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RETHINKING NIGERIA'S CONSTRUCTION PRACTICES: SUSTAINABLE MATERIALS AND THE CIRCULAR ECONOMY AS INNOVATION DRIVERS

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Abstract

Nigeria's construction sector stands at a pivotal moment, challenged to meet the rapid urbanization infrastructure demands while reducing its ecological footprint. This study examines how sustainable materials and circular economy principles can serve as innovation drivers in rethinking construction practices. Conventional methods, which rely on energy-intensive and non-renewable resources, are identified as major contributors to carbon emissions, construction waste, and unsustainable land use. This study evaluates both local innovations and global best practices, focusing on the potential of eco-friendly alternatives such as CSEBs, bamboo, recycled concrete aggregates, and industrial by-products such as fly ash. It also assesses circular economy strategies, including design for disassembly, material reuse, and waste valorization for their capacity to reduce environmental impacts, stimulate local economies, and create green employment opportunities. Drawing on case studies from emerging sustainable construction projects in Nigeria, complemented by comparative insights from other developing contexts, the analysis reveals significant opportunities and persistent barriers. Findings indicate that while sustainable material adoption and circular practices are technically viable, their diffusion is constrained by policy gaps, weak institutional support, limited technological expertise, and market resistance. The paper concludes by proposing strategic measures to integrate circular principles into national building codes, incentivize green construction practices, and foster research into context-specific sustainable materials. By embedding innovation within a sustainability and circular economy framework, Nigeria can redefine its construction paradigm advancing growth-oriented infrastructure delivery that is also resilient, efficient, and environmentally responsible.

Introduction

Nigeria, Africa's most populous nation, is experiencing unprecedented urban expansion driven by population growth, urban-in-migration, and increasing shelter and infrastructure demands. Urban centers such as Lagos, Abuja, and Port Harcourt are rapidly transforming, yet much of this growth is occurring with limited consideration for environmental sustainability or long-term resource management. The construction sector is at the heart of this

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transformation. It contributes significantly to national GDP and employment but is also one of the most resource-intensive and environmentally impactful industries. Traditional construction practices in Nigeria often rely on high-emission materials, such as cement, steel, and fired bricks, and are largely linear in nature-materials are extracted, used, and discarded with little attention to waste recovery or reuse. This model contributes to deforestation, air and water pollution, excessive energy use, and growing C&D waste in urban areas. Simultaneously, Nigeria faces acute challenges such as climate change, inadequate housing, energy scarcity, and poor waste management issues that are further intensified by unsustainable construction practices. Construction innovation, particularly the adoption of sustainable materials and circular economy principles, offers a transformative solution in this context. The circular economy promotes a regenerative approach, encouraging the reuse, recycling, and reintegration of materials into production cycles, thereby reducing environmental impact while unlocking economic and social benefits. When applied to construction, it supports the development of buildings and infrastructure that are not only efficient and cost-effective but also resilient and future-proof.

This study situates construction innovation within the broader goals of SUD in Nigeria. By examining practical pathways for integrating sustainable materials and circular practices, this study aims to demonstrate how Nigeria can reduce its built environment's ecological footprint while improving infrastructure quality, affordability, and inclusiveness.

Literature Review

This review synthesizes existing literature across academic publications, policy documents, technical reports, and industry studies to establish a foundational understanding of sustainable construction and circular economy principles within the Nigerian context. Key sources include authoritative organizations such as UN-Habitat, the World Bank, IFC, and the Nigerian Building and Road Research Institute (NBRRI), as well as peer-reviewed journals focusing on construction and environmental sustainability.

Overview of Nigeria's Construction Sector

Nigeria's construction industry is a significant contributor to the national economy, accounting for approximately 3%–4% of the gross domestic product (GDP) and employing over seven million people in both formal and informal sectors (NBS, 2021). Urbanization is rapidly increasing, with projections indicating that by 2050, over 60% of the population will reside in urban areas by 2050 (UN DESA, 2018). This growth intensifies the demand for housing, infrastructure, and urban services, posing challenges and opportunities for sustainable development. Despite its importance, the sector predominantly uses traditional linear construction methods that rely heavily on resource- and carbon-intensive materials such as cement, steel, and sand. Globally, cement production contributes approximately 8% to carbon emissions (IEA, 2020), with Nigeria being one of the largest producers in sub-Saharan Africa (Dania et al., 2022). Inadequate C&DW management intensifies environmental degradation, contributing to land pollution and urban health risks (Akinyemi et al., 2021). The prevailing "take-make-dispose" mindset reflects a minimal integration of circular economy principles, with scarce post-construction recycling or reuse efforts.

Challenges in Conventional Construction Practices

Several systemic and operational challenges undermine sustainability and innovation efforts within Nigeria's construction industry:

Overreliance on Resource-Intensive Materials: The sector's dependence on cement, steel, sand, and fired bricks results in high embodied energy and carbon emissions. Uncontrolled sand mining further harms ecosystems and agricultural lands (Dania et al., 2022). The lack of affordable and scalable alternatives hampers shifts toward sustainable materials.

High Construction Costs and Material Inaccessibility: Inflation, currency volatility, and transportation costs have escalated the prices of building materials, limiting access, particularly among low- and middle-income populations, thereby worsening the housing deficit (UN-Habitat, 2021). Imported materials intensify cost challenges, and local alternatives remain underdeveloped.

Weak Policy Enforcement and Regulatory Oversight: Nigeria has a National Building Code (2006) and related policies aimed at enhancing construction standards. However, corruption, weak institutional capacity, and overlapping agency mandates have resulted in inconsistent enforcement. Non-compliance particularly affects informal settlements and peri-urban areas (Afolabi et al., 2020).

Inefficient Design and Energy Use: Most buildings lack climate-responsive features, such as passive ventilation, solar orientation, and thermal insulation, and are increasingly dependent on energy-intensive cooling and lighting solutions, often powered by polluting diesel generators (Olotuah & Bobadoye, 2009). This inefficiency escalates operational costs and environmental impacts.

Limited R&D Support: Investment in R&D for alternative materials, green construction technologies, and sustainable design remains insufficient. A gap persists between academic research outputs, industry practices, and policy frameworks, impeding the scaling of innovative, locally appropriate solutions (Afolabi et al., 2020).

Dominance of Informal Construction: Informal builders often lack technical expertise, operate outside regulatory frameworks, and use low-quality materials, leading to substandard and unsafe structures (Adegun & Adedeji, 2017). This informal sector significantly influences the built environment's overall resilience and sustainability.

Lack of Awareness and Cultural Resistance: Developers, contractors, and end-users have limited understanding and acceptance of the benefits of sustainable materials and circular construction approaches. Conventional materials, such as cement blocks and steel, enjoy cultural preference, whereas sustainable alternatives, such as bamboo or stabilized earth blocks, are often perceived as inferior or temporary solutions (Olotuah & Bobadoye, 2009).

Policy and the regulatory landscape

A critical review of national and state-level policy frameworks, including the National Building Code and the National Urban Development Policy, reveals an intention to promote sustainable construction through green building initiatives. Nevertheless, gaps in policy enforcement, institutional fragmentation, and limited innovation incentives constrain the realization of these objectives.

Emerging Practices and Case Study Insights

Case studies from Nigerian metropolitan areas, such as Lagos, Abuja, and Port Harcourt, demonstrate the nascent adoption of sustainable materials and circular construction techniques. Comparative analyses between Nigerian cities and international examples from sub-Saharan Africa and Asia highlight transferable strategies and lessons that could advance the local adoption of CEC principles within construction.

Stakeholder Perspectives

Desk-based analysis of reports and professional statements from architects, urban planners, construction practitioners, and government agencies underscore the practical challenges faced, including material selection dilemmas, barriers to innovation adoption, and regulatory compliance issues.

Analytical Framework

Synthesizing these findings through a sustainability-focused analytical lens entails evaluating environmental impacts, economic feasibility, social inclusion, and policy alignment. This integrated perspective is crucial for guiding Nigeria's construction sector toward resilience, resource efficiency, and alignment with global sustainable development goals.

Methodology

This study employs a qualitative, exploratory approach based on a comprehensive review of secondary data. Our methodology includes the following:

Literature Review: This study reviews academic papers, policy documents, and reports from international organizations to establish a theoretical foundation.

Case Study Analysis: Pilot projects and emerging practices in Nigerian cities are analyzed to illustrate practical applications and challenges.

Policy and Regulatory Review: Examining national and state-level frameworks to identify gaps and opportunities.

RESULT

Sustainable materials: A local solution

The use of sustainable materials is a powerful way to reduce buildings' environmental footprint. These materials are often locally sourced, cost effective, and provide unique benefits.

Compressed Stabilized Earth Blocks

CSEBs represent a sustainable alternative to fired bricks and traditional concrete blocks, primarily due to their ability to incorporate locally sourced soil stabilized with small quantities of cement or lime, subsequently compressed under mechanical pressure. This process results in blocks with substantial thermal mass, which is ideal for reducing the energy demand for cooling in Nigeria's tropical climate (NBRRI, 2019). Pilot projects conducted by the Nigerian Building and Road Research Institute (NBRRI) in Kaduna and Abuja have confirmed that CSEBs are cost-efficient options for affordable housing, demonstrating reductions in both construction expenses and lifecycle energy use (NBRRI, 2020). However, rural regions face challenges, including limited accessibility to mechanical pressing technology, which limits its widespread adoption and production scalability (Adegun & Adedeji, 2017).

Bamboo

Bamboo's rapid maturation rate and exceptional tensile strength underscore its ecological benefits, making it a versatile building material for structural components such as frames, scaffolds, roofing, and flooring (Olotuah & Bobadoye, 2009). While bamboo is abundant in southern Nigeria, its utilization remains limited due to the absence of nationally recognized building standards, the need for preservation treatments to enhance durability, and prevailing cultural biases that associate bamboo with impermanence and low status (Afolabi et al., 2020). Notwithstanding these limitations, targeted interventions by NGOs within Cross River State have demonstrated bamboo's feasibility for sustainable, low-cost housing and eco-friendly educational facilities, reinforcing the need for formal guidelines and preservation protocols to enable broader acceptance (Cross River NGO Reports, 2022).

Agricultural and Industrial Byproducts

The use of industrial byproducts such as fly ash, rice husk ash, and ground granulated blast furnace slag (GGBS) as partial substitutes for Portland cement serves a dual purpose of reducing greenhouse gas emissions and enhancing concrete performance characteristics such as durability and resistance to chemical attack (IEA, 2020; Dania et al., 2022). Despite the environmental benefits, the adoption rate of these supplementary materials is hindered by challenges such as inconsistent material quality, inadequate local processing and supply infrastructure, and limited awareness within the construction community (Akinyemi et al., 2021).

Recycled concrete aggregates (RCA)

The reuse of construction and demolition waste as recycled concrete aggregates helps conserve natural aggregate sources and reduces the volume of landfill waste (UN-Habitat, 2021). However, fluctuating supply quality, a lack of formalized quality control standards, and resistance due to conservative engineering practices limit the full integration of RCA into new concrete production processes (IFC, 2020). Establishing stringent quality assurance frameworks is essential for mainstreaming RCA within Nigeria's construction market.

Timber from certified sources

Timber obtained from sustainably managed plantations is a renewable and energy-efficient building material that is particularly suitable for low-rise construction. Its lightweight nature contributes favorably to thermal insulation properties, improving building energy efficiency (World Bank, 2022). However, deforestation risks associated with improper logging practices, insufficient regulatory enforcement, and vulnerabilities to pests and fire necessitate robust treatment protocols and institutional oversight (Afolabi et al., 2019).

Plastic waste and recycled materials

Emerging Nigerian entrepreneurs are converting plastic waste into construction products, including paving blocks, tiles, and furniture. This innovation addresses the dual challenges of urban plastic pollution and affordable building materials while providing durable alternatives (Lagos State Environmental Report, 2023). Pilot projects implemented in Lagos and Ibadan showcase the viability of recycled plastic bricks for pedestrian walkways and shelters. However, a wider adoption requires formal incorporation into national building standards and enhanced public trust through demonstrated product reliability (Environmental NGOs, 2023).

Circular Economy Principles in the Nigerian Construction Industry

Core Principles

Circular construction advocates for a paradigm shift toward sustainable material lifecycle management by emphasizing designs that maximize material longevity, modularity, and adaptability, thereby reducing the extraction of raw materials (Ellen MacArthur Foundation, 2021). It prioritizes the reuse of existing building components and the effective recycling of construction and demolition waste into usable materials, thus fostering the circularity of resources. The deployment of digital technologies, particularly BIM, facilitates precise material quantification and waste control during construction phases (World Green Building Council, 2022). Circularity involves the implementation of closed-loop systems where materials, such as crushed concrete, are reintegrated into infrastructure layers. Although nascent in Nigeria, innovative business models, such as product-as-a-service (PaaS), can extend material utility through shared ownership and incentivized maintenance (IFC, 2020).

Relevance and Opportunities

Nigerian construction activities are estimated to result in material wastage levels between 30% and 40%, primarily due to poor site management and procurement practices (NBS, 2021). Circular economy applications offer tangible prospects for reducing these inefficiencies and addressing the critical infrastructure demand linked to urban population growth (UN DESA, 2018). This need is accentuated in metropolitan centers such as Lagos, which generates over 13,000 tons of municipal waste daily, with a significant share originating from building and demolition processes (Lagos Waste Management Authority, 2023). The adoption of circular construction also fosters job creation in emerging sectors, such as materials reclamation, recycling, and green manufacturing, advancing inclusive economic development goals (World Bank, 2022).

Barriers to adoption

Despite substantial benefits, several critical barriers impede the uptake of circular economy practices in Nigeria. These include the absence of cohesive regulatory frameworks and circular construction-specific incentives, which discourage investor engagement. The predominance of informal construction operators further complicates the enforcement and dissemination of circular principles. Additionally, widespread knowledge and skills deficits among professionals and tradespeople limit effective implementation. Infrastructure shortages, especially the inadequate availability of material recovery and recycling facilities outside major urban areas, restrict the scalability of circular construction solutions (Afolabi et al., 2020; UN-Habitat, 2021).

Policy and Institutional Recommendations

A coordinated multi-stakeholder approach is needed to effectively mainstream sustainable construction and circular economy practices within Nigeria, encompassing the following strategic actions:

Building Code Reform: Comprehensive revisions of Nigeria's National Building Code should incorporate explicit circular economy requirements, including material reuse, lifecycle assessment criteria, and standards for sustainable building materials (NBRRI, 2020).

Economic Incentives: Establishing fiscal incentives such as tax deductions, low-interest financing options, and grants targeted at green construction projects can incentivize the adoption of sustainable alternatives (World Bank, 2022).

Training and Capacity Building: Implementing structured training initiatives aimed at both formal and informal sector participants will bridge existing skill gaps, increase awareness of circular design methodologies, and promote best practices in sustainable material usage (Afolabi et al., 2020).

Public-Private Partnerships: Collaboration between government agencies, private sector entities, and civil society organizations can facilitate the development of recycling infrastructure, material recovery centers, and pilot demonstration projects, facilitating knowledge transfer and practical innovation (International Federation of Civil Engineers, 2020).

Public Awareness Campaigns: National and local campaigns that promote cultural acceptance and understanding of the environmental and economic benefits of sustainable materials and circular construction are essential for fostering market demand and stakeholder buy-in (Olotuah & Bobadoye, 2009).

Conclusion:

Nigeria can transform its construction sector into a driver of economic growth, environmental stewardship, and social inclusion by integrating sustainable materials and circular economy principles. This shift promises resilient, efficient, affordable, and environmentally responsible infrastructure, thereby supporting Nigeria's urbanization and sustainable development goals.

Recommendations

A coordinated effort across government, industry, and academia is required to accelerate this vital transition.

Enact Policy and Regulatory Reforms: The government should update the National Building Code to include mandatory standards for sustainable materials and C&D waste management. Tax breaks and subsidies should be provided to developers who use certified green materials and circular practices.

Invest in Infrastructure: Public-private partnerships (ppp) are needed to establish large-scale material recovery and recycling facilities, especially in major urban centers. Formalizing the supply chain for recycled materials will build trust and ensure consistent quality.

Prioritize education and capacity building: Integrate sustainable and circular construction principles into university curricula and professional training programs. This will equip the next generation of engineers, architects, and builders with the knowledge and skills needed for a greener industry.

Promote research and development: Increase funding for research into locally sourced, sustainable materials and building technologies. Create platforms for knowledge sharing and showcase successful pilot projects to build public trust and demonstrate viability.

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