FACULTY OF ENGINEERING,
BAYERO UNIVERSITY, KANO

Proceedings of the 5th ENGINEERING CONFERENCE

on

ENGINEERING INNOVATIONS AND ECONOMIC POLICIES: DRIVING SUSTAINABLE INDUSTRIAL GROWTH IN NIGERIA

Venue:
Dangote Business School, Bayero University, Kano

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Members of Editorial Committee

Welcome Address by the Chairman, Conference Organising Committee,

On behalf of the Management of Bayero University, Kano, the Faculty of Engineering, and the Local Organising Committee, I warmly welcome you to the 5th Faculty of Engineering Conference, Bayero University, Kano.

The Bayero University Engineering Conferences were conceived to provide a vibrant forum where researchers, policymakers, industry practitioners, entrepreneurs, and other stakeholders engage on topical engineering issues that are critical to national development. This vision was first realized through the Academia–Industry Conferences (ACICon), which created valuable opportunities for interaction between academia, industry, and government, particularly in addressing challenges related to knowledge transfer, technology development, and industrial application of research outcomes.

In December 2015, the Faculty of Engineering hosted the International Conference on Green Engineering for Sustainable Development (IC-GESD 2015) in collaboration with the Faculty of Engineering, Tanta University, Egypt. The conference emphasized green engineering as a pathway to minimizing environmental pollution, promoting sustainability, protecting human health, and achieving economic efficiency. Building on this success, the Faculty organized the second stream, IC-GESD 2017, in November 2017. Both conferences enjoyed strong local and international participation and further strengthened the Faculty's commitment to impactful research and global collaboration.

The 5th Faculty of Engineering Conference builds on this solid foundation. With the theme "Engineering Innovation and Economic Policies: Driving Sustainable Industrial Growth in Nigeria," the conference is timely in the context of Nigeria's pursuit of economic diversification, industrial competitiveness, and sustainable development. It provides a platform to examine how engineering solutions can effectively support national economic policies while addressing emerging areas such as start-ups and entrepreneurship, digital economy and artificial intelligence, energy transition, agricultural mechanization, infrastructure development, and healthcare technologies.

We are particularly pleased with the wide range of participants from academia, industry, government, development partners, and young innovators. This diversity reflects our belief that meaningful and sustainable engineering solutions can only be achieved through strong collaboration among all stakeholders.

I wish to sincerely acknowledge the Vice-Chancellor of the University, the Dean of the Faculty of Engineering, our distinguished keynote speakers, reviewers, sponsors, partners, and members of the Local Organising Committee for their dedication and support in making this conference possible.

As you participate in the technical sessions, plenaries, and interactive engagements, it is our hope that the discussions and outcomes will lead to practical insights, policy-relevant recommendations, and innovative ideas that will contribute to Nigeria's industrial growth and economic development.

Once again, you are warmly welcome, and I wish you a rewarding and successful conference.

Nurudeen Yusuf
Chairman, Local Organising Committee

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023-Assessing the Challenges for Implementation of Circular Economy Principles in Waste Management in Nigerian Construction Industry

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Abstract: The circular economy (CE) framework is based on principles that has emerged as a viable strategy for promoting sustainable construction and minimizing environmental impact. However, the strategy has not been effectively adopted in Nigerian construction industry due to certain challenges. Therefore, this study aimed to evaluate the challenges of circular economy principles for waste mitigation in construction projects in Abuja, Nigeria with a view for future research to investigate how the challenges can be reduced. The research adopted a descriptive survey research design. A structured questionnaire was administered to 450 respondents, while 427 valid responses were analyzed. Findings revealed that client preference, quality concerns and liability issues are the three most significant challenges of adoption of circular economy for waste mitigation in Nigerian construction industry. The study concludes that future studies should develop and test frameworks to address client perception and liability concerns in CE procurement, which could substantially enhance resource efficiency and, reduce material waste in Abuja's building projects.

Keywords: Circular economic, Principles, Waste management, Mitigation

1. INTRODUCTION

Abuja's rapid urbanization has led to unprecedented construction activities, resulting in substantial waste generation. Current estimates indicate that construction projects in the FCT generate between 15-20% waste of total project materials (Yu et al., 2019). This waste includes concrete, steel, wood, plastics, and other materials that often end up in landfills or are illegally dumped, causing environmental degradation and public health risks. The predominant linear economic model in Abuja's construction industry is characterized by resource extraction, production, consumption, and disposal. This model is inherently unsustainable, as it depletes natural resources, generates excessive waste, and contributes to environmental pollution (Ogunmakinde et al., 2022). The industry's reliance on virgin materials and lack of material recovery systems exacerbate these challenges. Despite global recognition of circular economy benefits, Nigerian construction projects, particularly in Abuja, show limited integration of CE principles. A survey study conducted by You et al (2020) revealed that only 12% of construction firms in Abuja have implemented any form of circular economy practices. This low adoption rate is attributed to various factors, including lack of awareness, inadequate policy framework, and economic constraints. The current policy landscape in Nigeria lacks specific regulations and incentives for circular economy implementation in construction. The National Environmental Standards and Regulations Enforcement Agency (NESREA) guidelines focus primarily on waste disposal rather than waste prevention and resource recovery (Xiao et al., 2023). The linear approach to construction not only affects environmental sustainability but also has economic implications. The continuous procurement of virgin materials, coupled with waste disposal costs, increases project expenses. Construction firms in Abuja report that waste management costs account for 3-5% of total project budgets (World Health Organization (WHO), (2024). The adoption of circular economy principles in Abuja's construction sector could significantly contribute to achieving Nigeria's commitment to the Sustainable Development Goals (SDGs), particularly Goal 11 (Sustainable Cities and Communities) and Goal 12 (Responsible Consumption and Production). Furthermore, it aligns with the National Environmental Policy and the National Action Plan on Climate Change (Adebayo et al., 2021). Recent studies have demonstrated the potential of CE in construction, showing waste reduction of up to 80% and cost savings of 20-30% in pilot projects (Rios et al., 2021). However, the implementation of CE principles in developing countries faces unique challenges, including limited financial resources, inadequate infrastructure, and lack of policy support (Wilts et al., 2021).

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2. METHODOLOGY

This study employed quantitative research design using a structured questionnaire to examine the challenges in adoption of circular economy strategies for waste management in construction projects in Abuja, Nigeria in the year 2025. The information for the various challenges for adoption of circular economy for waste management in Nigerian construction industry was obtained through desk study, which formed the first phase of the study. This design is appropriate as it enables the collection of data from a wide range of industry stakeholders at a single point in time (Creswell, and Creswell, 2017). The questionnaire consists of closed-ended questions with 5 point Likert-scale responses, allowing for easy quantification and analysis of the data. Data was collected through the distribution of questionnaires to the selected participants. The questionnaires were distributed electronically via email and online survey platforms to ensure convenience and accessibility for the participants. The target population for this study comprises professionals and stakeholders in the construction industry in Abuja, Nigeria, including project managers, site engineers, architects, quantity surveyors, contractors, waste management specialists, and regulatory officials. It should be noted that the sampling frame for the study includes a list of construction professionals in Nigeria. This list is compiled from professional associations, such as the Nigerian Institute of Quantity Surveyors (NIQS), the Nigerian Society of Engineers (NSE), and the Nigerian Institute of Building (NIOB). Additionally, construction firms and government agencies involved in infrastructure projects are included in the sampling frame. The sample size for the study was determined using Cochran's formula: $n = (Z^2pq) / e^2$

Where:

- n = sample size
- Z = standard normal deviate (1.96 for 95% confidence level)
- p = estimated proportion (0.5 for maximum variability)
- q = 1-p (0.5)
- e = margin of error (0.05)

Based on this calculation and considering the finite population, the minimum sample size is determined to be 4 respondents. The data obtained was analyzed quantitatively i.e., using descriptive statistics.

3. RESULTS AND DISCUSSION

3.1 Demographical Information of the Respondents

The total number of valid responses analyzed was 427, as reflected in both the Word document and the Excel file. Table 1 summarizes the demographic characteristics of the study respondents.

TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Attribute	Category	Freq.	Percentage
Gender	Male	335	78.50%
	Female	92	21.50%
Age Group	26–35 years	98	23.00%
	36–45 years	132	30.90%
	46–55 years	112	26.20%
	Above 55 years	85	19.90%
Years of Experience	0–5 years	89	20.80%
	6–10 years	134	31.40%
	11–15 years	98	23.00%
	16–20 years	67	15.70%
	Above 20 years	39	9.10%
Organization Type	Construction Firms	172	40.30%
	Government Agencies	85	19.90%
	Service Providers	89	20.80%
	Consultants	43	10.10%
	Others	38	8.90%

The respondent profile is dominated by mid-level professionals, with 54.4% having 6–15 years of experience. This experience profile is particularly valuable for circular economy research, as they possess both practical experience and technical expertise. Entry-level professionals (20.8%) and highly experienced respondents (24.8%) are less represented, making the dataset more reflective of operational and project-level realities. Mid-level practitioners often act as liaisons between strategic planning and on-site execution, positioning them ideally to assess waste management practices and propose actionable circular economy strategies. Their perspectives enhance the study's relevance to real-world construction challenges and implementation feasibility. The organizational distribution reflects broad stakeholder representation across the construction value chain. Construction firms dominate at 40.3%, aligning with their key role in waste generation and management. Strong participation from service providers (20.8%) and government agencies (19.9%) ensures policy and implementation perspectives are well captured. Additionally, input from consultants (10.1%) and other organizations (8.9%) adds diversity, incorporating insights from advisory and specialized sectors. This balanced representation is crucial for circular economy research, as effective implementation depends on coordinated efforts among various stakeholders with different responsibilities and influence within the construction and waste management ecosystem. The demographic profile underscores key enablers and limitations for circular economy (CE) adoption in Nigeria's construction sector. The dominance of mid-career professionals suggests a strong technical foundation for CE implementation, though limited input

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from younger professionals may restrict exposure to innovative, tech-driven solutions. Organizational diversity enhances the study's comprehensiveness, capturing views from across the construction value chain. High representation from construction firms ensures the insights of primary waste generators are reflected, while the inclusion of government agencies offers crucial perspectives on policy and regulation. Together, these factors support the development of holistic, system-wide CE strategies for the industry.

3.2 The Challenges of Implementing Circular Economy Practices in Construction Waste Management

To identify the challenges of implementing circular economy (CE) in Abuja's construction industry, factor analysis was conducted on 7 significant variables using principal component analysis (PCA).

TABLE 2: RANKING OF THE CHALLENGES IDENTIFIED

Variable Challenges	SD	MIS	Rank
Client Preference	0.81	4.97	1st
Quality Concerns	0.97	4.91	2nd
Liability Issues	0.83	4.87	3rd
Transport Constraints	0.94	4.85	4th
Storage Limitations	0.81	4.83	5th
Information Gaps	0.99	4.81	6th
Time Constraints	0.83	4.79	7th
Lack of guidelines and manuals for collection and sorting of materials	0.81	4.75	8th
Lack of standards on the quality of secondary materials	0.83	4.72	9th
Infancy of circularity technologies for building construction and demolition waste (BCDW) management	0.97	4.65	10th
Inadequate public awareness of the process and benefits of circularity in building materials	0.95	4.64	11th
Unavailability of BCDW data for prediction	0.97	4.34	12th
Lack of effective knowledge management on circular economy (CE)	0.74	4.21	13th
Lack of clearly defined CE indicators	0.87	4.11	14th
Fragmented attributes of the building and construction industry (BCI)	0.81	4.05	15th
Difficulty in identifying the properties of	0.97	4.03	16th
Suitability BCDW for circularity	0.83	4.01	17th
There exist so many fragments that often times are not well connected	0.94	3.91	18th
Uncertainty of the outcome of changing the construction business model	0.81	3.85	19th
Professionals' low acceptance of CE	0.99	3.83	20th
Doubt in the mind of stakeholders and practitioners on CE	0.83	3.81	21st
Infrastructure and effective process for effective waste management in a CE	0.97	3.75	22nd
Inadequate infrastructure to support BCDW management	0.95	3.73	23rd
Unavailability of construction waste refiners and recovery facilities	0.97	3.71	24th
High cost of CE infrastructure	0.74	3.69	25th
Onerous process of shifting a CE	0.87	3.65	26th
Difficulty in monitoring and tracing waste flow in the BCI	0.81	3.63	27th
Increased pressure on finite resources	0.97	3.61	28th
Financial commitment in the form of cost	0.83	3.55	29th
Unavailability of market for the secondary product	0.94	3.53	30th
Lack of financial and systemic planning for CE	0.81	3.51	31st
High capital and finance for CE development	0.99	3.45	32nd
Lack of demand in the market	0.83	3.44	33rd
Lack of market for CE materials	0.97	3.43	34th
Market mechanisms for product recovery are absent	0.95	3.41	35th
View on quality and uncertainties of supply	0.97	3.39	36th
Linear economy is defective in sustainability attainment and cleaner production of resources	0.74	3.35	37th
Lack of reuse supply chain, and traceability	0.87	3.31	38th
Development of a circular business model (CBM) for BCDW is time consuming	0.81	3.23	39th
Dearth of a complete CBM in BCDW management	0.97	3.21	40th
Inappropriate supply chain in a CE framework or model	0.83	3.20	41st

Note: MIS = mean item score and SD = standard deviation.

The assessment of data appropriateness for factor analysis was conducted through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. In Table 3, the obtained KMO value of 0.768 exceeded the recommended threshold of 0.5, indicating adequate sampling sufficiency for factor extraction. Additionally, Bartlett's test yielded a statistically significant result ($p < 0.001$), confirming that the correlation matrix possessed sufficient variance to warrant factor analysis procedures.

TABLE 3: KMO AND BARTLETT'S TEST FOR CHALLENGES OF CE IMPLEMENTATION

Test	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.768
Bartlett's Test of Sphericity	
Approx. Chi-Square	2847.592
Df	21
Sig.	0.000

Field survey (2025).

The Chi-Square value of 2847.592 with 21 degrees of freedom indicates that the correlation matrix is significantly different from an identity matrix, thus confirming the appropriateness of factor analysis for this dataset. Following the determination of the suitability of the data for FA, FA was thus, conducted and the result is presented in Table 4. The factor analysis test reveals

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three underlying factors as challenges of CE implementation. The results in Table 5 summarize the factor loading on each of the seven extracted factors and their variables. Varimax Rotation with Kaiser Normalization was performed to confirm the adoption of the grouping of the six-component solutions. This is presented in Table 4. The rotated solution in the Varimax Rotation further revealed the presence of simple structure with the three components showing a number of strong loadings indicating that the three components are good for adoption in this study.

TABLE 4: TOTAL VARIANCE EXPLAINED FOR CHALLENGES OF CE IMPLEMENTATION

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.247	46.39	46.39	2.156	30.80	30.80
2	1.398	19.97	66.36	1.847	26.39	57.19
3	1.089	15.56	81.92	1.731	24.73	81.92
4	0.643	9.19	91.11			
5	0.387	5.53	96.64			
6	0.154	2.20	98.84			
7	0.081	1.16	100.00			

Field survey (2025).

The principal component analysis of circular economy implementation challenges revealed 3 distinct dimensional barriers (components). The 3 components are having Eigenvalue greater than 1 (Kaiser's Criterion) that is, considered to be highly significant.in addition, the 3 components also explained enough variance (60% - 80%), making the remaining components less significant. This substantial variance explanation demonstrates that the identified components effectively capture the primary obstacles hindering circular economy adoption. The clear factor structure provides critical understanding to the multifaceted nature of implementation challenges and offers a systematic framework for understanding and addressing barriers to circular economy transition. Therefore, Table 5 presents the three identified challenges; the client/quality challenges as primary implementation barrier, logistics Infrastructure as critical operational barrier and knowledge/Time constraints as capacity barriers. This is similar to the study of Stahel (2022) on adoption of circular economy principles for waste reduction in construction projects.

TABLE 5: ROTATED COMPONENT MATRIX FOR CHALLENGES OF CE IMPLEMENTATION

Challenge Variable	Component 1	Component 2	Component 3	Communalities
Client Preference	0.876	0.142	0.087	0.794
Quality Concerns	0.847	0.213	0.116	0.778
Liability Issues	0.623	0.574	0.182	0.746
Transport Constraints	0.084	0.908	0.061	0.834
Storage Limitations	0.129	0.831	0.113	0.724
Information Gaps	0.074	0.118	0.869	0.774
Time Constraints	0.107	0.254	0.758	0.650

Field survey (2025).

The PCA identified Client/Quality Concerns as the dominant barrier to circular economy (CE) adoption, with high loadings on Client Preference (0.88) and Quality Concerns (0.85). This reflects the centrality of market acceptance and perceived product quality in shaping CE outcomes. Consistent with Rizos et al. (2017), stakeholder resistance, particularly consumer hesitation toward recycled or refurbished products, emerges as a critical impediment. Deep-rooted preferences for new products are often tied to status, perceived reliability, and cultural norms (Kirchherr et al., 2018). Similarly, quality concerns may stem from both actual performance inconsistencies and limited user familiarity with CE products (Lieder & Rashid, 2016). The close relationship between preference and quality perceptions suggests these factors are mutually reinforcing. Addressing them requires integrated strategies that combine product quality assurance, transparency, and targeted consumer education campaigns to shift behavioral norms and build trust in CE offerings. The Logistics component emerged as a key challenge in circular economy (CE) implementation, characterized by strong loadings on Transport (0.91) and Storage (0.83). These findings reflect the central role of physical infrastructure in enabling material flow within circular systems. Unlike linear models, CE requires sophisticated reverse logistics networks for collecting, transporting, and redistributing diverse material streams (Genovese et al., 2017; Lieder & Rashid, 2016). The high loading for transport highlights how inadequate transportation infrastructure complicates material movement, creating bottlenecks in reuse and recycling processes. Likewise, storage infrastructure is critical for sorting and holding materials until reuse opportunities emerge (Akinade et al., 2020). The joint prominence of transport and storage indicates that CE logistics barriers are both mobile and stationary. Addressing these requires coordinated policy efforts and investment in logistics infrastructure, as well as enabling frameworks that support efficient material recovery and flow. The Knowledge component, defined by high loadings on Information Gaps (0.87) and Time Constraints (0.76), highlights the human capital and operational challenges impeding circular economy (CE) adoption. Information Gaps reflect a lack of technical

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know-how, market intelligence, and regulatory awareness necessary for implementing CE strategies (Lieder & Rashid, 2016; Kirchherr et al., 2018). This deficiency restricts the ability of stakeholders to identify opportunities, assess risks, and comply with policy frameworks. Time Constraints further limit CE progress by restricting opportunities for training, system development, and collaboration (Rizos et al., 2017). Their strong association suggests that knowledge-building efforts are hindered by insufficient time allocation. Addressing this barrier requires targeted capacity-building interventions, including professional education, stakeholder training, and knowledge-sharing platforms, to equip industry actors with the tools needed for systemic CE transformation (Adu-Duodu et al., 2025; Stahel, 2022). The relatively distinct factor structure, with primary loadings above 0.76 and secondary loadings typically below 0.25, indicates that these challenge dimensions are largely independent, requiring different intervention strategies. However, the Liability challenge's moderate loadings across Client/Quality (0.62) and Logistics (0.57) components suggests its cross-cutting nature as a barrier spanning multiple implementation dimensions. This finding indicates that liability concerns affect both market acceptance (through quality assurance requirements) and operational systems (through logistics insurance and risk management needs). The cross-component nature of liability challenges suggests that comprehensive risk management frameworks are necessary for circular economy implementation across all dimensions.

4. CONCLUSION

This study investigated the challenges for implementing Circular Economy principles for waste management in Nigerian construction industry, with a specific focus on Abuja construction firms. The empirical findings presented in the paper are based on extensive quantitative analysis including Relative Importance Index (RII) and Principal Component Analysis (PCA), offer important insights into the state of challenges of CE adoption for waste mitigation in Nigerian built environment. The PCA conducted distilled CE adoption challenges into three dominant themes which are client/quality challenge (primary barrier), logistics infrastructure (a critical operational barrier) and knowledge /time constraints (capacity barriers). Overall, the study concluded that the most significant impediments stemmed from consumer resistance to non-virgin products, perceptions of inferior quality, and logistical constraints relating to storage and transportation. Based on this conclusion, the study recommends that logistics Infrastructure as critical operational barrier must be addressed to facilitate broader CE adoption in Nigerian construction industry.

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