CONFERENCE PROCEEDINGS

APGC

6th ASEAN 20 25
POSTGRADUATE CONFERENCE

THE GREAT TRANSITION: RESHAPING THE BUILT ENVIRONMENT FOR A CHANGING WORLD

11 NOVEMBER 2025
KUALA LUMPUR, MALAYSIA

Editorial Board

Editors' Preface

We are honoured to present the proceedings of the *ASEAN Postgraduate Conference 2025*, held at the Connexion Conference & Events Centre, The Vertical, Bangsar South, Kuala Lumpur, on November 11, 2025. Centered on the theme *"The Great Transition: Reshaping the Built Environment for a Changing World",* this conference provided an invaluable platform for postgraduate researchers to engage in meaningful dialogue about the future of the built environment.

The conference showcased 49 papers spanning 9 distinct sub-themes: *Sustainable and Regenerative Design, Smart and Resilient Cities, Decarbonization and Green Energy, Social Inclusivity and Well Being, Project Management, Policy, Governance and Economic Transitions, Cultural Heritage and Identity, Technological Disruptions and Future Building Methods, and Material Innovation and the Circular Economy.* These contributions offer critical insights into evolving challenges and opportunities, presenting innovative approaches and enriching the existing body of knowledge on the built environment.

As editors, we are privileged to oversee this compilation, which highlights the pioneering work of emerging scholars and contributes to sustainable, inclusive, and resilient solutions for urban spaces and infrastructures. The papers serve as a significant academic resource for those exploring the multifaceted issues and trends shaping the built environment.

We extend our heartfelt appreciation to all authors for their intellectual contributions and to the reviewers whose thorough evaluations upheld the publication's high standards. We also acknowledge the dedicated efforts of the organizing committee and participants, whose collaboration ensured the success of this event.

We trust that this collection will inspire further research and collaboration, serving as a valuable resource for the academic community and beyond.

Editors:
Heba Tareq Ziad Azouqah
Nurul Auni Zulkhairi

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Demographic growth and Land use, Landcover change (LULC): A Nexus for sustainable urban planning of Federal Capital City (FCC) Abuja, Nigeria

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Abstract: Rapid urbanization and industrialization in many developing countries often lead to considerable changes within urban areas, adversely affecting urban sustainability. Over the past forty years, the Federal Capital City (FCC), Abuja, and its surrounding towns have seen notable demographic growth due to heightened urbanization and industrialization. To propose sustainable urban planning, the impact of urbanization and demographic growth on green spaces must be assessed through change detection analysis. The change detection method used in this study is the 'Area Analysis method'. This involves the analysis which highlights the transition trend of vegetated area to built-up area and bare surface over the period under assessment. The processes involved the geo-processing, which was selected, and the earlier periods of the year, and the observed change of each period of the year, i.e., 1985 to 2025, geometry were calculated and intersected to estimate the change area. After the process was done, the output was inferred according to the change that occurred. After the change detection was identified and extracted using spatial query operation. Therefore, LULC change analysis and transition probabilities provide strong evidence of FCC Urbanization trajectory, rapid expansion, environmental degradation, planned greening efforts, and continued pressure from urban growth. These patterns emphasize the importance of sustainable planning to protect remaining green spaces while accommodating inevitable urban development.

Keywords: land use land cover change (LULC); built-up-areas; sustainable urban planning; urbanization and industrialization; and Federal Capital City (FCC)

1. INTRODUCTION

Rapid urbanization and industrialization in many developing countries often lead to considerable changes within urban areas, adversely affecting urban sustainability (Humbal et al., 2023). Urbanization has become a defining moment in the 21st century in Africa, with the continent rapidly urbanizing concurrently to other regions of the developing world, UN-Habitat World Cities Report (2020). This urbanization trend in the continent is particularly notable as it is

occurring alongside rising levels of social issues, including urban poverty and insecurity (Liu et al., 2021). According to UNDESA (2020), the entire world population is expected to become increasingly urbanized over the next decade, rising from 56.2 percent today to more than 60.4 percent by 2030. Consequently, when every region is expected to witness urbanization in the coming years,the growth rate in highly urbanized areas will likely drop. Thus,more than ninety percent of this urban growth will occur in underdeveloped regions such as East Asia,South Asia, and Africa, with India ,China, and Nigeria alone accounting for 35 percent of the total increase in the global urban population from 2018 to 2050(Gu et al., 2021). Similarly,majority of the projected growth is expected to occure in developing countries, including Nigeria (Nathan, 2020).The projections indicates that the population residing in urban areas of Nigeria will reach 100 million by 2020 (Ahumibe et al., 2023). In recent years, rapid urbanization has emerged as a global trend, impacting both developed and developing regions and contributing to the rise of unsustainable cities.Over the past forty years, the Federal Capital City (FCC), Abuja, and its surrounding towns have seen notable demographic growth and change in land use due to heightened urbanization and industrialization(Adebisi & Bankole, 2022). Literature indicates that Abuja is among Nigeria's ten most populous cities and is recognized as one of the fastest-growing cities worldwide. The rapid demographic growth in Abuja, Nigeria, poses significant challenges and opportunities for urban social sustainability(Momoh et al., 2018). As the capital city, Abuja has experienced a substantial influx of population due to factors such as migration, economic opportunities, and governmental relocation(Obiadi et al., 2019). However,this rapid urbanization has profound implications for social sustainability, covering elements such as fair access to resources, social integration, and the overall well-being of its inhabitants. Therefore, the need for effective urban planning is crucial to address the challenges of rapid urbanization, such as developing affordable housing, improving public transportation, and ensuring equitable access to social services.

Hence, the high population growth rate and rapid urbanization in developing countries, including Nigeria is increasingly putting pressure on the demand for urban social infrastructure and aminities(Okopi, 2021). Therefore, the absence of these social facilities and amenities as a result of rapid population growth and urbanization deprives the urban poor of the benefit of enjoying these social services and amenities as well as the social sustainability of our cities. Consequently affecting the SDGS 17 most expecially SDG3 "Ensuring a healthy life and promoting well-being for all ages" one of the interconnected goals, which relates to all other 16 SDGs and SDG s 11 which focuses on making cities and human settlements inclusive, safe, resilient, and sustainable to have urban centers and cities which fosters social inclusion, cohesion, and human development.

Therefore, this study aims to examine the pattern of demographic growth of Federal Capital City (FCC) through documents review and area analysis, by acquisition of satellite images of the study areas FCC, Abuja from 1985 to 2025, showing changes over a period and land use/land cover change (LULC), to determined the demographic Structure/pattern and extent of urban development of the city of Abuja for a sustainable urban planning of our towns and cities.

2. STUDY AREA

The area of the Federal Capital Territory (FCT) is approximately 8,000 square kilometres in size, with coordinates of 9º4°0'N and 7°29°0'E. The FCT is bordered with Niger, Kaduna, Nassarawa, and Kogi States, from which the FCT was formed. As a result, the FCT shares some of the characteristics of both zones, making it an intriguing place for urban development. According to Plan (1979),the Federal Capital City was initially designed to accommodate an estimated population of 157,750 people when it opened in 1986, then 485,660 people in 1990, 1,005,800 people in 1995, and 1,642,100 people in 2000, with a maximum projected population of 3.1 million expected by 2009 (IPA, 1979; Benna Associates; 2009 and Abubakar, 2014). Abuja grew at a 9.3 percent yearly rate between 2000 and 2010, making it the country's fastest-growing city (Udeh, 2010; Abubakar and Doan, 2010).
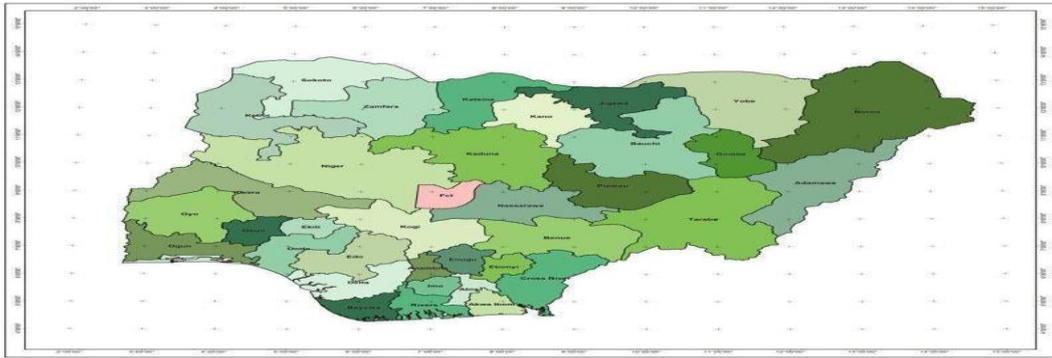
Figure 1: **Abuja in the National Context**
Source: Benna Associates, (2009)
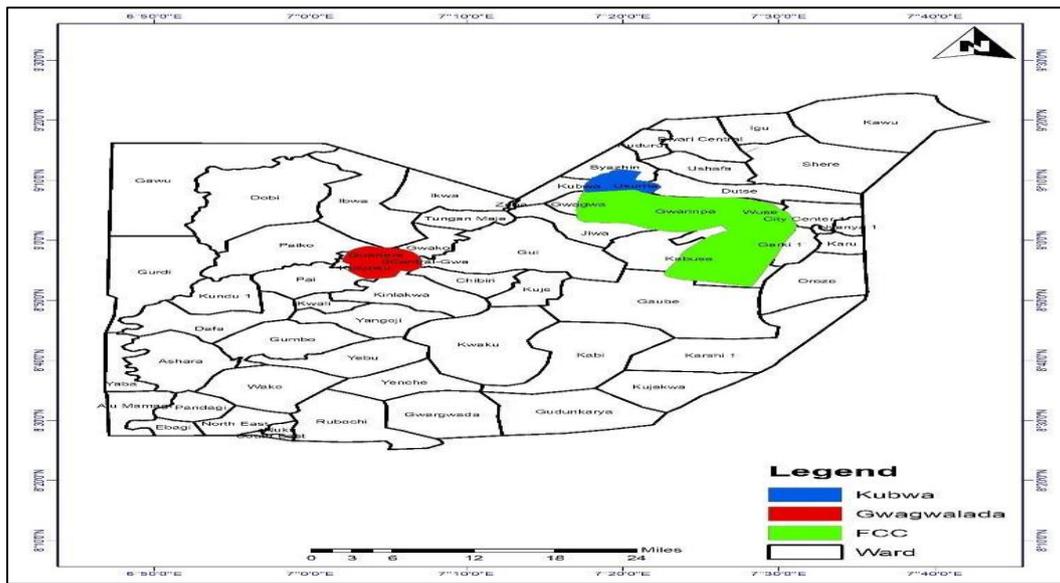
Figure 2: **Delineation of the Federal Capital City (FCC) in the context of other satellite towns**
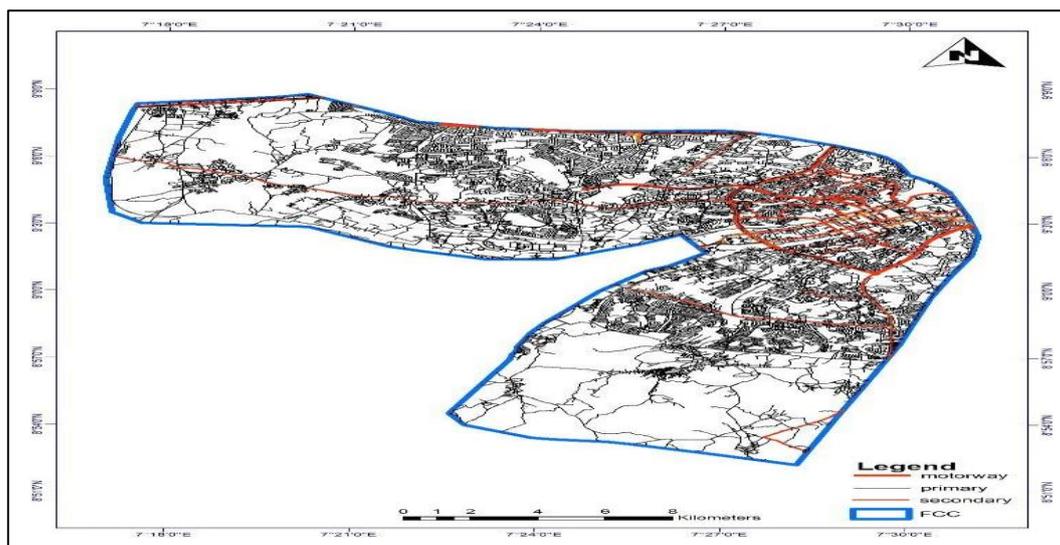
Figure 3: Delineation of the Federal Capital City

3. METHODOLOGY

The study adopted time series analysis method, that is Spatio temporal analysis which involves the process of employing space and time in determine the change dynamic of a spatial feature, thus the process involved; Satellite/Digital image preprocessing the digital or satellite image preprocessing is the process of rectifying errors in the satellite imagery caused by sensor, noise, sun angle and atmosphere. This preprocessing intended to correct errors in the pixels. The images were processed both geometrically, radiometrically, and spatially filtered to suppress the errors arising from the sensor, noise, sun angle, and atmospheric effects. The process involved.

   i.   Image enhancement
   ii.   Sub setting
   iii. Training sampling and creating signature file
   iv.   Image classification

   The overall objective of image classification is to automatically categorize all pixels in an image into land cover classes or themes. It is the process of grouping or categorizing different image classes into their pixel characteristics. The categorized data are then used to produce the thematic map present in the scene. For this study, a supervised classification approach was employed, utilizing an interactive maximum likelihood algorithm for image classification. Considering the visual and digital interpretation of satellite images, about four (4) different LULC types or classes were examined in the study area. The LULC classes were categorized and classified using a supervised classification approach into agricultural land, bare soil, built-up area, water bodies, and vegetation, then vectorization was done to convert raster to polygon for geometry summation. The four (4) classified land use types in the study area are shown in the table below.

Table 1: Various land use types in the study area.

Land use types	Descriptions
Built up area	These include Residential, commercial, and service, transportation, communication and utilities, industrial and commercial complexes.
Bare surface	These also includes dry salt flats, beaches, sandy areas other than beaches, bare exposed rocks, strip mines, queries and gravel pits.
Vegetation	This includes areas of natural vegetation of any plant species, trees, deciduous and ever greened forest lands.
Water bodies	These involve areas persistently lodge with waters such as streams, canals, lakes, reservoirs, bays and estuaries.

Source: Adopted from (Lillesand et al., 2015)

4. RESULTS AND DISCUSSION

This section presents the results obtained in the course of the analysis of the previous areas such as methodology. Maps, charts, and tables are used to illustrate the analysis carried out. LULC Analysis

   The result of the analysis statistically and graphically presents in Table 1 and Figure 15 as seen below.

Table 2: Statistically Analysis of LULC from 1985-2025

Epoch	LULC 1985		LULC 1995		LULC 2005		LULC 2015		LULC 2025	
Class	Km	%	Km	%	Km	%	Km	%	Km	%
Bare surface	578.189	32.68	971.172	54.89	1066.064	60.25	402.235	22.73	536.604	30.33
Built-up area	87.435	4.94	142.757	8.07	220.486	12.46	435.519	24.62	570.068	32.22
Vegetation	1102.327	62.3	619.188	35	464.555	26.26	916.08	51.78	658.325	37.21
Water Bodies	1.343	0.08	36.171	2.04	18.181	1.03	15.465	0.87	4.402	0.25
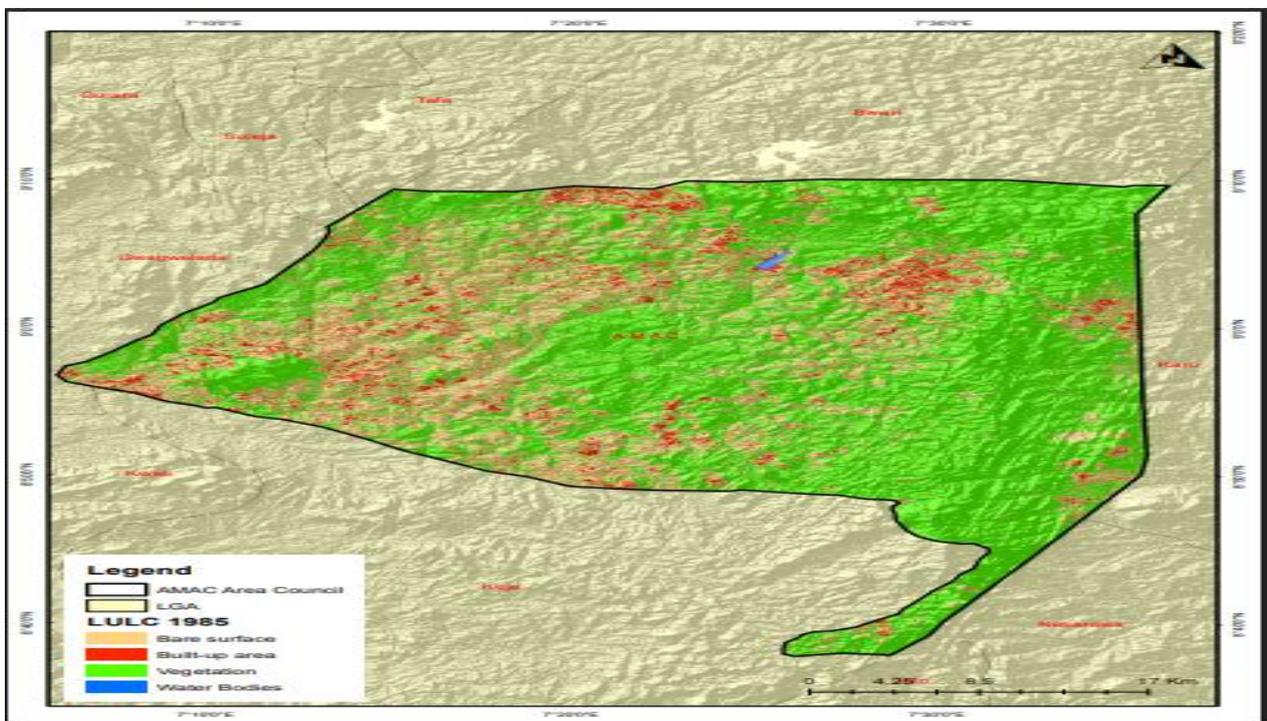
Figure 1: LULC 1985 -1995
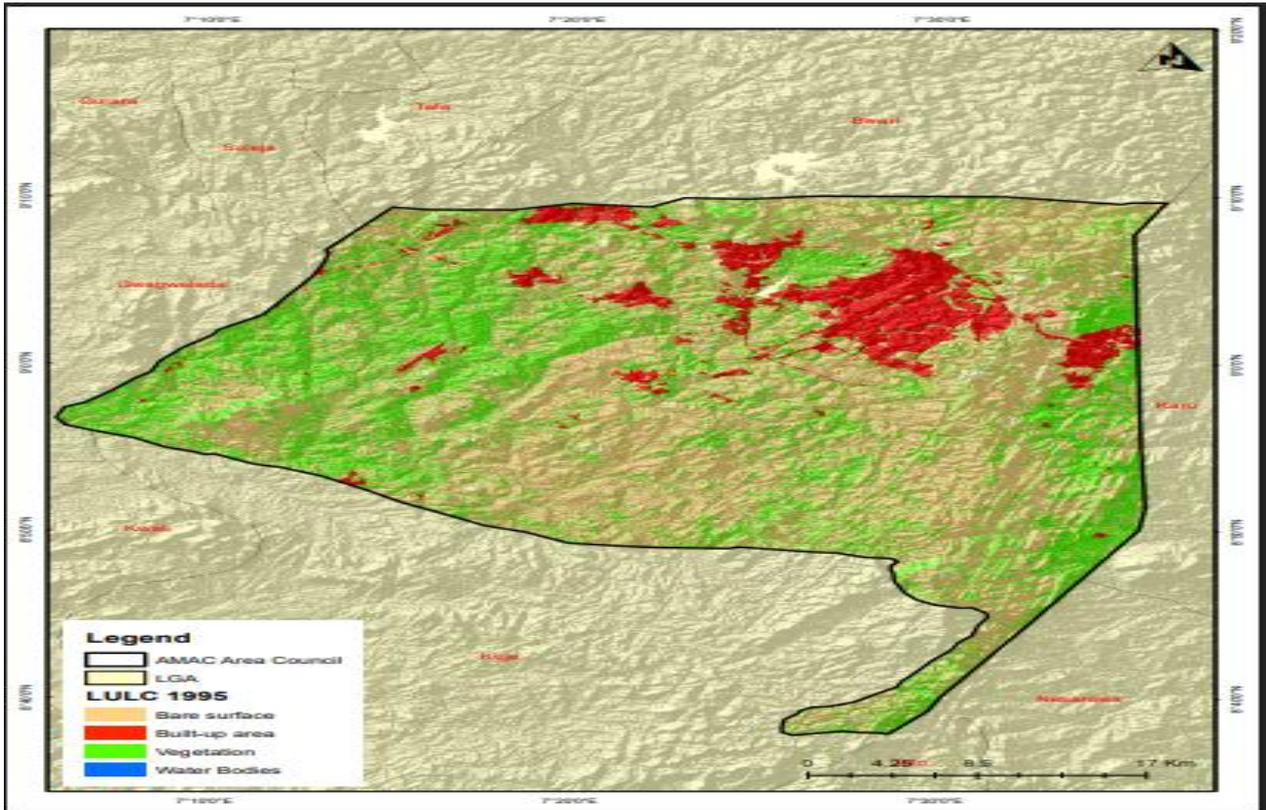
Figure 2: LULC 1995-2005

Figure 3: LULC 2005 -2015

Figure 4: LULC 2015-2025
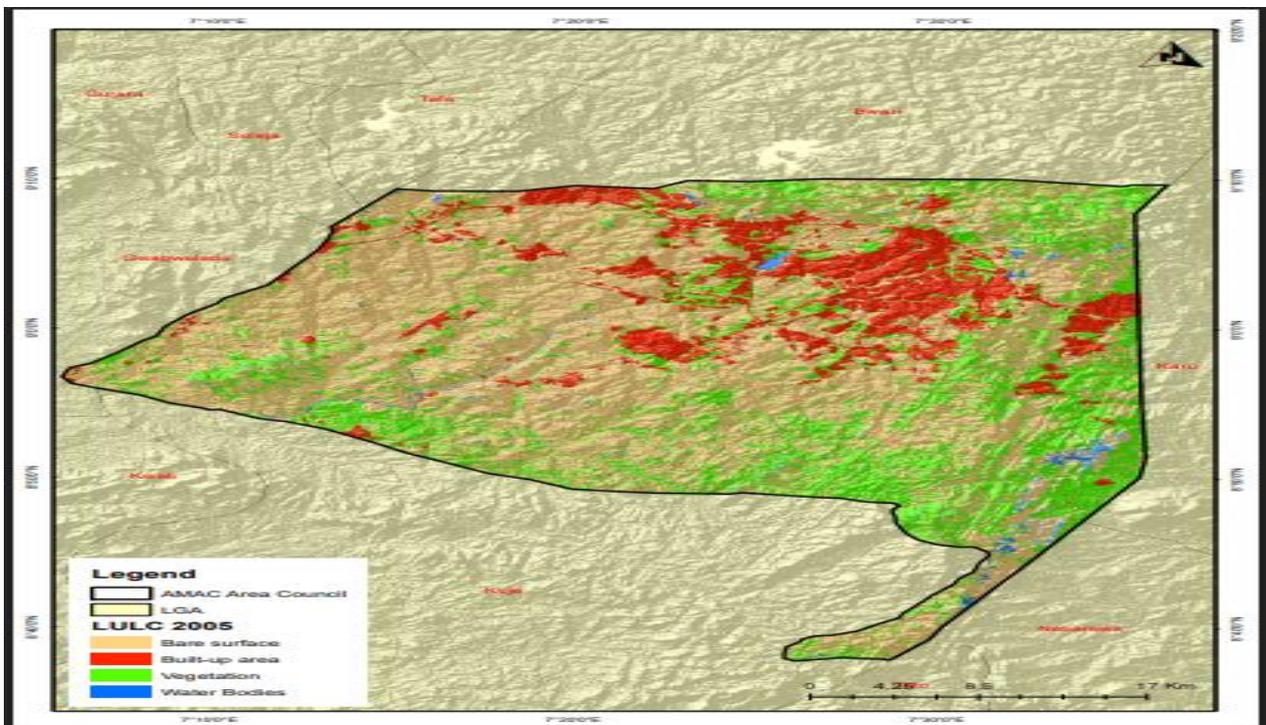
Figure 5: LULC 2025

The analysis of Land Use/Land Cover (LULC) changes between 1985 and 2025 highlights dramatic transformations within the Abuja Federal Capital City (FCC), reflective of the broader urbanization trends in Nigeria's Federal Capital Territory (FCT). In 1985, vegetation was the dominant land cover class, accounting for 62.3% of the landscape, while built-up areas made up only 4.94%. Bare surfaces were also significant, covering 32.68% of the area, and water bodies were minimal at 0.08%. These figures suggest that before intensive development, FCC was largely characterized by natural vegetation, fallow lands, and minimal human settlement (Federal Capital Development Authority [FCDA], 2010). Following Abuja's designation as Nigeria's capital city in 1991, AMAC experienced rapid urbanization and demographic growth. This is evident in the LULC trends, with built-up areas expanding steadily to 8.07% in 1995, 12.46% in 2005, 24.62% in 2015, and projected to reach 32.22% by 2025. The continuous rise in built-up land reflects the influx of population, expansion of infrastructure, and the establishment of government and private institutions. Studies have confirmed that Abuja's urban land expansion was one of the fastest in Sub-Saharan Africa during the 1990s and early 2000s, primarily driven by population growth and administrative policies favoring rapid construction (Musa & Shaibu, 2017).

The vegetation cover, on the other hand, saw a steep decline from 62.3% in 1985 to 26.26% in 2005, highlighting the significant deforestation and land clearing activities associated with urban development. However, there was a remarkable increase to 51.78% in 2015, likely due to the Abuja Master Plan's emphasis on maintaining green areas and the enforcement of environmental protection policies, including the establishment of green belts and urban parks (FCDA, 2010; Ezenwaji et al., 2020). By 2025, vegetation is projected to cover 37.21%, indicating ongoing urban pressures but also efforts at balancing built-up and green spaces.

Bare surfaces, which represent cleared but undeveloped lands, increased sharply from 32.68% in 1985 to a peak of 60.25% by 2005. This surge corresponds with the period when large tracts of land were cleared in preparation for urban expansion. However, by 2015, bare surfaces had reduced significantly to 22.73%, suggesting that many previously cleared lands were developed into residential, commercial, or institutional spaces. The slight projected rise to 30.33% by 2025 could be attributed to ongoing construction projects or land banking practices within FCC.

Hence, Water bodies remained a minor component of the landscape throughout the study period, with slight fluctuations. The increase from 0.08% in 1985 to 2.04% in 1995 may have resulted from artificial reservoirs, drainage systems, and flood control projects; however, FCC generally has limited natural water resources. Urban infrastructure developments, including small dams and artificial lakes, contributed to these modest changes (Abubakar & Doan, 2017).

In summary, the LULC changes in FCC between 1985 and 2025 reflect a transformation from a predominantly vegetated and natural landscape to an increasingly urbanized environment. This mirrors Abuja's role as a planned capital city designed to accommodate Nigeria's growing administrative and socio-economic activities. The dynamic changes emphasize the need for sustainable urban planning that balances development with environmental conservation.

The overall accuracy of the classified images for the various years indicates a high level of agreement with ground reference data. The classification accuracy for 1985 and 1995 was 75%, 79% with a kappa coefficient of 0.64 and 0.71, while 2005 showed 71% accuracy with a kappa coefficient of 0.67. The 2015 classification had an 82% accuracy with a kappa coefficient of 0.70, whereas the 2025 classification achieved the highest accuracy of 85% with a kappa coefficient of 0.72. This suggests that the classified images for all year's exhibit a near-perfect agreement with ground-truth data, as summarized in Table 3.

Table 3: The Kappa coefficient statistics interpretation

S/N	Kappa value	Interpretation
1	<10	No agreement
2	0.0 – 0.20	Slight agreement
3	0.21 – 0.40	Fair agreement
4	0.41 – 0.60	Moderate agreement

| 5 | 0.61 – 0.80 | Substantial agreement |
| 6 | 0.80 - 1 | Almost perfect agreement |

Source: (Zhang et al., 2018)

Transition Probability Matrix

The Land Use/Land Cover (LULC) change analysis and transition probabilities between 1985 and 2025 for the Abuja Federal Capital City (FCC) shown in Table 4 and Figure 6 reveal distinct patterns of urban transformation, landscape degradation, and partial regeneration.

Table 4: Transition probability matrix

Epoch	LULC1985-1995		LULC 2005	1995-	LULC 2015	2005-	LULC 2015-2025	
Class	Km	%	Km	%	Km	%	Km	%
Bare surface	392.983	22.21	94.892	5.363	-663.829	-37.52	134.369	7.6
Built-up area	55.322	3.13	77.729	4.392	215.033	12.16	134.549	7.6
Vegetation	-483.139	-27.3	-154.633	-8.744	451.525	25.52	-257.755	-14.57
Water Bodies	34.828	1.96	-17.99	-1.012	-2.716	-0.16	-11.063	-0.62
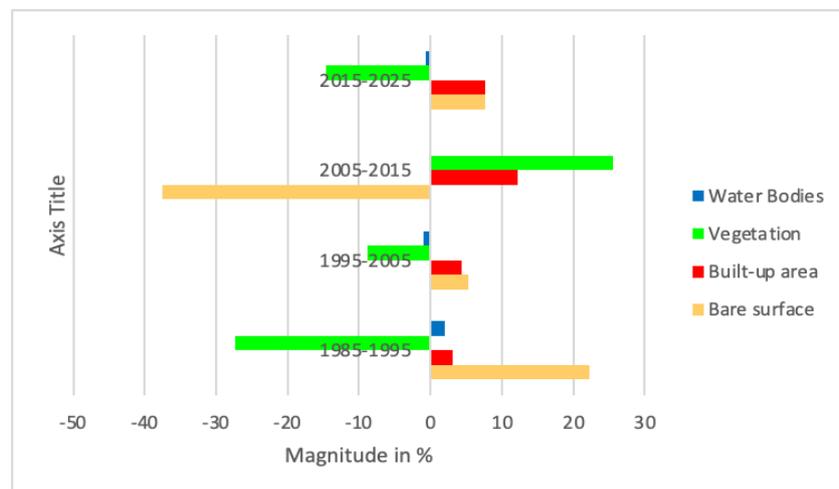
Figure 6: Bar Chart representation of transition probability analysis

Between 1985 and 1995, bare surfaces increased substantially by 392.983 km² (22.21%), indicating widespread land clearing activities in preparation for urban expansion. This coincides with the early stages of Abuja's development as Nigeria's new capital. Built-up areas also increased by 55.322 km² (3.13%), reflecting initial infrastructure development (Federal Capital Development Authority [FCDA], 2010). Vegetation, however, declined sharply by 483.139 km² (-27.3%), confirming significant deforestation and land conversion during this period. Water bodies experienced a modest increase (34.828 km²), likely due to construction of artificial lakes and dams for urban water supply (Abubakar & Doan, 2017). Between 1995 and 2005, the trends continued but at a slower rate. Bare surfaces only increased slightly by 94.892 km² (5.36%), while built-up areas expanded by 77.729 km² (4.39%). The smaller rate of vegetation loss (-154.633 km², -8.74%) suggests that urban expansion persisted but

may have become more structured, aligned with Abuja's Master Plan promoting zoning and preservation of green spaces (Ezenwaji et al., 2020).

The period between 2005 and 2015 shows a major reversal. Bare surfaces decreased dramatically by -663.829 km² (-37.52%), while built-up areas expanded significantly by 215.033 km² (12.16%). Vegetation surprisingly rebounded, gaining 451.525 km² (25.52%). This transition highlights the infill development of previously cleared lands into built-up areas and the reestablishment of green areas through urban parks, green belts, and environmental initiatives under the Abuja Environmental Protection Board (AEPB).

Between 2015 and 2025, there is a slight increase in land clearing, with a bare surface area of 134.369 km² (7.6%), and a continued expansion of built-up areas by 134.549 km² (7.6%). Vegetation is expected to decline by 257.755 km² (-14.57%), indicating ongoing urban pressure and development activities.

The transition probability matrices further reveal that in FCC, there is a high probability of bare surfaces transitioning to built-up areas, particularly between 1995–2005 and 2005–2015, which aligns with construction booms. Vegetation, meanwhile, either remains as vegetation or transitions into bare surface first before final urbanization. Water bodies show low resilience, with negative changes across most epochs, reflecting low stability or encroachment due to land development pressures.

In summary, the LULC change analysis and transition probabilities together provide strong evidence of FCC's urbanization trajectory, characterised by rapid expansion, environmental degradation, planned greening efforts, and continued pressure from urban growth. These patterns emphasize the importance of sustainable planning to protect remaining green spaces while accommodating inevitable urban development.

Change Detection

The change detection analysis for FCC between 1985 and 2025 provides a detailed understanding of land cover transformations over four decades as presented in Table 5 and demonstrated in Figure 7

Table 5: Change detection analysis

Change detection	Km²
Bare surface - Bare surface	222.913
Bare surface - Built-up area	211.784
Bare surface – Vegetation	142.633
Bare surface - Water Bodies	0.7
Built-up area - Bare surface	26.813
Built-up area - Built-up area	39.95
Built-up area – Vegetation	20.407
Built-up area - Water Bodies	0.245
Vegetation - Bare surface	286.467
Vegetation - Built-up area	318.083
Vegetation – Vegetation	494.827
Vegetation - Water Bodies	2.491
Water Bodies - Water Bodies	0.965
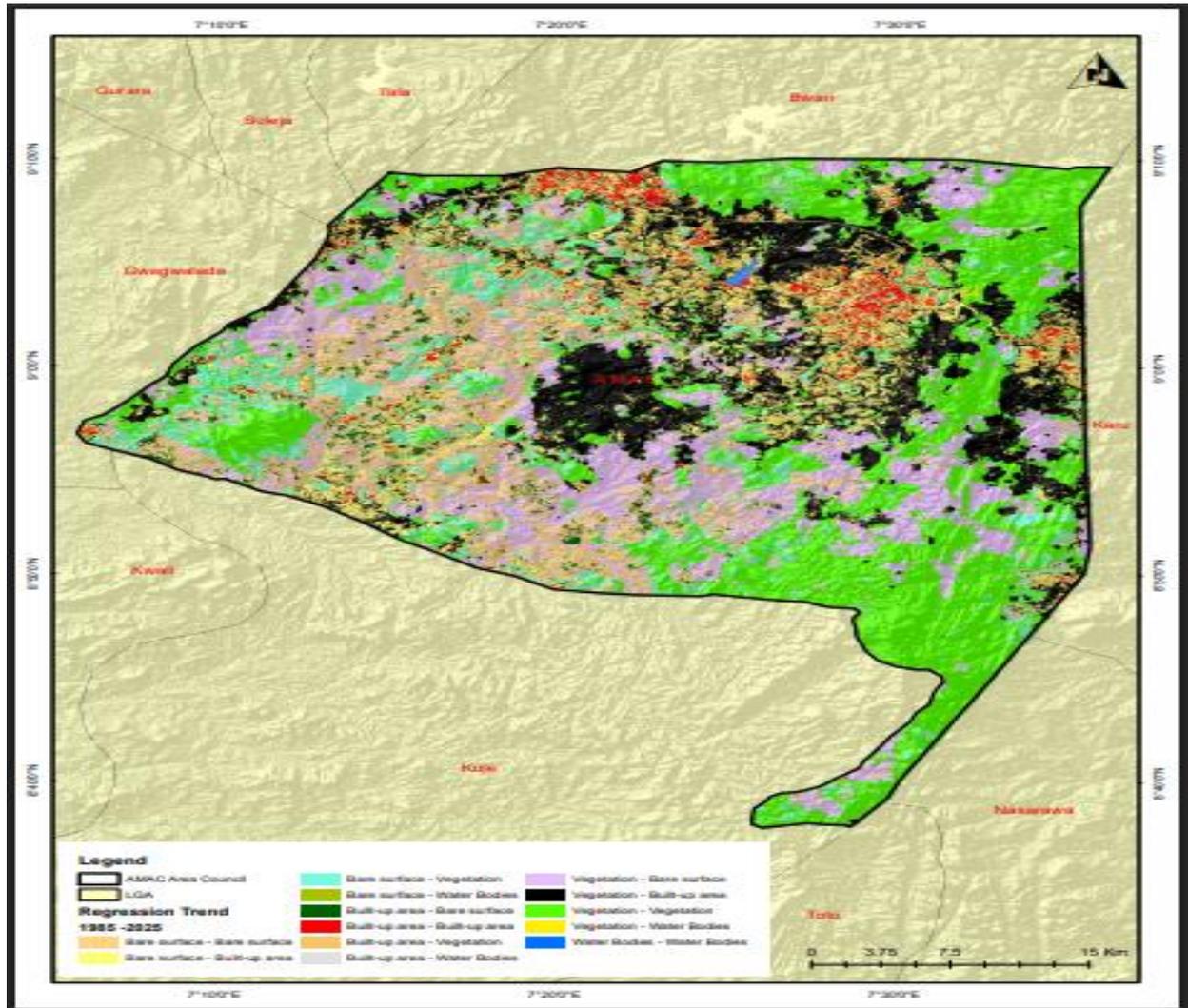
Figure 7: Change detection analysis map from 1985-2025

The results reveal that a significant portion of land that was classified as bare surface in 1985 remained bare surface by 2025, with 222.913 km² persisting. However, a substantial 211.784 km² of the 1985 bare surface transitioned into built-up areas, showing how land cleared early in Abuja's planning phases was eventually developed into residential, commercial, and institutional structures (Federal Capital Development Authority [FCDA], 2010). Additionally, 142.633 km² of bare surfaces reverted to vegetation, suggesting areas that either underwent natural regeneration or were intentionally preserved or reforested as part of Abuja's environmental conservation efforts (Ezenwaji et al., 2020). Minimal conversion of bare surface to water bodies (0.7 km²) occurred, likely linked to the construction of small artificial lakes or drainage reservoirs (Abubakar & Doan, 2017).

Built-up areas also exhibited some dynamics. While 39.95 km² of built-up land persisted from 1985 to 2025, 26.813 km² converted back to bare surface, possibly due to demolition activities, redevelopment processes, or abandonment (Musa & Shaibu, 2017). Moreover, 20.407 km² of built-up land was overtaken by vegetation, reflecting urban greening initiatives such as parks, green zones, and ecological restoration in Abuja's city planning (Ezenwaji et al., 2020). Only a negligible portion (0.245 km²) transitioned into water bodies, potentially tied to localized flood control projects (Abubakar & Doan, 2017).

Vegetation demonstrated the most complex transition patterns. A considerable 494.827 km² of vegetation persisted, showing resilience and the success of green preservation measures (FCDA, 2010). However, 286.467 km² of vegetation transitioned to bare surfaces, indicating ongoing deforestation pressures (Musa & Shaibu, 2017). Most

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notably, 318.083 km² of vegetation transformed into built-up areas—an explicit reflection of Abuja's rapid urbanization and land conversion to support a growing urban population (Abubakar & Doan, 2017). Additionally, 2.491 km² of vegetation transitioned into water bodies, likely linked to changes in drainage systems and minor hydrological projects (Ezenwaji et al., 2020).

Finally, water bodies remained relatively stable, with 0.965 km² persisting. This stability suggests that while water bodies constitute a very small percentage of AMAC's land cover, they have been relatively protected or minimally disturbed compared to other land cover types (FCDA, 2010).

Therefore, the transition patterns demonstrate a strong urbanization signal: vegetation loss to urban development, bare surface conversion to built-up areas, and a minor but meaningful trend toward environmental restoration in certain pockets. This dynamic captures the dual reality of Abuja's planned growth and the ecological tensions it has produced, emphasizing the need for integrated land use planning that supports sustainable urbanization (Musa & Shaibu, 2017; Abubakar & Doan, 2017).

5. CONCLUSIONS

The findings of this study highlight profound transformations in the Land Use and Land Cover (LULC) patterns of Abuja Federal Capital City (FCC) between 1985 and 2025. Over the four decades, the region experienced a significant shift from predominantly vegetated landscapes to a more urbanized environment. The persistence of bare surfaces and their eventual conversion into built-up areas reflect the deliberate and strategic development efforts linked to Abuja's designation as Nigeria's new capital city in the late 20th century (Federal Capital Development Authority [FCDA], 2010). However, while planned urbanization was necessary for national development, it has come at a notable ecological cost.

Vegetation loss was particularly pronounced, with large tracts converted into urban infrastructure and residential spaces. The transition of over 318.083 km² of vegetation into built-up land illustrates the strong urbanization drive (Musa & Shaibu, 2017). Although some vegetation persisted and even regenerated in isolated cases, the overall trajectory indicates a decline in natural habitats and an increase in environmental degradation risks. Such changes threaten ecosystem services that are vital for urban resilience, such as flood regulation, carbon sequestration, and urban cooling (Ezenwaji et al., 2020).

The stability of water bodies, albeit in minimal proportion, suggests a degree of environmental protection in hydrologically sensitive areas. Nevertheless, the small overall area of water bodies within FCC (less than 1% across all epochs) indicates a vulnerability to water scarcity issues, especially under the increasing pressures of climate change and urban demand (Abubakar & Doan, 2017).

Transition probability analysis further reveals the trajectories of change, emphasizing that bare surfaces were increasingly predisposed to becoming built-up areas rather than reverting to natural states. This reinforces the notion that without strong policy interventions, urbanization in FCC is likely to continue in a largely irreversible manner, leading to the eventual dominance of impervious surfaces across the landscape.

From a policy and planning perspective, these trends underline the urgent need for integrated urban land management frameworks that prioritize green infrastructure, sustainable urban expansion, and ecosystem-based adaptation strategies. Measures such as enforcing green belts, promoting urban reforestation, enhancing land reclamation efforts, and protecting critical biodiversity areas must be institutionalized to counterbalance rapid development pressures.

Moreover, continuous monitoring using geospatial technology and remote sensing should be mainstreamed into urban planning practices to provide real-time data for informed decision-making. Such an approach would not only support achieving Nigeria's Sustainable Development Goals (SDGs) - particularly Goal 11 (Sustainable Cities and Communities) and Goal 15 (Life on Land) - but also ensure that Abuja evolves as a truly livable, resilient, and sustainable African capital.

In conclusion, the LULC change patterns observed in FCC between 1985 and 2025 encapsulate the complexities of urban growth in rapidly developing regions. While urbanization has brought about infrastructural advancements

and economic opportunities, it has simultaneously posed substantial challenges for environmental sustainability. The future trajectory of FCC will depend largely on how well land use policies balance development needs with ecological stewardship.

ACKNOWLEDGMENTS

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