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Innovative Approaches to Sustainable Building Practices in Nigeria: Advancing Green Construction Through Local Materials and Technological Integration: A Case Study of Abuja Municipal Area Council (AMAC)

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Abstract: Nigeria needs to rethink how its cities grow by adopting building methods that are both eco-friendly and affordable. This review looks closely at how sustainable construction is being used in the Abuja Municipal Area Council (AMAC). It focuses on the combining local materials with modern technology to create smarter and greener buildings. Through the use of real-life examples, research studies, and government policies from Nigeria, the paper examines how green building methods can help reduce harm to the environment, reduce construction costs, and save energy. It also discusses the benefits and challenges of using these methods. Furthermore, the study adds to global conversations by showing how local creativity and the smart use of technology can help improve sustainable building in growing countries like Nigeria.

Keywords: Sustainable Building, Green Construction, Local Materials, Nigeria, Technological Integration

I. Introduction

Sustainable construction is gradually gaining attention in Nigeria, but it is still faced with a lot of challenges. These include poor enforcement of building policies, limited public understanding, high cost of start-up, and a lack of skilled professionals (Onyegiri *et al.*, 2016). Despite these setbacks, a lot of persons are beginning to see the value of using local materials like laterite, bamboo, stones, and compressed earth blocks to build homes that are both affordable and environmentally friendly (Ezeokoli *et al.*, 2015). When combined with modern tools such as prefabricated building systems, solar panels, and digital design methods like Building Information Modelling (BIM), these local materials can help create a more sustainable, practical solutions.

For instance, cities like Abuja are rapidly expanding, and this puts a lot of pressure on the environment and infrastructure (Adelekan, 2010). however, sustainable construction offers a way to lessen these problems, while also promoting economic savings, environmental care, and inclusive development. Furthermore, around the world, green building practices focus on reducing pollution, using clean energy, and making sure buildings are more efficient throughout their lifespan (Kibert, 2016). But in Nigeria, moving towards these practices has been slow due to financial, technical, and unfavourable policy issues.

Hence, with global concerns about climate change, pollution, and shrinking natural resources, the demand for sustainable buildings is rising. Buildings alone account for 36% of global energy use and nearly 39% of CO_2 emissions (IEA, 2022). As cities in developing countries grow, it is important to adopt building methods that reduce harm to the environment, while still meeting people's basic needs.

Background

Nigeria's construction industry is growing rapidly, due to increasing populations, urban expansion, and a high demand for housing. It is hoped that by 2050, the country's population will go beyond 400 million. Major cities like Abuja, Lagos, and Port Harcourt are seeing a huge rise in urban development (NPC, 2020). However, Abuja's Municipal Area Council (AMAC), the heart of the capital region, has changed significantly in the last 20 years, and most recently due to the transformative leadership of the current FCT Minister Nyesom Wike. But this fast growth has often ignored environmental concerns. Problems like poor waste disposal, deforestation, pollution, and heavy use of non-renewable materials are becoming more prevalent (Ede *et al.*, 2021).

According to Kibert, 2016; Edwards, 2002, green construction aims to solve these problems by using energy-saving methods, reducing waste, and improving the health and comfort of building occupants. It promotes the use of eco-friendly materials, smart energy systems, and designs that fit the local climate, culture, and economy. In Nigeria, and most especially in AMAC, sustainable building is not just about following global trends; it is a practical way to deal with the housing crisis, power shortages, and climate risks.

Therefore, this review paper looks at sustainable construction practices in Nigeria using AMAC as a case study. It reveals how local materials like bamboo and compressed earth blocks are being combined with modern technologies such as solar power, prefabrication, and BIM. It also examines relevant policies and the challenges that affect how well these solutions are being implemented.

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Sustainable Building: Global and Nigerian Context

Sustainable construction is the creation and responsible management of a healthy built environment based on resource-efficient and ecological principles (Edwards, 2002). It entails materials, technologies, design practices, and policies that minimize environmental damage while maximizing long-term benefits.

However, in Nigeria, sustainable building movement is still in its growing stage. While there are growing initiatives, such as the Nigerian Building Code and the Green Building Council of Nigeria (GBCN), awareness and practical implementation remain limited (Onyegiri *et al.,* 2016).

Drivers of Sustainable Building in Nigeria

Urban Growth and Population Increase:
Abuja is growing fast, and this is putting a lot of pressure on roads, housing, and other infrastructure. Because of this, there is an urgent need to build in ways that are more sustainable (NPC, 2020).

Climate and Environment Issues:
People are becoming aware that Nigeria is faced with potential risk from climate change. This has led to more interest in building homes and structures that are better for the environment.

Energy Problems:
With ongoing power supply issues in Nigeria, it is more important than ever to build energy-efficient buildings that use less electricity (Oladokun and Aigbavboa, 2018).

Sustainable Building Around the World

Sustainable or "green" building means designing and constructing homes and structures in a way that is better for the environment, saves energy, and creates healthier spaces for people. It focuses on using fewer resources, improving indoor air quality, and making buildings adaptable to future needs (Kibert, 2016; Ding, 2008).

The idea of building sustainably gained global attention after the 1992 Earth Summit in "Rio de Janeiro". Since then, many systems have been created to guide green building, like LEED in the United States (USA), BREEAM in the United Kingdom (UK), and the WELL Building Standard, which focuses on people's health and well-being.

Moreso, green buildings help the planet by reducing energy use and pollution, but they also make financial sense. According to the World Green Building Council (2021), these buildings can reduce running costs by up to 20%, improve quality of indoor air, and give more value to properties. For instance, in fast-growing cities, they also help in reducing heat and make communities more resilient to climate change (Pérez-Lombard *et al.,* 2008).

Technology is playing a big role too. Tools like smart systems, solar design, and prefabricated parts are making buildings more efficient and eco-friendly (Azhar, 2011). These sustainable building practices also support United Nations Sustainable Development Goals (SDGs), including SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action), thus; making cities safer and fighting climate change.

Sustainable Building in Nigeria

Nigeria is growing fast, with more people expected to live in cities by 2030 (UN-Habitat, 2022). This puts a lot of pressure on housing and infrastructure. However, the building industry makes up over 4% of the country's economy, hence; making it more sustainable is essential, most especially; since Nigeria is faced with housing shortage of over 17 million homes (World Bank, 2019).

Despite the fact that people are becoming more aware of the need to build sustainably, green building is still not common in Nigeria. Challenges include high upfront costs, lack of trained professionals, weak enforcement of rules, and continued use of traditional, high-energy materials like cement and steel (Oluwatobi *et al.,* 2020).

Conversely, progress is being made. The Nigerian Building and Road Research Institute (NBRRI, 2020) has created cheaper, more eco-friendly materials like laterite bricks and interlocking blocks (Ameh and Osegbo, 2011). Government-backed projects, such as the Energy Efficient Model House in Abuja, show what is obtainable.

Also, the Green Building Council Nigeria (GBCN) and universities are also helping by promoting sustainable design and policies (GBCN, 2021). In Abuja, the city's planning authority; the Federal Capital Development Authority (FCDA) has introduced new building codes to encourage climate-friendly designs. However, enforcement remains a challenge due to limited resources and corruption (Adebayo and Agunbiade, 2021).

Furthermore, Nigeria is gradually moving in the right direction. To speed things up, the country needs to focus more on using local materials, adopt new technologies, enforce building standards, and educate everyone involved, from builders to homeowners; about the benefits of sustainable construction.

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Local Materials in Sustainable Building in AMAC

The utilization of local materials in construction is the foundation of sustainable development, especially in rapidly urbanizing regions such as the Abuja Municipal Area Council (AMAC). Local materials offer a lot of advantages, including reduced transportation costs, lower embodied energy, job creation for local communities, and cultural relevance in architectural design (Olotuah and Adesiji, 2005).

In the context of AMAC, where the built environment is rapidly expanding to meet housing demands, the integration of indigenous materials has emerged as a cost-effective and environmentally responsible way to conventional building products. Furthermore, the availability of lateritic soils, timber, bamboo, and a booming informal recycling economy offers a great opportunity to fix sustainability within construction practices.

Compressed Stabilized Earth Blocks (CSEBs)

Compressed Stabilized Earth Blocks (CSEBs), are one of the most promising sustainable building materials currently gaining traction in AMAC. They are produced by mixing local laterite soil with a stabilizer, typically cement or lime and compressing the mixture using either manual or mechanical presses. The resulting blocks are sun-dried rather than kiln-fired, significantly reducing their embodied energy (Ezeokoli *et al.*, 2015).

Moreso, CSEBs offer several technical and environmental advantages. Their high thermal mass helps regulate indoor temperatures, reducing the need for artificial cooling and thereby lowering energy consumption in residential buildings (Akinmade et al., 2020). Furthermore, their modular shape allows for accuracy in construction, leading to reduced waste and more efficient labor use. In terms of cost, CSEBs are considerably cheaper than conventional fired bricks or concrete blocks, especially when produced on-site with locally sourced materials (NBRRI, 2020).

In AMAC, CSEBs have been adopted in a number of pilot low-cost housing projects, including initiatives by non-governmental organizations and the Federal Ministry of Housing. These projects have demonstrated that, beyond sustainability, CSEBs can meet structural performance requirements when properly produced and cured (Ede *et al.*, 2021). However, widespread adoption is still limited due to lack of awareness, inadequate technical skills among local builders, and limited access to appropriate compaction equipment.

Bamboo and Timber

Bamboo and sustainably harvested timber are renewable, fast-growing materials with significant potential in green construction. In the peri-urban and rural areas of AMAC such as Karu, Orozo, and Garki villages, bamboo is increasingly used for scaffolding, roofing frames, interior partitioning, and even flooring systems. However, treated bamboo is lightweight yet strong, resistant to earthquake vibrations, and capable of being integrated into hybrid structures alongside steel and concrete (Janssen, 2000; Ogunbiyi and Adebayo, 2017).

Timber, obtained from eucalyptus and gmelina species, is also widely available in AMAC, and used in roofing, doors, window frames, and flooring. When properly treated against termite infestation and moisture degradation, timber provides a warm aesthetic and a renewable alternative to metal or PVC-based building components. In addition, the use of laminated bamboo or engineered timber can significantly improve mechanical performance, enabling their use in multi-storey green buildings (Lippke *et al.*, 2004).

Despite these important benefits, concerns around deforestation and unsustainable logging practices have limited timber's green credentials in Nigeria. To address this, government bodies and conservation NGOs have been advocating for the use of fast-growing species and encouraging community-based bamboo plantations for sustainable harvesting (Ogunsemi *et al.*, 2021).

Recycled and Reclaimed Materials

In a region marked by socio-economic inequality and housing shortages, recycled and reclaimed materials are widely being incorporated into low-cost and informal housing developments within AMAC. These materials include salvaged timber, discarded metal roofing sheets, broken concrete slabs, and used glass panels, all of which are used to create structurally sound and affordable shelters.

Consequently, recycled concrete, is being utilized for sub-structure works and paving applications. Its production from demolition waste help to reduce landfill loads and conserve natural aggregates. According to Ajayi *et al.*, (2017), recycled aggregates, when properly processed, can achieve up to 80% of the compressive strength of virgin concrete, making them suitable for non-load-bearing walls and foundation works.

However, informal recycling activities in AMAC markets, such as the Gosa dump site and Mpape quarry area, support a small-scale, but impactful circular economy. Notably, here; artisans and small contractors recover, clean, and resell reusable construction components. These practices does not only lower construction costs, but also contribute to waste reduction and environmental sustainability (Nzeadibe and Anyadike, 2012).

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Nevertheless, the lack of formal regulation and standards for recycled materials poses quality control challenges. Hence, there is a pressing need for policy frameworks, public-private partnerships, and capacity-building initiatives to standardize and scale up the use of recycled building materials across AMAC and beyond.

Technology and Sustainable Building in AMAC

In fast-growing areas like Abuja Municipal Area Council (AMAC), technology plays an important role in helping buildings become more environmentally friendly. With more people moving in and more houses being built, it is important to use methods that save energy, reduce waste, and are cost-effective. However, new technologies like prefabricated buildings, solar energy, smart design, and digital tools like Building Information Modelling (BIM) are making construction smarter and greener in Nigeria (Oladokun and Aigbavboa, 2018).

Prefabricated and Modular Buildings

Prefabrication means making parts of a building including walls and roofs in a factory and putting them together at the building site. This process reduces waste, speeds up construction, and improves the quality of the work (Lawson *et al.*, 2014). It also makes it easier to reuse materials and save energy during the building process.

For instance, in AMAC, companies like Urban Shelter, Cosgrove, and Brains and Hammers are using this method in places like Lugbe and Gwarinpa. They use pre-made wall panels and roof parts to build faster and better. These techniques are even being used to build temporary homes and emergency shelters quickly and efficiently. This supports the global goal of building sustainable cities (United Nations, 2015).

However, using prefabrication widely in AMAC is still a challenge because of the high upfront costs, lack of skilled workers, and limited awareness. More training and support are needed to help more builders adopt it (Ameh and Omisore, 2013).

Solar Energy and Smart Building Design

Saving energy is a big part of sustainable building. In AMAC, this is being done through solar energy and smart building design. However, Nigeria has lots of sunlight; about 5.5 kilowatt-hours per square meter each day, so using solar panels is a smart way to reduce dependence on unreliable power from the grid (Akinyele and Rayudu, 2014).

Conversly, many homes and government buildings now have adopted solar panels, inverters, and batteries. Some estates developed by APDC (Abuja Property Development Company) have added solar water heaters and solar-powered streetlights respectively. Therefore, passive design techniques also help. These include things like placing windows where they catch cool breezes (cross-ventilation), adding shade to windows, using insulation, and positioning buildings to avoid direct sun.

In places like Jabi, Asokoro, and Wuse, buildings are being designed with features like wide verandas and trees for shade, which help keep them cool naturally (Ogbonna and Harris, 2008). Some builders are even bringing back traditional methods like using courtyards and earth tunnels to keep homes comfortable. These techniques does not only lower energy bills, but also improve air quality indoors, most especially helpful in a place where electricity can be unstable (Okonkwo *et al.*, 2020).

Building Information Modelling (BIM)

Building Information Modelling, or BIM, is a digital tool that helps architects and engineers plan and manage buildings using a 3D computer model. It allows everyone involved in a project to work together easily, avoid mistakes, and make sustainable decisions (Azhar, 2011).

Though it is not yet widely used in Nigeria, BIM is slowly catching on in large projects, especially those funded through partnerships between the government and private companies. For example, according to Olawumi and Chan, (2018), some hospitals, office buildings, and smart estates in areas like Maitama and Guzape are already using BIM to design and coordinate construction.

Moreso, BIM helps reduce waste, accurately calculate materials, and test energy efficiency before building starts. Programs like Revit and ArchiCAD allows users simulate things like sunlight, temperature, and airflow to design better, more energy-efficient buildings.

Although BIM has not been fully embraced in AMAC yet because the software is expensive, training is limited, and many builders are used to traditional methods. Hence, to speed things up, the government could require BIM use in public projects and support training programs in schools and universities (Edirisinghe and London, 2015).

Challenges of Green Building in Nigeria

Even though more people are beginning to understand how important green building is for a cleaner, healthier future, putting these ideas into practice in Nigeria especially in places like Abuja Municipal Area Council (AMAC) is still very difficult. However, there are many issues, including poor policies, high costs, lack of skilled workers, and low public awareness, that make it hard to build in a sustainable way, even as the country deals with climate change, overcrowded cities, energy problems, and a big housing shortage (Oyedele *et al.*, 2014).

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Weak Policies and Poor Regulation

One major problem is that Nigeria does not have strong or up-to-date building laws that focus on sustainability. While there are building standards from agencies like the Nigerian Building and Road Research Institute (NBRRI), they do not include enough rules about energy-saving or eco-friendly construction (Okonkwo *et al.*, 2020). Hence, there is also no official green building rating system like LEED in the United States or BREEAM in the United Kingdom, so developers do not have a clear roadmap for building green.

Going further, local authorities like the Federal Capital Development Authority (FCDA) also have not made green standards a must-have for getting building permits. Because of this, many developers are not motivated to go green, and investors are hesitant to fund sustainable projects (Daramola and Ibem, 2010). hence, Nigeria urgently needs a nationwide green building code that fits our weather, economy, and culture.

High Costs and Lack of Funding

A lot of people believe green buildings are too expensive, especially because eco-friendly materials, solar panels, and modern designs often cost more at the beginning (Oladokun and Aigbavboa, 2018). But what they do not realize is that green buildings save money in the long run through lower electricity and water bills, fewer repairs, and higher property value.

On top of that, most homeowners and developers in AMAC do not have the money to think long-term. They build what they can afford now, even if it costs more later. There are also no special loans, tax breaks, or green investment programs to help them go sustainable (Adenle *et al.*, 2017). Banks and lenders do not offer better deals for green projects, which makes it even harder to build sustainably.

Not Enough Skilled Professionals

Another challenge is that Nigeria does not have enough experts in green construction. While some schools and training centers teach about sustainable building, there are too few programs, and hands-on training is rare (Olotuah and Adesiji, 2005). Most architects, builders, and engineers still use old building methods that waste energy and harm the environment.

Skilled workers like bricklayers, carpenters, and plumbers often do not know how to use green materials or techniques. For example, many do not know how to make or properly use compressed earth blocks (CSEBs) or design buildings for natural ventilation (Ede *et al.*, 2021). Because of this skill gap, even when a project tries to be green, the results often fall short. Hence, groups like the Nigerian Institute of Building (NIOB) and COREN are working to train more professionals in sustainable methods, but the progress is still slow.

Lack of Awareness and Cultural Beliefs

Many Nigerians simply do not know the benefits of green building. When building a house, people usually think about size, beauty, and price not energy use or environmental impact (Ameh and Omisore, 2013). Because of this, there is still a strong demand for traditional construction methods and materials, even if they are wasteful.

Additionally, cultural attitudes also play a role. For instance, concrete houses with air-conditioning are seen as a sign of success, while homes built with local materials like bamboo or earth blocks are seen as poor or rural; even if they are more sustainable (Nzeadibe and Anyadike, 2012). These beliefs make it hard for people to accept better, greener options.

Hence, to solve this problem, public awareness campaigns are needed to show that green buildings are modern, smart, and valuable. Demonstration projects, media outreach, and awards for eco-friendly buildings could help change minds. Government, NGOs, and the private sector all need to work together to educate people about why green construction matters and how everyone can benefit.

Opportunities and Recommendations

Even though there are many challenges to building in a sustainable way in Nigeria especially in the Abuja Municipal Area Council (AMAC), there are also real opportunities to make progress. With the right policies, education, public involvement, and new ideas, Nigeria can move toward greener and more efficient buildings.

Better Policies and Incentives

A good starting point is to create strong policies that encourage green building. Right now, Nigeria does not have a national standard or green building code like other countries. Hence, the government should create one that suits Nigeria's climate and economy (Oladokun and Aigbavboa, 2018).

However, to encourage developers and homeowners to build green, the government can offer:

- Tax breaks for eco-friendly buildings and renovations.
- Subsidies for solar panels and renewable energy systems.
- Duty-free import of sustainable building materials and technologies.

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The government can also lead by example. For instance, all public buildings could be required to meet green building standards just like Rwanda does with EDGE certification (World Bank, 2020). This can push private builders to follow suit.

To make this work, agencies like the Ministry of Works and Housing, Federal Capital Development Agency (FCDA), and Nigerian Building and Road Research Institute (NBRRI) need clear responsibilities and tools to monitor building projects and include sustainability requirements in their approvals.

Training and Skill Development

A big challenge right now is that there are not enough people trained in green building. But this also means there is a big opportunity to grow a skilled workforce. Hence, we need more training programs, updated school curriculums, and hands-on workshops to teach people how to build sustainably (Ede *et al.,* 2021).

This can be achieved through:

- Starting certification courses in green construction, energy-efficient design, and sustainability planning.
- Updating university courses in architecture and engineering to include sustainability.
- Partnering with global groups like LEED, BREEAM, and Green Building Councils to share knowledge and best practices.

Furthermore, organizations like the Nigerian Institute of Building (NIOB), COREN, and the Nigerian Institute of Architects (NIA) can work with NGOs and development partners to train not just professionals, but also artisans and small contractors who do the bulk of construction work.

Raising Public Awareness

To get more people to embrace green building, we need to change the idea that it is a luxury only for the rich. Public awareness campaigns can help Nigerians see the financial, health, and environmental benefits of sustainable construction (Daramola and Ibem, 2010).

This can be achieved through:

- Broadcasting public service messages about how green buildings save money and protect the environment.
- Organizing green expos, design contests, and public events to showcase eco-friendly ideas.
- Involving community leaders and religious groups to help spread the message.
- Adding green labels to buildings (like energy star ratings) to help people make informed choices.

Hence, mobile phones and social media can play a big role here, especially with Nigeria's young population (Ameh and Omisore, 2013).

Research and Innovation

Moving forward with green building also depends on investing in research and developing ideas that work in Nigeria's unique environment. The country has different climate zones and lots of natural materials that could be used to create low-cost, eco-friendly buildings.

Therefore, areas to focus on include:

- Making better-quality Compressed Stabilized Earth Blocks (CSEBs) for city use.
- Improving fire and insect resistance in bamboo and wood structures.
- Creating smart systems like IoT energy monitors and automatic lighting.
- Designing Life Cycle Assessment (LCA) tools that suit local building styles.

Summarily, partnerships between universities, research centers like NBRRI, and private companies will be key to driving innovation. Nigeria should also try to access international funding and join platforms like the Climate Technology Centre & Network (CTCN) to support homegrown green technologies (Adenle *et al.,* 2017).

II. Conclusion

The adoption of innovative sustainable building practices within the Abuja Municipal Area Council (AMAC) signifies an encouraging shift in Nigeria's urban development trajectory toward environmental sustainability and climate resilience. This review has explored the major role of local materials such as compressed stabilized earth blocks (CSEBs), bamboo, timber, and recycled components in reducing construction-related emissions, enhancing thermal efficiency, and lowering costs.

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Simultaneously, technological integrations such as prefabricated construction, solar power utilization, passive design strategies, and emerging applications of Building Information Modelling (BIM) demonstrate that green innovation is both possible and progressively underway in the Nigerian context.

However, while these initiatives mark notable progress, their long-term viability and scalability remain constrained by a series of systemic challenges. Poor policy framework, inadequate technical expertise, low public awareness, and a persistent misconception of high costs continue to hinder widespread adoption. These issues are not unique to Nigeria; they are common across many developing economies transitioning toward sustainable development models (Adenle *et al.*, 2017; Oladokun and Aigbavboa, 2018).

Hence, addressing these barriers requires a multi-pronged strategy involving policy reform, targeted incentives, capacity building, and a strong culture of research and innovation. Most importantly, this review reveals the need for contextualized and culturally appropriate green building frameworks. Unlike the direct transplantation of foreign models, sustainable practices in AMAC and Nigeria at large, must be grounded in local realities, climatic conditions, socio-economic constraints, and available resources. Tailoring green building strategies in this way enhances their acceptance, cost-effectiveness, and practical implementation.

As global concern over climate change, energy consumption, and urbanization grows, developing countries like Nigeria have a unique opportunity to leapfrog traditional, carbon-intensive building methods in favor of low-impact, resource-efficient alternatives.

Stakeholders including architects, engineers, urban planners, policy makers, educators, and the private sector must collaborate to advance this vision. AMAC's emerging practices can serve not only as a model for other Nigerian cities but also as a regional case study for sustainable urbanization in sub-Saharan Africa.

Conclusively, by aligning local ingenuity with modern technologies and policy support, Nigeria can achieve its sustainable development goals in the built environment, contribute meaningfully to global climate action, and improve the quality of life for its urban populations.

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