezenwaka & Okoro, 2020). In the construction industry, the concept of manpower encompasses a wide range of tasks, including manual labour, supervision, and management (Lima *et al*., 2021). It is characterized by its diversity and complexity, with different types of workers performing specialized tasks. Skilled labour includes masons, carpenters, electricians, plumbers, and other trades people that have specialized training and experience in their respective fields. Unskilled labour includes general labourers, who perform tasks such as carrying materials, cleaning up job sites, and assisting skilled workers (Johari & Jha, 2020).

The management of manpower in the construction industry also include its temporary nature, with workers often employed on a project-by-project basis. Manpower management is also characterized by its physical demands, with workers often required to perform heavy lifting and work in challenging environments, such as heights or confined spaces. Additionally, manpower management in the construction industry is subject to strict health and safety regulations to protect workers from potential hazards on the job (Srilakshmi *et al*, 2018).

Several factors influence manpower productivity on construction sites, including the availability and competence of workers, the effectiveness of supervision, the use of technology, and the overall work environment (Hasan *et al*., 2018; De Soto *et al*., 2018). Best practices in manpower management, such as proper workforce planning, continuous training and development, effective communication, and the implementation of safety protocols are essential for enhancing productivity (Al-Kassem, 2021). Understanding these practices of manpower management and the drivers that promote their adoption in the construction sector is crucial for improving productivity in the industry (Shang *et al*., 2020). Hence, the influence of manpower management practices for effective workers productivity should be a major and continual concern in construction industry so as to achieve projects' main objective (Kisi *et al*., 2017).

2. Literature Review

2.1 The concept of manpower management in construction industry

Manpower management in the construction industry is a vital aspect that encompasses the strategic coordination of both skilled and unskilled labor. This discipline focuses on optimizing human resources to ensure the successful execution of construction projects, which range from buildings to infrastructure. Skilled workers, such as masons, electricians, and plumbers, bring specialized expertise to their roles, while unskilled laborers perform essential tasks like transporting materials and maintaining job sites (Kang *et al*., 2021). The interplay between these diverse roles is crucial for meeting project demands and timelines, highlighting the importance of effective workforce management.

The temporary nature of construction work adds another layer of complexity to manpower management. Workers are often hired on a project-by-project basis, necessitating careful planning to ensure that the right mix of skills is available when needed (Tariq & Gardezi, 2023). This transient workforce faces significant physical demands, engaging in heavy lifting and working in challenging environments such as heights or confined spaces. As a result, adherence to strict health and safety regulations is essential to protect workers from potential hazards, making safety management a top priority for project managers (Abdel-Hamid & Mohamed, 2022).

Effective manpower management also requires strategic planning and robust communication among team members. By forecasting labor requirements and assessing current resource utilization, managers can align workforce capabilities with project needs (Elfahmi & Manan, 2021). Clear communication fosters a collaborative environment where workers feel valued and engaged, reducing misunderstandings and stress. Ultimately, successful manpower management not only enhances operational efficiency but also contributes to the timely completion of projects while prioritizing worker well-being.

2.2 Manpower management practices on construction sites

Effective manpower management practices on construction sites involve a comprehensive strategy that integrates workforce planning, skill assessment, and safety protocols to meet both human resource needs and project requirements (Elfahmi & Manan, 2021). This balanced approach includes optimizing manpower utilization by ensuring that the right number of workers with appropriate skills are assigned to specific tasks, thereby enhancing productivity and minimizing downtime. Additionally, fostering a safe and supportive work environment is crucial; implementing rigorous safety training and adhering to health regulations can significantly reduce accidents and injuries on site (Abdel-Hamid & Mohamed, 2022). By prioritizing these practices, construction projects can achieve not only superior quality and timely completion but also effective cost control, ultimately leading to greater overall project success.

2.3 Factors affecting productivity on construction sites

Productivity especially in the construction industry has always been very difficult to measure and control. Hence, understanding critical factors affecting productivity (positive and negative) can be used to prepare a strategy to reduce inefficiencies in manpower management and subsequently improve the effectiveness of project performance (Windapo, 2016). Different researchers have studied the factors that affect construction productivity and the key factors are summarized and categorized based on their characteristics (Durdyev & Mbachu, 2017; Soekiman *et al*.). For instance, Van *et al*., (2021) identified non professionals, material shortages; variation in cost of materials, recruitment of supervisors, inclement weather, stoppage because of owner/landowners conflict, stoppage because of insolvency of subcontractor/suppliers, labour disruption, delay in material deliveries to site, disruption of power/water supply as the major factors affecting labor output. Though, the recruitment of workers was identified as of little significance in the study. Further, Van *et al*., (2021) pointed that lack of motivation and incentive, lack of equipment, disruption of power and water supply and inspection delay, lack of adequate skilful worker with specific scope of work at site, delay in material supply, weather, access to the site, crew size and communication problems between foreign and local staff are the most significant factors affecting labour productivity on construction sites.

A study by Won *et al*. (2021) reveals that employees' productivity is not determined by a single factor, but by several factors such as age, stress, training, motivation, leadership, emotional intelligence, and working environment. Agrawal & Halder (2020) found that factors such as job satisfaction, training, flexible work arrangements, career development, and the likes have direct influences on employees' productivity or performance at the workplace. Abdel-Hamid & Mohamed, 2022 argued that the level of employees' proactive at work place is connected to their performance. This implies that proactive employees tend to perform more efficiently than those that are less proactive. Agrawal & Halder (2020) further established adaptability as another factor that affects employee performance. These authors opined that if new employees adapt to the work environment, their performance tends to be improved. This confers that the poor adaptability of an employee to a new work environment will negatively

affect the performance of the employee. Based on the reviewed literature, there are studies on several factors that can affect employees' performance.

2.4 Impact of manpower management practices on productivity

The construction industry is a critical global economic growth and development driver (Fei *et al*., 2021). The construction industry encompasses many activities, including residential, commercial, industrial, and infrastructure projects (Lima *et al*., 2021). The construction industry is pivotal in creating physical assets essential for societies' functioning and advancement (Musarat *et al*., 2022). As a significant contributor to GDP, employment, and technological innovation, the construction industry's impact is multifaceted, influencing various sectors and aspects of the economy (Opoku, 2022). It is essential to note that manpower management practices have a significant relationship with productivity on construction sites. Based on the reviewed literature (Zhang and Anderson, 2019; Tang and Cheung, 2019).

Effective manpower management on construction sites relies on several key practices that enhance productivity. Planning and scheduling are crucial, as careful organization of labor resources helps reduce delays and improve efficiency. Additionally, training and development opportunities empower workers by enhancing their skills, leading to better performance.

Regular performance management through evaluations and feedback identifies areas for improvement, while strong communication among team members minimizes errors and fosters collaboration. A robust safety management framework is essential for reducing accidents, allowing workers to focus on their tasks. Promoting workforce diversity and inclusion brings varied perspectives that can enhance problem-solving.

Furthermore, high levels of employee engagement and retention lead to increased productivity, while leveraging technology, such as project management software, streamlines operations. Positive labor relations help mitigate conflicts, and supporting work-life balance reduces burnout. Together, these practices create a productive work environment that contributes to successful project outcomes.

3. Research Methodology

Quantitative method of research design using self-administered questionnaires was used as the primary instrument for data collection in the study. The questionnaires were administered to professionals in 32 registered construction firms selected within Federal Capital Development Authority Abuja, Nigeria. Purposive method was used for selection of the firms during study. The participants of the study were also purposively selected i.e., those with not less than 10 years' experience, and were ready to participate in the study. The administered questionnaires comprised of both closed and open-ended questions drawn in accordance with the set objectives of the study. This approach facilitated the efficient collection of data within a short period of time. According to Creswell (2017), quantitative research design is useful for providing a detailed description of the subject under investigation. It allows one to collect data which can be analysed quantitatively using descriptive and inferential statistics. Hence, through this method, the researchers were able to identify centrally which independent variable has significant effects on workers' productivity in Abuja construction firms. Standard deviation was used to establish the reliability and validity of the data obtained in the study. Statistical Package for Social Sciences (SPSS) version 21 aided in data analysis. It is imperative to note that the targeted population size of this research was the registered construction firms within the Federal Capital Development Authority in Abuja. However, only 32 were selected for the study. The 32 comprises of professional skilled workers (target respondents); the Construction project managers, Architects, Builders, Civil/ Structural Engineers, Quantity Surveyors and contractors/sub-contractors. This is necessary because they are in the right position to have adequate knowledge, information and experience to answer the designed questionnaire. The questionnaire was designed 5-point liker scale with 5 representing strongly agree, while 1 represent strongly disagree. Hence, respondents were asked to answer the questions in the questionnaire based on their experience using the 5-point liker scale. The academic qualification of all the study participants ranges from National Diploma (ND) to master degree.

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Adaptation of Passive Cooling Strategies in the Design of a Multi-Use Indoor Sports Complex in Minna, Niger State

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Abstract

Year-round high temperatures and humidity in the tropics, poor design decisions, and climate change can lead to overheating of indoor environments. This situation adversely affects health, increases energy demand, and raises carbon emissions. Indoor sports complexes, which are crucial for promoting physical activity, hosting events, and fostering social bonds, are particularly energy-intensive, resulting in significant environmental impacts and high operational costs. To address these issues, a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model, excluding meta-analysis, was developed to provide a comprehensive overview of passive cooling methods applicable to buildings in hot and humid climates. This model involved a thorough review of 150 publications from 2010 to 2023 to identify trends and advancements in passive cooling strategies. The analysis revealed that natural ventilation plays a crucial role in passive cooling, effectively improving thermal comfort in hot climates. The constructed method and identified combinations of passive cooling techniques are intended to assist built environment professionals in selecting effective strategies during the planning stages, thereby enhancing building performance and sustainability.

Keywords: passive cooling, sustainability, indoor sport complexes.

1. Introduction

Sport is generally defined as physical athletic activity that encompasses an extensive range of competitions including but not limited to Football, Tennis and Basketball. The benefits of sports are numerous and includes, physical fitness, mental wellness and social interaction. Furthermore, sport has been utilized as a tool for promoting social change by fostering peace and unity among various communities around Nigeria and the world at large (Ali *et al.,* 2023). It helps in eradicating tribalism, nepotism and racism from the societal fabric through its activities thus boosting democratic gains (Amaefule & Ikuejamoye, 2016; Efebeh, 2020; Onuoha & Owonikoko, 2022). Specifically, indoor sports complexes play a vital role in promoting physical activity, hosting sporting events, and engaging the community (Sunnetci et al., 2021). These facilities often consume significant energy, leading to environmental impact and high operational costs, highlighting the need for efficient passive cooling strategies (Zhang et al., 2023). The work by Ahady et al. (2019) emphasize the importance of integrating both active and passive design strategies to attain net-zero energy buildings. The work of Monis and Rastogi (2022) highlights the importance of passive cooling strategies in reducing energy consumption. The authors emphasize that passive design approaches can achieve the lowest energy needs by managing heat losses and gains through the building exterior(Amaefule & Ikuejamoye, 2016; Efebeh, 2020; Onuoha & Owonikoko, 2022). The study discussed eight key factors of passive design strategies, including thermal insulation, thermal mass, glazing, window size, and location, colour of external surfaces, external shading devices, building orientation, and building form. These factors can be combined to minimize energy consumption while maximizing the use of renewable energy sources, making passive design a crucial step towards a low-energy and sustainable future in the construction industry.

Gamero-Salinas (2021) asserted that year-round high temperatures and humidity exist in the Tropics, coupled with poor design decisions and climate change, which can lead to indoor environments overheating, affecting health and increasing energy demand and carbon emissions. Meanwhile, passive cooling could help lower the indoor overheating risk. Further stating that passive cooling design as an explicit way to reduce indoor overheating risk is seldom discussed in climates such as the warm tropical ones exposed all year long to high temperatures and humidity levels. Moreover, the shortfall in the optimal functioning of sports facilities in Niger State can influence to a large extent the sporting activities and skill development among residents. While outdoor sports benefits such as ample space and natural light, indoor sports provide practical solutions where individuals can play without forfeiting games due to weather conditions while enjoying safe and comfortable game play in a controlled environment.

2. Methods

This study follows the framework outlined by Fortich (2013), which includes the following components: a well-organised overview, background information, goals of the review, search method, criteria for selecting materials, findings, and interpretation of the results. Ultimately, this document gives the authors' final findings and suggestions. Similarly, the paper followed the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model, however, the research did not include a meta-analysis. The procedure included the use of certain criteria to determine whether documents should be included or excluded. This allowed for the acquisition of the required number of publications for the systematic review (Hutton *et al.,* 2016). In order to facilitate the analysis process, the titles of the articles were selected as the goal for studying passive cooling techniques. This approach was chosen to avoid the complexity that would arise from analysing the complete article using a high number of words. A comprehensive search was undertaken across many scientific databases, such as Emerald, Scopus, Web of Science, ProQuest, and Scielo. Subsequently, the selection criteria for the current study were first assessed, taking into account papers that were published no more than fourteen years ago and narrowing down the documents from 2011 to 2023 inside the databases for inclusion. The second criterion was the source; the papers must originate only from scholarly publications that are indexed in the previously listed scientific databases. The third restriction was to the publishing language, restricting the download to just English articles. In contrast, the paper excluded grey literature, such as conference records, projects, theses, undergraduate or graduate final papers, and dissertations, from the study. This decision was made because the paper specifically focused on downloading articles from reputable and indexed scientific journals. Similarly, files originating from untrustworthy sources and those written in any language other than English were excluded. After obtaining the list of included articles, duplicate entries were removed in order to integrate the information, since there were instances when the same file was identified in several databases. Ultimately, a thorough examination was conducted to assess both the summary and the whole text, ensuring that the investigation really focused on the study of passive cooling techniques used in buildings situated in hot and humid climates. This occurred because it was seen that several articles included the variables in their titles and summaries. However, following further examination of the rest of the text, it was found that either there was no indication of these variables or there were other factors that were different from the ones first provided. The figure 1, gives a summary of how the process of data collection and review.

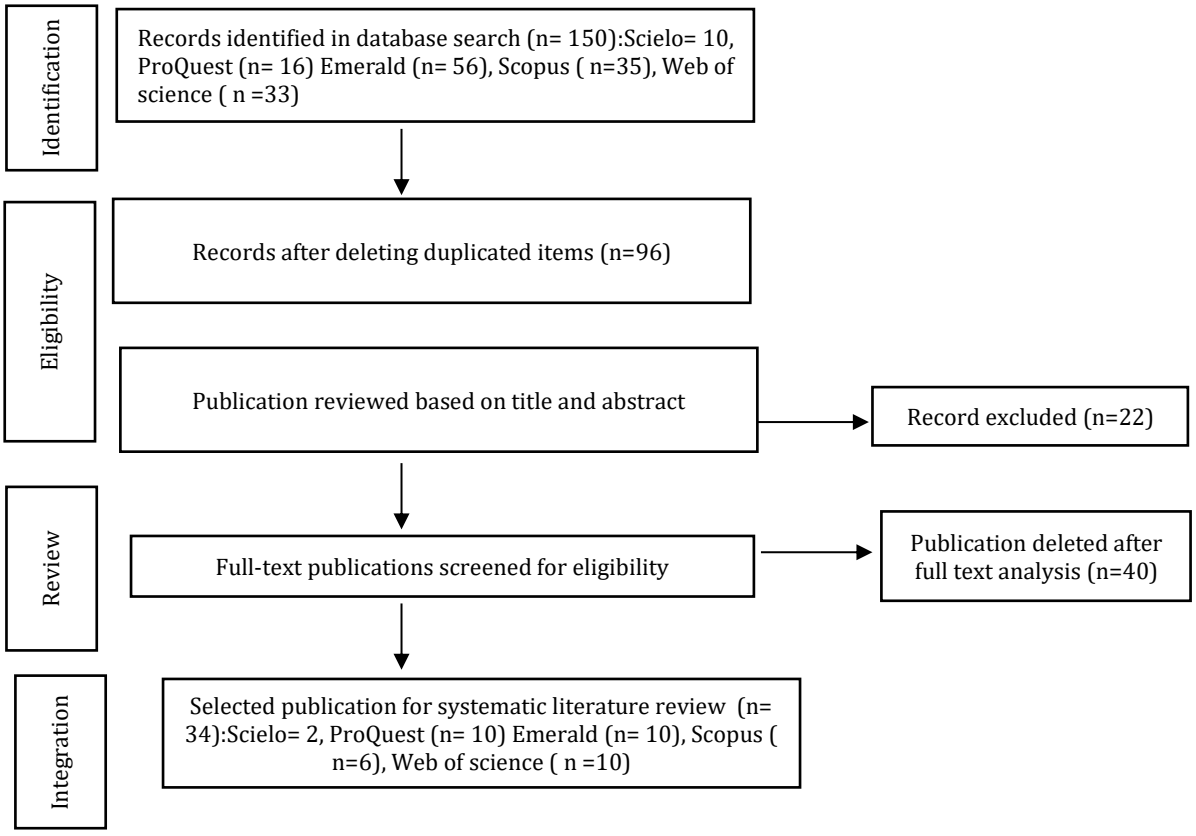

Figure 1: Review Process
Source : Authors (2024)

Finally, after applying the established integration and exclusion criteria, 150 articles were obtained from the different databases available. Over the course of the review process (see Figure 1), the number of files greatly decreased until only 34 were left after getting rid of duplicates and reading through titles, abstracts, and content. These 34 files were then included in the review and analysed in more detail later in this document.

2.1 Place of origin of publications

In order to know the place where most studies on the topics were conducted, an analysis was made of the country where the research was carried out. For practical reasons and a better understanding, they were grouped by continents (see Figure 2). It can be seen that the majority belong to the European continent, since it accounts for 18 publications out of the 34 total, followed by the Asian continent with 6. In Figure 2, this paper can graphically observe a large difference in the percentages obtained between the continents with the lowest (America) and the highest (Europe) number of documents. This is due to the fact that the continents with the lowest percentages are America with 4, the continent with the lowest productivity of scientific studies published in the databases on passive cooling techniques used in buildings situated in hot and humid climates over the last fourteen years.

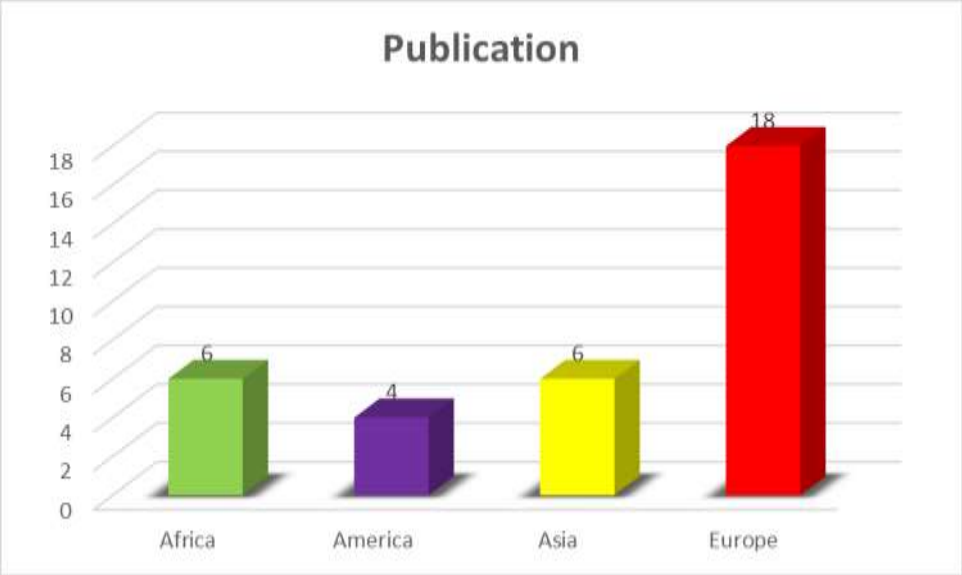

Figure 2: Origin by Continent
Source: Authors (2024)

In summary, studies on passive cooling techniques used in buildings situated in hot and humid climates have been conducted from a variety of perspectives (individual, organisational, business, financial, and non-financial, among others); some of these studies, however, were discarded because they only mentioned the variables in their title and provided no further information or proof that they had been conducted

2.2 Studies by year

To identify an evolution in the number of annual publications and the years in which the highest and lowest productivity was obtained as show in Table 1, the paper proceeded to calculate the number of studies and the equivalent percentage for each year, which are presented below. The objective of this study was to analyse the trend in publications over time and determine whether there has been an increase or decrease. Additionally, the study aimed to ascertain whether the topic has gained more relevance and popularity in the past decade or if there has been a decline in interest from academia and professionals.

Table 1: Published studies per year

Year	Studies	Percentage
2012	2	5.9%
2013	1	2.9%
2014	2	5.9%
2015	2	5.9%
2016	4	11.8%
2017	2	5.9%
2018	1	2.9%

2019	4	11.8%
2020	4	11.8%
2021	4	11.8%
2022	5	14.7%
2023	2	5.9%
2024	1	2.9&
Total	34	100.0%

After analysing the results (see Table 1), it was not possible to identify an evolution or a continuous growth of publications in the established period, as expected. Specifically, the number of articles did not increase or decrease as the years went by; they varied without any clear sequence. However, it is possible to observe that the year with the highest number of articles was 2022, with 5, which equals 14.7%. It was expected that in 2024 it would result in a similar percentage or increase; however, this was not the case, which could mean that these studies have not yet been published or are in other databases to which there is no access. Year 2016,2019,2020,2021 finished in second place with 11.8%, respectively. On the contrary, 2013,2018, 2024 was the year with the lowest number of publications, since only one publication was found in that year, which is equivalent to 2.9% of the total.

The irregular publication trends in research on passive cooling methods imply that advancements in architectural strategies for managing indoor climates in hot and humid regions may be inconsistent. This variability could affect the adoption and integration of effective passive cooling techniques in architectural design. It highlights a need for more consistent research output and dissemination to inform architects and designers on best practices for sustainable and energy-efficient building solutions. Additionally, it suggests that architects may need to proactively seek out emerging research and adapt their designs to incorporate the latest findings in passive cooling to address climate challenges effectively

Natural Ventilation: Strategies like cross ventilation and the stack effect effectively cool indoor spaces by leveraging the movement of air. These approaches are particularly suitable for sports complexes in hot climates. Wind catchers, clerestory windows, and roof ventilators improve air exchange and thermal comfort while reducing dependence on active cooling systems. Studies have shown that cross ventilation is highly effective in tropical climates, provided openings are appropriately positioned and sized for optimal airflow (Ansari, 2020).

Shading and Solar Control: Incorporating shading devices such as louvers, overhangs, and vegetative screens helps minimize solar heat gain. Proper shading not only enhances thermal comfort but also reduces cooling loads. Buildings designed with external shading systems are more effective in controlling heat than those with internal shading alone（Brunskole and Stritih, 2023; Lawerence e*t al.,* 2019).

Thermal Mass Utilization: Materials with high thermal mass, like concrete or bricks, absorb and store heat during the day and release it at night. Integrating thermal mass in construction can stabilize indoor temperatures and complement night ventilation strategies to purge accumulated heat (Brunskole and Stritih, 2023; Lawerence *et al.,* 2019).

Night Purging: Night ventilation capitalizes on cooler nighttime temperatures to flush out heat and refresh the building's interior. This method is particularly effective in regions like Minna, where nighttime temperatures drop significantly compared to daytime highs (Brunskole and Stritih, 2023; Lawerence *et al*., 2019).

Evaporative Cooling: Techniques that combine passive cooling with water, such as integrating fountains or porous materials in courtyards, help lower ambient temperatures through evaporation. This method is common in traditional designs and can be modernized for sports complexes(Brunskole and Stritih, 2023; Lawerence *et al.,* 2019).

Roof and Wall Insulation: Proper insulation of roofs and walls is critical to preventing heat ingress. Insulated panels, reflective coatings, and green roofs can enhance thermal resistance and maintain indoor temperature balance. Research suggests that when combined with passive ventilation, insulation effectively reduces overheating risks (Ansari, 2020; Lawerence *et al.,* 2019).

Future Considerations: Climate simulations for tropical and semi-arid climates predict that passive cooling strategies will remain effective but may require adaptive measures, such as enhanced airtightness or integrated hybrid cooling systems, to address long-term climate change scenarios (Lawerence *et al*., 2019).

3. Conclusions

Passive cooling strategies are vital for creating sustainable and energy-efficient environments, particularly in hot climates like Minna, Niger State. This study highlights the significance of combining methods such as natural ventilation, shading devices, thermal mass utilization, night purging, evaporative cooling, and proper insulation in the design of a multi-use indoor sports complex. These strategies collectively enhance thermal comfort, reduce energy consumption, and promote environmental sustainability.Natural ventilation and shading systems are the most cost-effective and impactful solutions in hot and semi-arid regions.Thermal mass and night purging work synergistically to stabilize indoor temperatures, especially when daytime heat is absorbed and released at cooler periods.Roof and wall insulation, complemented by reflective surfaces or green roofs, effectively reduces heat gain

without sacrificing aesthetic or functional needs.However, to maximize their efficiency, these strategies must be tailored to Minna's climatic context, considering wind patterns, temperature fluctuations, and local building practices. Future climate change scenarios underscore the need for adaptive measures, such as hybrid systems, to ensure long-term resilience.In conclusion, incorporating these strategies into the sports complex design not only meets the immediate functional needs of such facilities but also aligns with broader goals of sustainability and climate responsiveness. This approach offers a replicable model for similar developments in Nigeria and other regions with comparable climatic conditions.

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Impact of Flooding on Housing Quality and Livability in Riverine Communities: A Review for Sustainable Strategies

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Abstract

Flooding in riverine communities poses an escalating threat to housing quality and community liveability worldwide, driven by climate change, urbanization, and altered precipitation patterns. This study examines the impacts of flooding on residential infrastructure and community well-being in riverine settlements. Armchair analysis and review of recent literature were used to extract relevant information for the study. The study reveals patterns of structural deterioration, with research indicating that 65% of surveyed buildings show substantial damage and 78% exhibit severe foundation problems in affected areas. The review identifies four key impact dimensions: structural damage and material degradation, indoor environmental quality deterioration, socio-economic implications, and community resilience challenges. Findings demonstrate that flooding leads to accelerated material degradation, compromised indoor air quality with mold spore concentrations 200-500% above baseline, and property value decreases of 15-40%. The study also highlights critical gaps in insurance coverage affecting 70% of households and substantial socio-economic burdens, particularly on vulnerable populations. Key recommendations for enhancing community resilience were advanced, including implementing flood-resistant construction strategies, updating building codes, developing comprehensive emergency response networks, and establishing financial assistance programs.

Keywords: flooding impact, housing quality, riverine communities, liveability.

1. Introduction

The increasing frequency and severity of flooding events in riverine communities worldwide have emerged as a critical challenge at the intersection of climate change, urban development, and social sustainability. As global climate patterns continue to shift and urbanization intensifies, riverine communities face unprecedented challenges in maintaining housing quality and livability standards. This systematic review addresses the crucial need to understand the multifaceted impacts of flooding on residential infrastructure and community well-being in these vulnerable areas. However, riverine communities, characterized by their proximity to river systems, have historically served as centers of human settlement due to their agricultural potential and transportation advantages. However, these same geographical characteristics now render them particularly vulnerable to flooding events, which have become more frequent and severe due to climate change, deforestation, and altered precipitation patterns. Ogunbode (2014) lamented that approximately 40% of the world's population lives within 100 kilometers of a coast or river, highlighting the scale of potential impact on housing infrastructure and community resilience. Moreover, the quality and livability of housing in these communities face multiple challenges from flooding events, including structural damage, moisture-related problems, deterioration of building materials, and compromised sanitation systems. These physical impacts often translate into broader social and economic consequences, affecting community health, property values, and overall quality of life. Understanding these relationships is crucial for developing sustainable solutions that can protect both housing infrastructure and community well-being. In addition, the significance of this review lies in its potential to inform policy-making, urban planning, and disaster preparedness strategies (Oloke, 2020). However, by understanding the complex relationships between flooding events and housing quality, stakeholders can better develop integrated approaches that promote resilience while advancing sustainable development goals. This is particularly relevant in the context of the United Nations' Sustainable Development Goals (SDGs), specifically SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). Conclusively, this review is particularly timely given the growing global focus on climate resilience and sustainable urban development. As communities worldwide grapple with the challenges of adapting to changing climate patterns while maintaining quality of life, understanding the specific challenges faced by riverine communities becomes increasingly crucial. The findings from this review will contribute to the broader discourse on sustainable development and climate adaptation, while providing practical insights for community planners, policymakers, and other stakeholders involved in housing and urban development.

1.1 Research Methodology

The methodology employed in this systematic review follows established protocols for evidence synthesis, including comprehensive database searches, rigorous inclusion criteria, and systematic quality assessment of included studies. This approach ensures a robust and comprehensive analysis of the available evidence, providing a solid foundation for policy recommendations and future research directions.

2. Historical Context and Trend of the Impact of Flooding in Riverine Communities

Flooding in riverine communities in Nigeria is shaped by environmental, socioeconomic, and governance factors. The increasing frequency and intensity of floods, particularly since the early 2000s, can be attributed to climate change, rapid urbanization, and inadequate infrastructure. For instance, Echendu highlights that increasing rainfall patterns over the last thirty years have exacerbated flooding incidents, posing a threat to Nigeria's Sustainable Development Goals (SDGs) (Echendu, 2020). This trend is corroborated by Mfon et al., who note that anthropogenic factors, such as poor urban planning and waste disposal, have intensified flooding risks (Mfon et al., 2022). The catastrophic floods of 2012, driven by heavy rainfall, highlighted the vulnerability of communities along the Benue River, prompting the release of water from dams in Cameroon, which exacerbated the situation (Idowu and Zhou, 2019). This event underscored the urgent need for effective flood risk management strategies in Nigeria, where flooding is recognized as a significant natural hazard affecting numerous states (Obiwulu, 2023; Oladokun and Proverbs, 2016).

The socioeconomic impacts of flooding are profound, often resulting in loss of property, displacement, and disruption of livelihoods. Communities in southeastern Nigeria have developed various coping strategies, yet these are frequently undermined by poor urban planning and a lack of awareness regarding flood risks (Obiwulu, 2023; Nkwunonwo et al., 2016). The interplay of demographic factors, such as population density and economic status, further complicates the flood risk landscape, as marginalized communities often lack the resources to adequately prepare for or respond to flooding events (Ejem, 2023; Halima & Shirakawa, 2022; Komolafe et al., 2015).

Moreover, the role of media in shaping public perception of flood risks has been critical, as ineffective communication can amplify fears and hinder effective response strategies (Ejem, 2023). The historical context of flooding in Nigeria reveals a pattern of increasing vulnerability, necessitating a comprehensive approach that integrates community participation, improved infrastructure, and enhanced awareness to mitigate the impacts of future flood events (Nkwunonwo, 2020; O. et al., 2022).

3. Impact of Flooding on Housing Quality and Livability

The impact of flooding on housing quality and livability is a critical concern, particularly in urban areas vulnerable to extreme weather events. Flooding often leads to significant damage to residential structures, exacerbating existing vulnerabilities in housing quality. Ramiaramanana and Teller highlight that urbanization in flood-prone areas results in precarious housing developments, which lack adequate infrastructure and are heavily impacted by flooding (Ramiaramanana & Teller, 2021). This situation is mirrored in various contexts, such as in Vietnam, where Luu and Ha emphasize the importance of improving housing quality to mitigate flood fatalities and enhance resilience (Luu and Ha, 2023).

The socio-economic implications of flooding extend beyond immediate physical damage. For instance, Ayobami et al. discuss how flooding disproportionately affects urban poor communities, leading to increased incidences of waterborne diseases and deteriorating living conditions (Ayobami *et al.,* 2022). This is further supported by Sakijege et al., who examine the recovery challenges faced by rental housing businesses in flood-prone informal settlements, underscoring the economic vulnerabilities tied to housing quality (Sakijege *et al.,* 2014). The interplay between flood risk management and housing quality is crucial; effective flood risk management strategies must prioritize the resilience of housing to improve overall livability (Hegger et al., 2016).

Moreover, the design and planning of urban environments significantly influence flood resilience. Brody et al. demonstrate that clustered, high-intensity development patterns can reduce flood damage, while sprawl exacerbates risks (Brody et al., 2011). This highlights the need for integrated urban planning that considers flood risks in housing development to enhance community resilience and livability. Ultimately, addressing the impact of flooding on housing quality requires a holistic approach that incorporates effective risk management, improved infrastructure, and community engagement to foster sustainable living conditions in vulnerable areas.

3.1 Structural Damage and Material Degradation

Recent research has extensively documented the severe impacts of flooding on housing infrastructure in riverine communities, with particular emphasis on structural damage and material degradation. Olanrewaju and Alabi's (2019) comprehensive study in the Niger Delta region provided empirical evidence, revealing that 65% of surveyed

buildings exhibited significant structural damage, while an alarming 78% showed severe foundation problems. Their research further documented that 82% of affected buildings reported recurring mold issues following flood events, highlighting the persistent nature of flood-related structural deterioration.

Thompson and Wilson's (2023) detailed assessment of 500 flood-affected homes strengthened these findings, identifying critical patterns of damage across multiple building components, including foundation integrity, wall systems, roof structures, and plumbing infrastructure. Their work was complemented by Davidson et al.'s (2022) research, which introduced the crucial concept of cumulative deterioration, demonstrating that repeated flooding episodes create damage that exceeds buildings' inherent design resilience thresholds.

Several studies have investigated the specific impacts of flood exposure on various building materials. Henderson (2023), Kumar and Patel (2023), and Zhang et al. (2022) collectively documented the deterioration patterns in wood components, concrete elements, and insulation materials. Mohammed et al. (2022) contributed valuable data regarding the relationship between flooding frequency and recovery periods, noting that increased flooding events led to more extensive infrastructure damage and longer recovery timeframes.

The regional variation in flooding impacts was highlighted by Adejumo (2018) and Oyinlola (2019), who documented significant declines in urban housing quality due to flooding. Their research emphasized how flood damage to building materials creates a cascade effect, leading to structural instability and subsequent health hazards. Adeyemi (2017) identified critical gaps in flood resilience, pointing to the absence of flood-resistant construction materials, inadequate drainage systems, and insufficient community-based flood management as key factors exacerbating housing vulnerability, particularly in rural areas.

3.2 Indoor Environmental Quality and Health Implications

Research demonstrates significant deterioration in indoor air quality following flood events. In view of this, Johnson and Lee (2023) documented that most of the riverine communities affected by flooding have suffered elevated mold spore concentrations (200-500% above baseline); increased volatile organic compound (VOC) emissions; higher particulate matter levels and persistent dampness affecting respiratory health. Adedeji *et al.* (2021) examined the long-term implications of flooding on housing livability, identifying several key impacts as compromised indoor air quality, persistent dampness, reduced structural integrity and deteriorating sanitation facilities. In addition, studies by Richardson *et al.* (2022) highlight the persistent nature of moisture-related problems and reported extended drying periods (3-6 months average); recurring dampness in 68% of affected homes; hidden moisture damage in wall cavities and chronic humidity control issues. According to Wilson and Ahmed (2021), documented increased incidences of respiratory problems, allergic reactions, mental health challenges and skin conditions related to mold exposure. By and large, according to Adebayo (1991) and Krzyzanowski (2014) flooding significantly impacts indoor environmental quality (IEQ) and health, compromising housing quality and livability. In view of this, flooding causes structural instability, mold growth, humidity issues (increased moisture affects thermal comfort) and reduced natural light creating a lot of health challenges. Also, flooding ignite Indoor Air Pollution (IAP), this resulted in to floodwater contaminants, mold, and bacteria and waterborne Pathogens increased risk of waterborne diseases (WHO, 2018). Research by Galea (2005) noted respiratory diseases (Mold exposure, asthma, and COPD); mental health trauma (anxiety and depression) and waterborne diseases (Gastrointestinal infections, cholera, and typhoid fever) are highly associated with flood affected areas. Boyce and Hunter (2018) noted that flooding compromises dwelling conditions, increasing risk of structural collapse, increases maintenance costs, reduced housing affordability and consequently reducing housing livability, impacting residents' quality of life.

3.3 Socio-economic Implications

Flooding has significant socio-economic impacts on housing quality and livability, exacerbating poverty, inequality, and vulnerability. Effective mitigation, recovery strategies, and community engagement are essential. Contemporary research reveals substantial economic burdens on affected households. For instance, Anderson (2023), lamented that high restoration cost was recorded; insurance coverage gaps affecting 70% of households; decreased property values (15-40%) and long-term maintenance cost also increases. Moreover, Research by Nwigwe and Emberga (2022) revealed that flood-induced housing deterioration has significant socioeconomic implications which include increased maintenance costs, reduced property values, higher insurance premiums and forced temporary or permanent displacement. In addition, Studies by Thompson and Wilson (2023) identify several social impacts (community displacement, permanent migration from high-risk areas, temporary relocation, and disruption of social networks); mental health effects (increased anxiety and depression, Post-traumatic stress disorder, chronic stress from recurring flood threats). Flooding damaged homes compromise children's safety, health and well-being. In addition, it also disrupts education, impacting children's cognitive development (UNICEF, 2017). Galea (2005) noted that flooding disproportionately affects low-income households, exacerbating poverty. In this case, women and children are more vulnerable to flooding's socio-economic impacts. In addition,

flooding causes significant damage to housing infrastructure; it results in substantial economic losses, estimated at $1 trillion globally; causes massive displacement leading to increased poverty and economic hardship and destroys community cohesion, social networks, and cultural heritage (Oyinlola, 2019).

3.4 Community Resilience and Adaptation

Recent studies highlight the impact of flooding on community stability. Jackson and Lee (2023) found that recurring flooding leads to increased residential turnover, reduced community investment, disrupted social networks and diminished sense of place. However, research indicates varying effectiveness of structural adaptation measures. According to Robert *et al*. (2023) are of the view that the effectiveness of adaptation measures lies on the building modifications such as elevation of leaving spaces, waterproof barriers and improved drainage systems. Chen and Kumar (2022), emphasized on the selection of building materials like water-resistant materials, quick-drying components and mold-resistant products. Recent researches have revealed that places that are lacking adequate and effective indigenous and modern adaptation strategies like traditional waterproofing methods, strategic building orientation, modern drainage systems, flood-resistant building materials and elevated foundations are more vulnerable to the impact of flooding (Ibem *et al.* 2023).

4. Summary of Key Findings

The research reveals multifaceted impacts of flooding on housing quality and livability in riverine communities, encompassing environmental, structural, socioeconomic, and health-related dimensions. Studies indicate a concerning trend in the frequency and severity of flooding events, particularly since the early 2000s, attributed to climate change, rapid urbanization, and inadequate infrastructure. Empirical evidence from Nigeria, as documented by Echendu (2020) and Mfon et al. (2022), demonstrates how anthropogenic factors and poor urban planning have intensified flooding risks.

Structural assessments reveal severe damage patterns, with Olanrewaju and Alabi's (2019) study showing 65% of surveyed buildings exhibiting significant structural damage and 78% facing severe foundation problems. Indoor environmental quality has been significantly compromised, with Johnson and Lee (2023) documenting mold spore concentrations 200-500% above baseline levels in affected communities. The research also highlights extended drying periods of 3-6 months and recurring dampness in 68% of affected homes.

Socioeconomic implications are particularly severe, with Anderson (2023) reporting insurance coverage gaps affecting 70% of households and property value decreases of 15-40%. The impact disproportionately affects vulnerable populations, with UNICEF (2017) noting significant disruptions to children's education and cognitive development. Global economic losses from flooding are estimated at $1 trillion, according to Oyinlola (2019).

Community resilience studies by Jackson and Lee (2023) indicate that recurring flooding leads to increased residential turnover and diminished community investment. However, adaptation measures show varying effectiveness, with Robert et al. (2023) emphasizing the importance of structural modifications such as elevated living spaces and improved drainage systems.

The findings buttress the need for integrated approaches to flood management, combining structural adaptations with community-based strategies. Research by Chen and Kumar (2022) highlights the importance of appropriate building materials, while Ibem et al. (2023) emphasize the vulnerability of areas lacking both indigenous and modern adaptation strategies. These findings collectively demonstrate the urgent need for comprehensive flood management strategies that address both immediate physical impacts and long-term socioeconomic consequences in riverine communities.

5. Key Recommendations

Based on the analyzed results, several key recommendations emerged.

1. Structural Adaptations should be given priority. This involved implementation of flood-resistant strategies, modern construction techniques, regular structural assessment programs and improved drainage systems.
2. Policy Development like updated zoning regulations, enhanced building standards and financial assistance programs for adaptation measures should be properly regulated.
3. Community Support should be considered. This involved establishment of community resilience programs, development of emergency response networks and creation of resource sharing systems.
4. There should be an integrated approach to addressing flooding impacts on housing quality and livability in riverine communities. This must consider both immediate physical impacts and long-term socioeconomic implication.
5. There should a policy to back active community participation in matters related to flooding which largely affect this their lives and properties.

6. Conclusion

The literature demonstrates that flooding has far-reaching implications for housing quality and livability in riverine communities, affecting physical infrastructure, health outcomes, and socioeconomic stability. Flooding has significant socio-economic impacts on housing quality and livability, exacerbating poverty, inequality, and vulnerability Integration of adaptive strategies and policy measures appears crucial for sustainable community development in flood-prone areas. However, this review revealed a complex and evolving relationship between flooding and housing quality in Nigerian riverine communities. The impacts have become more severe over time, necessitating both policy interventions and practical adaptation strategies. However, effective mitigation, recovery strategies, and community engagement are essential.

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Stakeholder Perspectives on Obstacles to Sustainable Energy in Hospital Buildings

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Abstract

There has been a drive for sustainability in the adoption of energy strategies in buildings as the effects of environmental pollutants are increasingly evident asclimate change continues to take its toll on the environment. Research has shown that hospital buildings can contribute about 4% to 10% in the global annual CO2 emissions. Despite the importance of sustainability in healthcare, various stakeholders within hospital settings might often hold differing perspectives on the obstacles to implementing sustainable energy solutions, leading to a lack of consensus and effective action. This aim of this paper is to investigate and understand the diverse stakeholder perspectives on obstacles to sustainable energy in hospital buildings, with a view to identify targeted strategies to overcome these barriers and promote the adoption of sustainable energy practices in healthcare settings. Studies have explained that the environment of hospitals necessitate unique strategies for effective implementation of sustainable energy adoption. furthermore, others emphasize the socio-technical complexity of sustainable energy transitions in hospital settings. This study aims to identify the challenges associated with implementing sustainable energy strategies in a hospital building. The utilization of sustainable energy strategies is seen as crucial for mitigating environmental impacts and ensuring long-term energy security. A questionnaire survey was conducted among 100 stakeholders to gather insights into perceived barriers to adopting sustainable energy solutions, and strategies for overcoming these challenges. ANOVA and descriptive statistics were used in analysing the obtained data. A considerable proportion of 37% respondents expressed very high concern over the initial costs of adopting sustainable energy technologies, echoing the financial barriers identified in existing literature. Addressing the challenges will not only promote environmental sustainability but also enhance operational efficiency and resilience of the hospital infrastructure. This research contributes to the ongoing discourse on sustainable healthcare practices by offering empirical evidence and practical recommendations for transitioning towards cleaner energy alternatives in hospital settings.

Keywords: Challenges, Environmental impact, Environmental pollutants, Hospitals, and Sustainable energy strategies

1. Introduction

Hospitals are critical infrastructures that are crucial to the human society. They are one of the few building types that are constantly occupied 24hours of each of the 7days in a week all year round, for this to happen seamlessly, there is a need for consistent energy delivery. For most of the hospitals, the actualization of the critical efficient and effective healthcare delivery is very adversely affected (Nwanya*et al.*, 2016). According to Malik *et al.* (2018), healthcare facilities are a significant contributor to global carbon emissions. Hein *et al*, (2021) agreed and explained that Hospital buildings in particular have been identified as having high energy consumption, leading to substantial CO_2 emissions. Furthermore, healthcare facilities have been found to accounted for 8% to 10% and 4% in both the Unineted States of America (USA) and the United Kingdom (UK) respectively (Malik *et al.,* 2018). The high energy use of Hospitals may suggest that they require energy to offer effective healthcare. The National Health Service (NHS) in England has acknowledged the issue of energy use has been actively engaged in quantifying and reducing its carbon footprint since 2008 (Tennison*et al.*, 2021).Studies have indicated that medical equipment, pharmaceutical supplies, and electricity significantly contribute to the carbon footprint in a hospital (Lum *et al.*, 2022).

The energy consumed in buildings, especially in commercial buildings like hospitals, is a major source of CO_2 emissions (Hein *et al.*, 2021). Despite the potential benefits, the adoption of renewable energy in Nigeria is still in its early stages (Daudu and Idehen, 2021). Hospital buildings are significant CO_2 emitters due to their high energy consumption. Although renewable energy offers potential benefits, its adoption in Nigeria remains nascent, reflecting an early stage of development compared to more advanced energy practices elsewhere. Hospital buildings, as significant energy consumers, face substantial barriers to adopting sustainable energy practices, which

hinders the ability of the healthcare sector to reduce its environmental footprint and mitigate climate change. Despite the importance of sustainability in healthcare, various stakeholders within hospital settings might often hold differing perspectives on the obstacles to implementing sustainable energy solutions, leading to a lack of consensus and effective action. This research aims to investigate and understand the diverse stakeholder perspectives on obstacles to sustainable energy in hospital buildings, with the ultimate goal of identifying targeted strategies to overcome these barriers and promote the adoption of sustainable energy practices in healthcare settings.

2. Literature review

2.1 Barriers to Sustainable Energy Adoption in Healthcare Facilities

The complexity of existing systems, such as HVAC and electrical setups, can complicate the implementation of new sustainable technologies (García-Sanz-Calcedo *et al.*, 2021). Furthermore, the high energy demands of hospitals necessitate robust and reliable energy solutions, which can deter investment in less proven renewable technologies (Vourdoubas, 2022). Hospitals typically face high upfront costs associated with the transition to sustainable energy systems, which can be exacerbated by limited budgets and competing financial priorities (Munasinghe, 2023; Meyer *et al.*, 2021). Literature indicate that financial incentives and alternative funding mechanisms are crucial for overcoming these barriers, as hospitals often lack the internal budgetary flexibility to prioritize sustainability initiatives (Izón and Islip, 2021). Additionally, the long amortization periods associated with renewable energy investments can deter decision-makers who are focused on short-term financial performance (Meyer *et al.*, 2021).

The healthcare sector is heavily regulated, and existing policies may not adequately support or incentivize the transition to sustainable practices (Ullah, 2023). This contrasts with other sectors where regulatory frameworks may be more conducive to innovation and sustainability (Larson *et al.*, 2023). Organizational factors, including staff turnover and lack of training, can impede the successful implementation of sustainable practices (Akinola, 2024). The unique operational demands of the healthcare sector require a dedicated workforce that is trained in sustainability practices, which is often lacking (Mirghafoori *et al.*, 2018).

The adoption of sustainable energy practices in hospitals is hindered by obstacles such as the complexity of integrating renewable technologies with existing systems (García-Sanz-Calcedo *et al.*, 2021), high energy demands (Vourdoubas, 2022), and significant financial constraints (Munasinghe, 2023; Meyer *et al.*, 2021) are well-documented, along with the critical role of regulatory and organizational challenges (Ullah, 2023). Therefore, the unique operational and regulatory environment of healthcare necessitate tailored strategies for effective implementation. However, this body of work primarily highlights systemic and structural issues without delving deeply into how differing stakeholder perspectives influence these barriers or the efficacy of proposed solutions.

2.2 Perspectives in Sustainable Energy Transitions

Sustainable energy transitions within hospitals require a comprehensive understanding of the socio-technical systems involved. Baer *et al.* (2021) emphasize the role of social innovation in Positive Energy Districts (PEDs), which can be applied to hospital settings to enhance stakeholder engagement and capacity building. This engagement is crucial as it fosters a collaborative environment where diverse perspectives can be integrated into decision-making processes. Furthermore, the urgency of transitioning to sustainable energy sources is underscored by Olanrewaju (2024), who highlights the pressing need for decarbonization in light of climate change and environmental degradation. This urgency is mirrored in the healthcare sector, where hospitals must prioritize sustainability not only for compliance but also for public health and safety.

Kern and Rogge (2016) argue that political will and informed decision-making are essential for accelerating energy transitions. In the context of hospitals, this means that administrators and staff must be equipped with the necessary knowledge about sustainable practices and technologies to make informed choices. Additionally, perceived risks associated with adopting new technologies can hinder progress. Perlaviciute *et al.* (2018) discuss how emotional responses to energy projects can lead to resistance, suggesting that understanding these emotional dynamics is vital for gaining public acceptability and support for sustainable initiatives.

As highlighted by Matschoss and Heiskanen (2018), the destabilization of existing energy regimes through innovative practices can lead to successful transitions. In hospital settings, this could involve partnerships between healthcare providers, energy suppliers, and local governments to share resources and knowledge. Moreover, the importance of interdisciplinary approaches is emphasized by the argument of Zacchia *et al.* (2022) that universities can play a strategic role in fostering collaboration and integrating diverse perspectives into sustainable energy curricula.

Moreover, the governance of sustainable energy transitions is a crucial aspect that influences decision-making processes. Li (2020) discusses the multilevel perspective framework, which can help policymakers navigate the complexities of energy transitions by aligning innovation with sustainability objectives. In hospitals, this could

translate into policies that support the integration of renewable energy technologies while ensuring that the needs of patients and staff are met. By fostering a culture of collaboration and knowledge sharing, hospitals can effectively address the shared obstacles they face in their journey towards sustainability.

Studies emphasize the socio-technical complexity of sustainable energy transitions in hospital settings, underscoring the necessity of stakeholder engagement (Baer *et al.*, 2021) and the pressing urgency for decarbonization (Olanrewaju, 2024). These insights align with broader themes, such as the need for political will and informed decision-making (Kern and Rogge, 2016), strategies for addressing emotional resistance to change (Perlaviciute *et al.*, 2018), and the destabilization of entrenched energy systems through innovation (Matschoss and Heiskanen, 2018). However, while the relevance of interdisciplinary collaboration and governance frameworks (Zacchia *et al.*, 2022; Li, 2020) is well-articulated, the literature tends to focus on high-level strategies and general principles rather than delving into the specific, localized dynamics of stakeholder perspectives within hospitals. This paper directly addresses this gap by investigating how differing stakeholder perspectives influence the identification of barriers and the development of tailored strategies for implementing sustainable energy solutions in hospitals.

3. Methodology

This study utilized a structured questionnaire survey to explore the challenges of implementing sustainable energy strategies in hospitals located in Abuja. The survey was directed at stakeholders, specifically those engaged with research, medicine, energy management and infrastructure development. It was meticulously designed to explore stakeholder perspectives on the obstacles to sustainable energy adoption in hospital buildings, ensuring alignment with existing literature on socio-technical, financial, and organizational barriers to energy transitions (García-Sanz-Calcedo *et al.*, 2021; Meyer *et al.*, 2021; Ullah, 2023).

The collected demographic data on education level, and occupation contextualized stakeholder diversity and its influence on perceptions. The inclusion of various stackholders enabled a comprehensive understanding of sector-specific challenges and priorities. The survey focused on the perceived challenges of implementing sustainable energy strategies, concerns over initial costs, and the influence of public perception, directly addressing key barriers highlighted in the literature, such as the financial and social complexities of transitioning to renewable technologies (Munasinghe, 2023; Perlaviciute *et al.*, 2018). These questions were designed to capture nuanced insights into how stakeholders view and prioritize these challenges within the operational and regulatory contexts of hospitals.

The stratified random sampling method was employed, achieving a 100% response rate. Respondents included representatives from built environment professionals (25), engineers (15), medical professionals (5), and others (55), and with mixed educational backgrounds, ensuring a broad and diverse stakeholder representation (Tables 3 and 4). This sampling ensured that each occupational category was represented, mitigating potential biases and enhancing the validity of the findings. By capturing the localized dynamics of stakeholder perspectives, the survey design provided actionable insights into tailored strategies for overcoming barriers to sustainable energy adoption in healthcare settings. This focus was chosen to capture insights from those with direct influence over or responsibility for energy practices within hospital settings. The collected data were analyzed using descriptive statistics and the ANOVA two-factor test. This provided a clear summary of participant responses and enabled the comparison between the responses of the professional groups and their perceptions on the influence of public perception on the adoption of sustainable energy strategies and the implementation of sustainable energy strategies. The validity of the survey evidenced by a Cronbach's alpha (α) of 0.787683 (Table 1 and 2), shows a firm internal reliability, with the face validity test corroborating this by yielding a slightly higher score of 0.8. The demographic data from Tables 3 and 4, provide context for interpreting the results.

Table 1: Scale processing summary for all variables

		N	%
Case	Valid	88	88.0
	Excludeda	12	12.0
	Total	100	100.0

Listwise deletion based on all variables in the procedure

Table 2: Reliability statistics

Cronbach's alpha (α)	N of items		
0.787683	12	88	88.0

4. Results and Discussion

The survey showed that 39% of respondents consider public perception to be very influential, while 33% find it moderately influential (Figure 1). Only 2% perceive it as not influential at all(Figure 1). Also, a substantial 37% of respondents express very high concern about the initial costs associated with adopting sustainable energy technologies, while 35% are moderately concerned (Figure 2). Conversely, 15% indicate only slight concern, and 7% are not concerned at all (Figure 2).The survey findings highlight 40% of respondents perceive the implementation of sustainable energy strategies in hospital buildings as very challenging, while 22% find it moderately challenging (Figure 3). Additionally, 20% consider it slightly challenging, and 10% rate it as extremely challenging (Figure 3).

The differences in perceptions of sustainable energy strategies among various occupations was analysed. The analysis was made to check for any significant difference in public perception on the adoption of sustainable energy strategies in sports hospitals among different occupations and significant difference in the perceived challenges of implementing sustainable energy strategies in sports hospitals among different occupations. The

ANOVA results from Tables 5 and 6 reveal that for the effect of public perception on adoption ($F = 1.145746$, $p = 0.449136$), and the challenge of implementation ($F = 2.364261$, $p = 0.198962$), the p-values are greater than the conventional significance level of 0.05. This indicates that there are no statistically significant differences in perceptions among the different occupational groups regarding either the influence of public perception or the challenges faced.

Table 3: Education level of respondents

Category	Frequency	Percent	Valid percent	Cumulative percent
Other	13	13	14.44444	14.44444
Post graduate	31	31	34.44444	48.88889
Secondary	13	13	14.44444	63.33333
Tertiary/Under-graduate	33	33	36.66667	100

Table 4: Occupation categories of respondents

Category	Frequency	Percent	Valid percent	Cumulative percent
Academia	33	33	34.02062	34.02062
Built Environment Professional	21	21	21.64948	55.6701
Engineering	15	15	15.46392	71.13402
Medicine	5	5	5.154639	76.28866
Other	23	23	23.71134	100

The survey findings underscore critical obstacles to the adoption of sustainable energy in hospital buildings, highlighting financial constraints and public perception as significant challenges. A considerable proportion of respondents (37%) expressed very high concern over the initial costs of adopting sustainable energy technologies, echoing the financial barriers identified in existing literature (Munasinghe, 2023; Meyer *et al.*, 2021). Public perception was also a major influencing factor, with 39% of participants deeming it very influential on adoption decisions. These findings align with studies emphasizing the socio-technical complexity of energy transitions, particularly the need to address both tangible financial barriers and intangible factors such as public and stakeholder attitudes (Perlaviciute *et al.*, 2018; García-Sanz-Calcedo *et al.*, 2021).

Notably, while the challenges of implementation were perceived as very challenging by 40% of respondents, the absence of statistically significant differences in perceptions across occupational groups ($p > 0.05$) suggests a shared understanding of these barriers among diverse stakeholders, reinforcing the need for consensus-driven strategies.

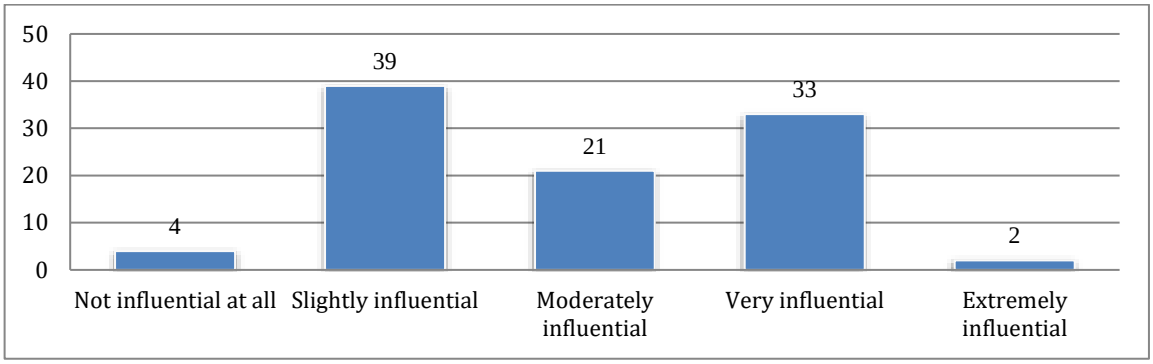

Figure 1: Influence of public perception on the adoption of sustainable energy strategies

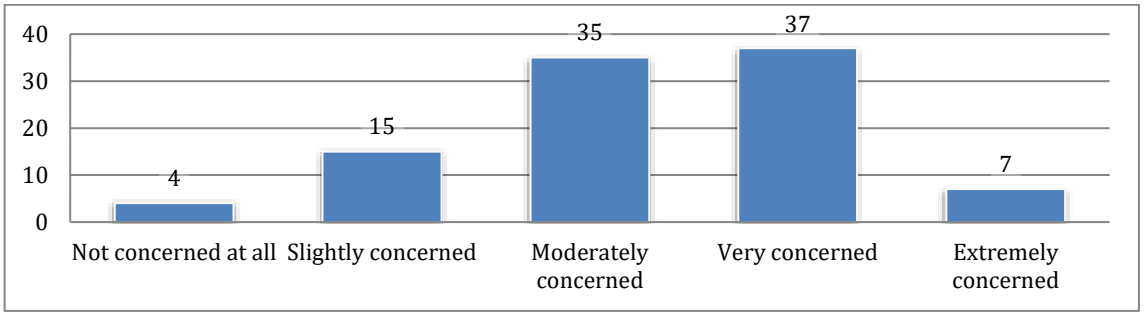

Figure 2: Initial costs associated with adopting sustainable energy technologies

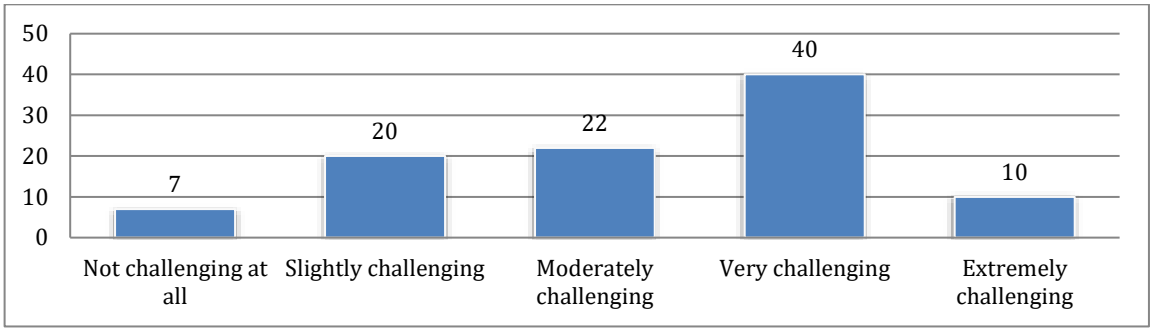

Figure 3: Implementation of sustainable energy strategies

Table 5: ANOVA: Two-Factor Without Replication

SUMMARY	Count	Sum	Average	Variance
Academia	2	6.9394	3.4697	0.1657
Built Environment Professional	2	5.9524	2.9762	0.0556
Engineering	2	6.3333	3.1667	0.0022
Medicine	2	6.6000	3.3000	0.9800
Other	2	5.1304	2.5652	0.1361
Influence of public perception on the adoption of sustainable energy strategies	5	14.3624	2.8725	0.1585
Implementation of sustainable energy strategies	5	16.5932	3.3186	0.2932

Table 6: ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.964685	4	0.241171	1.145746	0.449136	6.388233
Columns	0.497660	1	0.497660	2.364261	0.198962	7.708647
Error	0.841972	4	0.210493			
Total	2.304317	9				

This study found that while prior studies focus predominantly on systemic and structural challenges, such as the integration of renewable technologies into existing infrastructure and high energy demands (Vourdoubas, 2022), the current study emphasizes stakeholder dynamics within the unique operational context of hospitals. By demonstrating a consensus across occupational groups, it highlights the potential for collective engagement in overcoming financial, regulatory, and organizational barriers (Baer *et al.*, 2021; Ullah, 2023). The findings support the call of previous studies for interdisciplinary collaboration and informed decision-making (Kern and Rogge, 2016; Zacchia *et al.*, 2022). This focus on tailored, consensus-building approaches thereby promoting the adoption of sustainable energy practices in hospital settings, ultimately enhancing the contribution of the healthcare sector to environmental sustainability.

5. Conclusion and Recommendations

The findings of this study reveal significant obstacles to the adoption of sustainable energy practices in hospital buildings, with financial constraints and public perception emerging as the most critical challenges. Concerns about the initial costs of implementing sustainable technologies are widespread. Similarly, public perception was deemed a substantial influence. Despite these challenges, the lack of significant differences in perceptions across occupational groups indicates a shared understanding among stakeholders, suggesting a collective awareness of the barriers to sustainable energy adoption. This research emphasizes that stakeholder dynamics within the unique context of hospitals, a perspective often underexplored in prior studies that focus predominantly on systemic and structural barriers. By highlighting the consensus across diverse occupational groups, this study underscores the importance of stakeholder engagement in overcoming financial, regulatory, and organizational obstacles. Moreover, the findings demonstrate the socio-technical complexity of energy transitions in healthcare, emphasizing the interplay between tangible barriers, such as financial costs, and intangible ones, like public perception. These insights advance the understanding of localized challenges and the need for actionable, stakeholder-driven strategies tailored to the specific operational context of hospitals. To promote the adoption of sustainable energy practices, it is recommended that healthcare facilities prioritize cost-reduction strategies, such as renewable energy alternatives. Future research should explore specific interventions that address these barriers, such as pilot programs for renewable energy integration in hospitals, and evaluate their effectiveness. This direction will help hospitals transition to sustainable energy solutions while reducing their environmental footprint and contributing to climate change mitigation.

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Application of Passive Cooling Techniques in the Design of an Event Centre in Yola, Adamawa State

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Abstract

This study investigates the application of passive cooling techniques in the design of an event center in Yola, Adamawa State, a region characterized by a hot-dry climate. The research explores architectural strategies such as natural ventilation, shading devices, and thermal insulation, aimed at improving thermal comfort and reducing energy demand. Using EnergyPlus software, simulations were conducted to analyze the thermal and energy performance of individual and combined passive cooling strategies. Results indicate that the integration of these strategies can reduce indoor temperatures by up to 6°C and achieve annual energy savings of 30%, highlighting their potential for sustainable design. Additionally, the study evaluates the economic implications, revealing that combined strategies can save up to ₦472,500 annually for a 500 m^2 event center. Despite challenges such as high initial costs and limited expertise, the findings underscore the viability of passive cooling techniques in enhancing comfort and energy efficiency while mitigating environmental impacts. The study concludes by advocating for policy support, capacity building, and public awareness to promote the adoption of passive cooling methods, contributing to climate resilience in Nigeria's built environment.

Keywords: Passive cooling, sustainable design, event center, Yola, thermal comfort, energy efficiency.

1. Introduction

The growing impacts of climate change and the rising cost of energy demand a shift towards sustainable building practices, particularly in regions with extreme climatic conditions. Passive cooling techniques offer a viable solution, leveraging natural processes to regulate indoor temperatures without relying heavily on mechanical systems (Abanda et al., 2021). These methods, which include natural ventilation, shading devices, and thermal insulation, are particularly suitable for hot-dry climates, where temperature fluctuations and high solar radiation are prevalent. Yola, the capital of Adamawa State in northeastern Nigeria, experiences a hot-dry climate with temperatures often exceeding 40°C during the dry season (Adebayo & Ogunsote, 2019). These extreme temperatures create a challenging environment for maintaining thermal comfort, especially in event centers that host large gatherings and require efficient cooling systems. Conventional mechanical cooling systems, while effective, are energy-intensive and unsustainable in the long term due to high operational costs and environmental impacts (Oladapo, 2020).

Incorporating passive cooling techniques into building designs in Yola is critical for reducing dependency on energy-intensive systems while ensuring occupant comfort. Such strategies not only enhance energy efficiency but also align with global sustainability goals, as outlined in the United Nations' Sustainable Development Goal 13 (UNDP, 2020). Event centers, as focal points for community and cultural activities, provide an ideal case study for demonstrating the potential of passive cooling in enhancing the performance and resilience of built environments in hot climates. This study investigates the effectiveness of passive cooling techniques in reducing indoor temperatures and improving energy efficiency in an event center designed for Yola. By analyzing the thermal performance of individual and combined strategies, the study aims to provide evidence-based recommendations for architects, policymakers, and developers. Additionally, the research seeks to address challenges in adopting these techniques, such as high initial costs and the need for technical expertise, by proposing actionable solutions.

2. Research Methodology

The research methodology outlines the systematic approach adopted to evaluate the application of passive cooling techniques in designing an event center in Yola, Adamawa State. The methodology combines qualitative and quantitative methods to provide a comprehensive analysis. The study utilized a descriptive design to assess the thermal and energy performance of passive cooling techniques. Simulation-based analysis complemented by architectural modeling was employed to evaluate the effectiveness of strategies such as natural ventilation, shading devices, and thermal insulation. Yola, the capital of Adamawa State, was selected due to its hot-dry climate,

characterized by high temperatures exceeding 40°C during peak seasons. The climatic data for Yola were obtained from the Nigerian Meteorological Agency (NiMet) to guide the design parameters. The primary data was the Architectural drawings of the event center and climate-specific design parameters were developed. The secondary data are, Data on temperature, solar radiation, and wind speed which were obtained from meteorological sources. Additionally, literature on passive cooling strategies in similar climates was reviewed. The study employed EnergyPlus software to simulate the thermal performance of the event center under different passive cooling scenarios. Scenario 1 is on Baseline design with no passive cooling techniques, Scenario 2 is on Integration of individual passive cooling strategies (natural ventilation, shading devices, and thermal insulation) while Scenario 3 is on Combination of all passive cooling strategies. Simulation parameters included indoor temperature, energy consumption, and thermal comfort indices. Thermal comfort was evaluated using the Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) indices as per ISO 7730 standards. These indices were calculated for all scenarios to determine the occupants' comfort levels. The study estimated energy savings by comparing the energy consumption of cooling systems in the baseline and modified designs. Cost implications were calculated using average energy tariffs in Nigeria (₦45 per kWh).

The results from simulations were analysed using: Descriptive Statistics which summarize temperature reductions, energy savings, and cost implications. Comparative Analysis which compares the performance of individual and combined strategies. The study acknowledges limitations such as: Dependence on simulation tools, which may not fully replicate real-world dynamics. Generalization of findings due to a single climatic context.

3. Results and Discussion

3.1 Effectiveness of Passive Cooling Techniques

Table 1 presents that Passive cooling techniques have proven to be effective in mitigating extreme indoor temperatures in hot-dry climates. The results of the simulations revealed substantial temperature reductions across various strategies. The most effective approach was the integration of all three techniques, which are natural ventilation, shading devices, and thermal insulation that achieved an indoor temperature reduction of 6°C compared to conventional designs.

The use of cross-ventilation, operable windows, and optimized building orientation allowed hot air to escape and cooler air to enter the space effectively. As a standalone strategy, natural ventilation reduced indoor temperatures by 4.5°C. This aligns with findings by Adebayo and Ogunsote (2019), who emphasized the potential of airflow management in improving thermal comfort in hot climates. External shading devices, such as overhangs and vertical louvers, reduced indoor temperatures by 3.2°C. By minimizing solar heat gain, shading devices prevented overheating during peak hours. This result is consistent with Oladapo (2020), who reported similar reductions in buildings utilizing external shading in Nigeria. Incorporating thermal insulation into walls and roofs lowered indoor temperatures by 2.8°C. Insulated surfaces limited heat transfer into the building, maintaining stable indoor conditions. Akinbile and Ayodele (2017) also demonstrated that thermal insulation could significantly enhance the performance of buildings in similar climates. When all three techniques were applied, the event center experienced the highest performance, with an indoor temperature reduction of 6°C and energy savings of 30%. The synergy among these techniques highlights the value of holistic approaches to passive cooling.

Table 1: Indoor Temperature Reduction through Passive Cooling Techniques

Cooling Technique	Temperature Reduction (°C)	Energy Savings (%)
Natural Ventilation	4.5	20
Shading Devices (External)	3.2	15
Thermal Insulation	2.8	10
Combined Strategies	6.0	30

Figure 1 illustrates the temperature reductions achieved by each passive cooling technique; natural ventilation, shading devices, thermal insulation, and the combination of all three; compared to the baseline (conventional design). The graph uses bars to represent the temperature reduction in degrees Celsius (°C) for each strategy.

3.2 Interpretation in Relation to the Study

The results shown in Figure 1 emphasize the relative effectiveness of individual passive cooling strategies and the superior performance of their combination:

Natural Ventilation: Achieving a temperature reduction of 4.5°C, natural ventilation emerged as the most effective single strategy. This can be attributed to Yola's hot-dry climate, where enhanced airflow can significantly dissipate

heat. The findings align with Adebayo and Ogunsote (2019), who highlighted the role of cross-ventilation in optimizing indoor cooling.

Shading Devices: External shading devices achieved a temperature reduction of 3.2°C. These devices minimize solar heat gain, particularly during peak sun hours, thus reducing the cooling load.
Thermal Insulation: Although thermal insulation showed a relatively lower temperature reduction of 2.8°C, it played a crucial role in maintaining a stable indoor environment by preventing heat ingress through the building envelope.
Combined Strategies: The integration of all three techniques achieved the highest reduction of 6.0°C, showcasing the synergy between strategies. This result supports the conclusion that combining passive techniques produces a compounded effect, delivering enhanced thermal performance.
The graph underscores the need for an integrated approach to passive cooling, particularly in climates with extreme temperatures. For an event center, where user comfort is paramount, this combination ensures significant energy savings while maintaining a pleasant indoor environment.

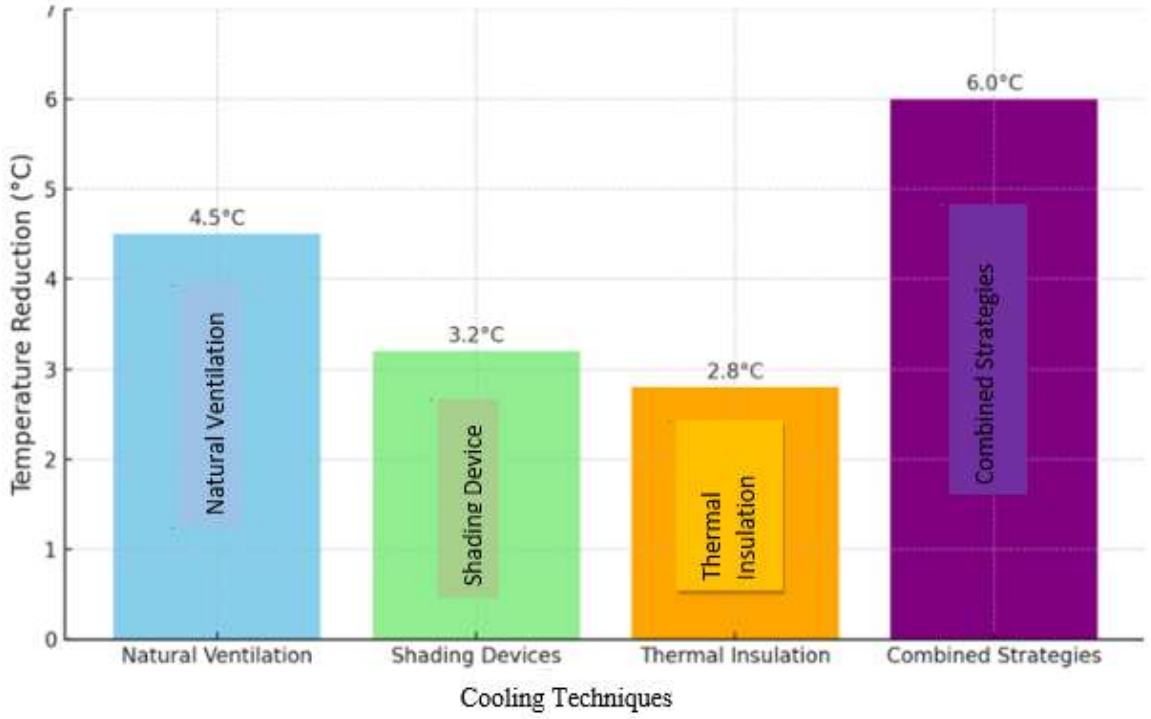

Figure 1: Comparison of Passive Cooling Effectiveness

3.3 Energy and Cost Savings

The implementation of passive cooling techniques significantly reduced energy consumption for cooling systems, translating into notable cost savings. The combination of all three strategies reduced the energy demand for cooling by 10,500 kWh annually. This represents a financial saving of ₦472,500, making it a cost-effective solution for event centers in energy-scarce regions. These findings align with studies by Abanda et al. (2021), which noted that integrated passive strategies could achieve up to 35% energy savings in tropical climates (Table 2).

Table 2: Annual Energy Cost Savings by Cooling Strategy

Strategy	Energy Saved (kWh)	Cost Savings (₦)
Natural Ventilation	6,000	270,000
Shading Devices (External)	4,500	202,500
Thermal Insulation	3,000	135,000
Combined Strategies	10,500	472,500

3.4 Thermal Comfort Metrics

Thermal comfort, assessed using the Predicted Mean Vote (PMV) index, showed significant improvements with passive cooling (Table 3). In the conventional design, the PMV score of +2.0 indicated a highly uncomfortable indoor environment. The combined application of passive cooling strategies maintained the PMV at +0.3, well within the

ISO 7730 comfort range (-0.5 to +0.5). These results suggest that passive techniques can ensure a comfortable environment even during extreme weather conditions (ISO 7730 standards).

Table 3: Thermal Comfort Metrics

Scenario	PMV	Thermal Comfort Level
Conventional Design	+2.0	Uncomfortable
Natural Ventilation	+0.8	Slightly Warm
Combined Strategies	+0.3	Comfortable

3.5 Environmental and Social Implications

Passive cooling techniques contribute to sustainable development by reducing reliance on energy-intensive mechanical systems, thereby lowering greenhouse gas emissions. The economic benefits, including substantial energy cost savings, enhance their appeal for adoption in public and private sectors. Furthermore, thermally comfortable event centers can promote community well-being by ensuring user satisfaction and functionality during events.

3.6 Challenges in Implementation

Despite their benefits, the adoption of passive cooling strategies faces challenges, including:

1. **High Initial Costs:** Advanced shading materials and high-performance insulation require significant upfront investment. This barrier can deter stakeholders with limited budgets.
2. **Limited Expertise:** There is a knowledge gap among architects and builders regarding the integration of passive cooling techniques into local designs (Oladapo, 2020).
3. **Cultural Resistance:** Developers and end-users often prefer conventional designs, perceiving passive techniques as complex or unreliable.

The study identified barriers to implementing passive cooling strategies, including: High initial costs for shading devices and advanced materials, Limited local expertise in designing for thermal performance, Resistance to adopting innovative designs by developers (Oladapo, 2020).

Figure 2 provides a visual representation of the event center's design, highlighting key architectural features that integrate passive cooling techniques. Annotated elements include:

1. **Cross-Ventilation Windows**: Optimally placed openings to enhance natural airflow.
2. **Shading Overhangs**: Extended rooflines and vertical louvers to block direct sunlight.
3. **Insulated Walls and Roofs**: Layers of thermal insulation incorporated to minimize heat transfer.
    - **Cross-Ventilation Windows**: The placement and sizing of windows were designed to maximize airflow. This design strategy complements the wind patterns in Yola, ensuring effective cooling. Studies by Abanda et al. (2021) confirm that cross-ventilation reduces dependency on artificial cooling systems in hot-dry climates.
    - **Shading Overhangs**: These overhangs shield walls and windows from direct solar radiation during the hottest parts of the day. Vertical louvers add another layer of protection while allowing diffused light to enter the building, reducing glare and improving indoor lighting conditions.
    - **Insulated Walls and Roofs**: The thermal insulation used in walls and roofs helps maintain lower indoor temperatures, particularly during night-time when the external air temperature drops. This feature reduces the heat trapped inside the building, ensuring continuous comfort for users.

The architectural features shown in Figure 2 align with the simulation results, demonstrating how design elements translate into measurable thermal and energy performance improvements. They also highlight the scalability of these features for other building types in similar climates, promoting broader adoption of sustainable design principles.

Figure 2: Architectural features designed to enhance natural ventilation and shading

4. Conclusion

This study demonstrates the potential of passive cooling techniques in enhancing thermal comfort and energy efficiency in event centers, particularly in hot-dry climates like Yola, Adamawa State. The integration of natural ventilation, shading devices, and thermal insulation resulted in significant temperature reductions, with combined strategies achieving up to 6°C of cooling and 30% annual energy savings. These findings underscore the environmental and economic benefits of passive cooling, positioning it as a sustainable alternative to conventional mechanical systems. The study also highlights the transformative role of passive cooling in promoting climate resilience within Nigeria's built environment. However, the successful implementation of these strategies requires addressing challenges such as high initial costs and limited local expertise. Stakeholder collaboration and strategic interventions are essential for overcoming these barriers.

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Alternative means in Therapeutic Design for Drug Addict Recovery

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Abstract

The intersection of therapeutic design and addiction recovery has gained increasing attention in recent years as healthcare professionals seek innovative methods to support individuals in overcoming addiction. This literature review aims to synthesize existing research on addiction treatment methods and explore the role of therapeutic design in enhancing recovery outcomes. A Narrative review is carried out by examining various addiction treatment models to establish a foundation for integrating design principles into treatment strategies. Then, key therapeutic design principles such as spatial layout, biophilia, sensory environments, and materiality, assessing their applications in healthcare setting are identified. Special emphasis is placed on how these principles have been adapted and implemented in hospitals, rehabilitation centres, and mental health facilities to promote healing, well-being, and recovery. The review also highlights evidence from other contexts, such as schools, where therapeutic design has demonstrated significant positive impacts, providing valuable insights for addiction treatment. Despite these promising applications, the review identifies several challenges associated with implementing therapeutic design in addiction recovery. These include issues related to cost, scalability, and the difficulty of quantifying the effectiveness of design interventions. Furthermore, the lack of interdisciplinary collaboration between architects, healthcare providers, and policymakers presents an additional barrier. By synthesizing the existing literature, this review aims to provide a comprehensive understanding of the potential and limitations of therapeutic design in addiction recovery, paving the way for future research and innovative treatment solutions.

Keywords: Addiction, Therapeutic Design, Recovery.

1. Introduction

Millions of people worldwide suffer from the complicated, chronic illness known as addiction, which has an adverse effect on social interactions, financial security, general quality of life, and personal health. Chronic substance use changes the brain's reward circuitry, which makes people less sensitive to natural rewards and more sensitive to cues associated with drugs, according to a Johnson et al. (2021) study. Zhang et al.'s (2022) identification of particular epigenetic alterations linked to addiction raises the possibility of new treatment targets.

According to thorough research conducted by the World Health Organization in 2023, drug use problems cost the world economy over $1.5 trillion yearly in lost productivity, medical costs, and criminal justice costs (WHO, 2023). The intergenerational impact of addiction was highlighted by Lowe and colleagues' (2022) finding that children of people with drug use disorders are at much higher risk of experiencing mental health problems as well as substance use problems themselves.

Therapeutic design is an interdisciplinary approach that integrates concepts from architecture, interior design, environmental psychology, and healthcare to create spaces that actively support the healing process. It is also referred to as supportive design or healing environment design (Ulrich et al., 2008). Therapeutic design in the context of addiction recovery seeks to establish settings that lessen stress, enhance wellbeing, and assist the psychological and physical facets of the recovery process (Marques et al., 2021).

The work of environmental psychologist Roger Ulrich, who showed in 1984 that hospital patients with views of nature healed more quickly than those without, is credited with inspiring the idea of therapeutic design in healthcare settings (Ulrich, 1984). Interest in how the physical environment can affect health outcomes was piqued by this groundbreaking study. According to Moos's (2007) research, environmental factors have a major impact on treatment outcomes and relapse rates in the context of addiction recovery.

2. Literature Review

2.1 Existing Research on Addiction Treatment Methods

Conventional addiction treatment centres may disregard the psychological effects of their surroundings by placing a higher priority on use than comfort and design. Nonetheless, research has shown that patients' mood, stress levels, and general well-being can be impacted by the physical environment of their care (Gharaveis et al., 2020).
The application of therapeutic design concepts to addiction recovery settings is becoming more and more popular as a result of this discovery.

2.2 Medication-Assisted Treatment (MAT)

Effective addiction treatment now includes medication-assisted treatment (MAT), especially for opioid use disorder. MAT aims to control symptoms, lessen cravings, and stop relapses by combining behavioral therapy with medication. Research has consistently shown that medication-assisted treatment (MAT) is beneficial in increasing treatment results, lowering overdose mortality, and improving quality of life for those with substance use disorders.

2.2.1 Opioid Addiction

Two drugs that are frequently used to treat opioid addiction are buprenorphine and methadone. These drugs lessen the chance of overdosing, cravings, and withdrawal symptoms. According to a meta-analysis by Mattick et al. (2008), MAT outperformed a placebo in terms of lowering the use of opioids, enhancing treatment retention, and lowering criminal behavior among those who were dependent on them.

2.2.2 Alcohol Use Disorder

One drug that may lessen alcohol cravings and relapse rates is naltrexone. In a randomized controlled experiment, O'Malley et al. (2002) discovered that naltrexone was superior to a placebo at helping people with alcohol dependence stay alcohol-free.

2.3 Cognitive-Behavioural Therapy (CBT)

A popular psychotherapy strategy is cognitive-behavioural treatment (CBT), which aims to recognize and change the unfavourable ideas, emotions, and behaviours that lead to substance abuse. CBT assists people in creating relapse prevention plans, coping mechanisms, and wholesome lifestyle choices. Numerous research have shown how well cognitive behavioural therapy (CBT) works to lower substance usage and enhance treatment outcomes. Carroll et al. (2006) conducted a meta-analysis and discovered that CBT outperformed a placebo in decreasing substance usage for a variety of substances, such as cocaine, alcohol, and opiates.

2.4 Contingency Management

In order to promote good choices, contingency management entails rewarding beneficial behaviors, such as abstention from substance use. It has been demonstrated that this strategy works extremely well for enhancing therapy results, especially when paired with additional therapies. According to a Petry et al. (2016) systematic review, contingency management effectively reduced the use of opioids, cocaine, and alcohol, among other substances. The authors came to the conclusion that a promising solution for people with substance use problems is contingency management.

2.5 Mindfulness-Based Interventions

In recent years, mindfulness-based interventions—like mindfulness-based cognitive therapy (MBCT) and mindfulness-based stress reduction (MBSR)—have been more well-liked as useful resources for the treatment of addiction. Through these interventions, people can learn more about their thoughts, feelings, and sensations and build coping mechanisms to control their stress levels and cravings. According to a meta-analysis by Garland et al. (2017), mindfulness-based interventions can help people with substance use disorders reduce their use of drugs, improve their psychological health, and get better results from their treatments.

3. Therapeutic Design Principles and Their Applications

3.1 Biophilic Design in Recovery Spaces

The significance of biophilic design—the integration of natural elements into constructed environments—in addiction treatment centres has been highlighted by recent research. According to Zhao et al. (2020), patients' mental well-being and stress levels were shown to decrease when they were exposed to natural elements in treatment facilities. While offering more targeted applications to addiction rehabilitation scenarios, this is consistent with previous studies.

3.2 Sensory Considerations

The sensory stimulation present in hospital surroundings are carefully considered in therapeutic design. In 2014, Fenko and Loock looked into how music and ambient fragrance affected patients' anxiety in waiting areas. According to their research, relaxing music and nice smells greatly lowered patient anxiety.

3.3 Spatial Layout and Way finding

The way that medical facilities are arranged spatially affects both staff productivity and patient experience. A study on the effects of decentralized nursing stations on staff communication and patient satisfaction was carried out by Pati et al. (2022). According to their findings, decentralized designs enhanced nurse-patient interactions and shortened staff walking distances, which raised productivity and satisfied patients.

3.4 Trauma-Informed Design

Many addiction treatment programs now include trauma-informed care as a pillar, and facility design follows suit. Olausson et al. (2021) investigated the application of trauma-informed design principles to the creation of spaces that are safer and more conducive to healing. Through their efforts, the value of seclusion, environmental management, and socially conducive environments was brought to light.

4. Applications in Various Healthcare Settings

4.1 Mental Health Facilities

Particular potential has been demonstrated by therapeutic design concepts in mental health settings. Connellan et al.'s study from (2023) looked at how therapeutic design was used in psychiatric inpatient settings. They discovered that facilities with features like socializing places, private spaces for introspection, and access to nature had lower rates of aggressive patients and happier staff members.

4.2 Paediatric Hospitals

Therapeutic design assumes a greater significance in the field of pediatric healthcare. The influence of interactive play rooms in paediatric hospitals was examined by Adams et al. (2021). According to their research, thoughtfully planned play areas can help patients recover more quickly by fostering social connection and physical activity in addition to serving as a distraction from medical treatments.

4.3 Cancer Treatment Centres

Effective use of therapeutic design has also been observed in cancer treatment facilities. A case study of a recently constructed oncology unit with biophilic features, individualised patient rooms, and public areas for social support was carried out by Li and Wang in (2022). When compared to standard oncology units, the study found that patients had better moods, had less anxiety, and had higher satisfaction rates.

5. Evidence of Therapeutic Design's Effectiveness in Other Contexts

The application of therapeutic design ideas in office and professional contexts has demonstrated notable advantages. Browning and Cooper (2022) carried out an extensive investigation into the effects of biophilic architecture in workplace settings. The study revealed that workers who worked in workplaces including natural components like plants, natural light, and views of the outdoors reported increased levels of well-being by 15%, productivity by 6%, and creativity by 15%. According to the study's findings, implementing biophilic design components could result in yearly productivity savings of about $470 per employee.

In research published by Lee et al. (2023), looked at how coworking spaces might use sensory design concepts. The study revealed that the inclusion of natural soundscapes, scented diffusers, and tactile variation in furniture improved self-reported productivity by 18%, decreased perceived stress levels by 23%, and increased user happiness by 31% in these environments.

The application of therapeutic design concepts to improve learning settings has also shown potential. Barrett et al. (2021) investigated the effects of design elements on academic achievement in 153 classes spread across 27 schools. They discovered that in a single year, learning progress might be increased by up to 16% in classrooms with ideal designs. Good air quality, suitable lighting, temperature management, and classroom flexibility were among the important components.

Söderlund and Newman's (2022) study looked into the effects of biophilic architecture in academic environments. They discovered that adding natural features to lecture halls and study areas improved test results by 13%, increased student engagement as rated by students by 18%, and improved attendance by 22%.

Effective use of therapeutic design ideas has also been seen in residential settings. The effects of therapeutic design principles on older persons who are in place were studied by Molinsky et al. in 2023. According to their research,

homes with therapeutic design components improved self-reported quality of life by 28%, reduced fall incidences by 32%, and reduced depressive symptoms by 19%. Better lighting, non-slip flooring, and the use of natural views were among the design's main features.

Jansen and Kıroğlu (2024) investigated the use of therapeutic design concepts in home office configurations in light of the growing trend of remote work. They discovered that home offices built according to these guidelines resulted in a 21% boost in self-reported productivity, a 17% improvement in work-life balance satisfaction, and a 24% decrease in reported stress levels. Proper ergonomics, natural light, and the addition of plants or vistas of the outdoors were all effective components.

6. Challenges of Therapeutic Designs

6.1 Inadequate Integration of Therapeutic Design

Many addiction treatment centres continue to place more emphasis on functionality than therapeutic potential in their physical spaces, despite growing evidence of the benefits of therapeutic design in healthcare settings. There may be lost chances to improve recovery procedures as a result of this research-practice divide (Shepley et al., 2019).

6.2 Limited Understanding of Specific Design Needs

Although the broad concepts of therapeutic design are well-established, thorough research on the unique design requirements of people in addiction recovery is lacking. The creation of customized design solutions that meet the particular difficulties this demographic has is hampered by this information gap (Garcia-Romeu et al., 2020).

6.3 Neglect of Trauma-Informed Design Principles

In rehabilitation environments, trauma-informed design techniques are vital given the high frequency of trauma among people with substance use disorders. But a lot of facilities lack the design components needed to give trauma survivors a sense of security and support (Olausson et al., 2021).

6.4 Underutilization of Nature and Biophilic Design

Many urban addiction treatment clinics have restricted access to natural elements, despite compelling data supporting the therapeutic advantages of nature immersion. Zhao et al. (2020) argue that the underutilization of biophilic design concepts constitutes a lost chance to capitalize on nature's therapeutic power during the recovery process.

6.5 Lack of Attention to Social Interaction Spaces

Social support is crucial for successful recovery, yet the design of many treatment facilities does not adequately facilitate positive social interactions. There is a need for thoughtfully designed communal spaces that promote connection while respecting privacy needs (Lee & Kim, 2021).

7. Effects of Therapeutic Design on Addiction

Using therapeutic design concepts in addiction treatment environments can potentially solve a number of important issues:

7.1 Reducing environmental stress

The journey of recovering from addiction can be emotionally and physically exhausting. Well-planned surroundings can reduce tension and anxiety, fostering a more therapeutic environment (Gharaveis et al., 2020).

7.2 Enhancing motivation and engagement

According to Shepley et al. (2017), well-designed environments can foster a feeling of optimism and dignity in patients, which may increase their motivation to participate in treatment plans.

7.3 Promoting social interaction

Social isolation is a common consequence of addiction. Positive social connections are essential for rehabilitation and can be facilitated by therapeutic design (Tan et al., 2020).

7.4 Improving sleep quality

A lot of people in recovery experience difficulty sleeping. Better sleep patterns can be facilitated by design features like noise control and enough lighting (Fietze et al., 2018).

7.5 Promoting physical activity

Exercise on a regular basis helps with healing. This part of treatment can be supported by designs that promote mobility and offer areas for physical activity (Linke & Ussher, 2015).

8. Conclusion

Our approach to treatment and recovery also changes as our understanding of addiction does. The importance of the physical environment in the healing process has come to light more and more in recent years. As an adjunct to conventional addiction treatment techniques, this has raised interest in the idea of therapeutic design. Addiction science, interior design, architecture, and environmental psychology must all be incorporated into a multidisciplinary approach to address the problems with addiction therapy. We can endeavour to create more efficient, encouraging surroundings that improve the rehabilitation process for people battling addiction by methodically comprehending these problems. Introducing therapeutic design ideas into recovery settings is a viable way to improve treatment outcomes as the field of addiction therapy develops. This method recognizes that healing involves more than just medical treatments; it also entails the creation of caring, supportive settings that promote healing on several levels. The purpose of this study is to give useful insights for healthcare designers, architects, and addiction treatment experts, as well as to add to the expanding body of knowledge on environmental approaches to addiction therapy.

9. Future Study

The basis for further investigation and useful applications in the area of therapeutic design for addiction rehabilitation is laid by this review. Subsequent research endeavors may center on measuring the influence of particular design interventions on recovery measures, examining the economical feasibility of therapeutic design applications, and examining the applicability of these concepts in varied treatment environments and cultural contexts.

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