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Evaluating the Influence of Green Building Certifications on Construction Practices in Nigeria: A Systematic Review

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Abstract

This research explores the impact of green building certifications—specifically LEED, EDGE, and BREEAM—on construction practices in Nigeria. Through a detailed review of literature published between 2015 and 2023, the study examines the rate of adoption of these certifications, the resulting changes in construction practices, and the associated economic and environmental outcomes. The findings show that while the uptake of green building certifications is gradually increasing, it remains significantly lower than global standards. Certified buildings in Nigeria have demonstrated marked improvements in energy efficiency, water conservation, and waste management, contributing to both environmental sustainability and reduced operational costs. However, several barriers continue to hinder broader adoption, including the high initial investment required for green construction, a lack of adequately trained professionals, and insufficient government policies and incentives to support sustainable building practices. The study highlights the need for enhanced regulatory frameworks that mandate minimum sustainability standards, along with financial incentives such as subsidies and tax breaks to offset the initial costs. Additionally, raising public awareness through education and outreach initiatives is vital for increasing demand for certified buildings. The research further underscores the importance of fostering local industries for sustainable building materials and the critical role of professional training programs in closing the skills gap. Future research should explore the long-term economic benefits of green buildings, investigate the specific barriers impeding their adoption, and conduct comparative studies with other developing nations to provide insights into overcoming these challenges. This study offers key recommendations for policymakers, developers, and industry professionals seeking to promote green building practices in Nigeria, contributing to the global sustainability agenda.

Keywords: Green building certifications, Sustainable construction, LEED, Environmental sustainability

1. Introduction

The construction industry is vital to global economic development but remains one of the largest contributors to environmental degradation. Buildings and construction account for 39% of carbon emissions and 36% of energy consumption globally (Global Alliance for Buildings and Construction, 2020; International Energy Agency [IEA], 2019). These figures underscore the pressing need for sustainability in the built environment. The adoption of sustainable construction practices, which integrate environmental, economic, and social considerations, has emerged as a critical strategy to mitigate climate change and resource depletion (Kibert, 2016; Zuo & Zhao, 2014). These practices are particularly urgent in developing countries, where rapid urbanization often exacerbates inefficiencies in resource utilization and environmental challenges (United Nations Environment Programme [UNEP], 2021).

Green building practices focus on minimizing a building's environmental impact throughout its lifecycle. These practices emphasize energy efficiency, water conservation, waste reduction, and improved indoor air quality (Yudelson, 2016; Berardi, 2013). Frameworks such as Leadership in Energy and Environmental Design

(LEED), Building Research Establishment Environmental Assessment Method (BREEAM), and Comprehensive Assessment System for Built Environment Efficiency (CASBEE) provide standardized tools for evaluating and improving the sustainability of construction projects (USGBC, 2020; BRE, 2018). Evidence from developed countries highlights the benefits of these certifications, including reduced energy consumption, lower carbon emissions, healthier indoor environments, and long-term cost savings (Azhar et al., 2013; Darko et al., 2017). For example, LEED-certified buildings in the United States consume 25% less energy compared to non-certified buildings (Newsham et al., 2009), while BREEAM-certified projects in the United Kingdom report notable reductions in operational energy use and waste generation (BRE, 2018).

While previous studies have explored the global adoption of green building certifications, limited research has examined their application, challenges, and localized impacts in developing countries such as Nigeria. As Africa's largest economy and most populous nation, Nigeria is undergoing rapid urbanization, which has intensified environmental degradation through deforestation, air pollution, and inadequate waste management (Olaniyan et al., 2018; Adedeji et al., 2020). The country's construction sector, heavily reliant on traditional practices, exacerbates these challenges due to high energy demands, unsustainable resource consumption, and limited recycling of construction waste (Agboola & Emmanuel, 2016; Akinola et al., 2020). The adoption of green building certifications in Nigeria remains minimal despite their recognized potential to address these environmental issues.

Efforts to promote sustainability in Nigeria's construction sector have included the introduction of locally tailored green building certifications. Initiatives by organizations such as the Nigerian Green Building Council (NGBC) and the Green Building Nigeria (GBN) program aim to align international standards like LEED and BREEAM with Nigeria's socio-economic and environmental context (Akinola et al., 2020). These certifications seek to enhance energy efficiency, reduce waste, and foster healthier urban environments. However, their implementation faces significant barriers, including high upfront costs, limited awareness, inadequate technical expertise, and weak regulatory frameworks (Adebayo et al., 2021; Darko et al., 2019). Financial constraints, in particular, deter both private developers and public-sector stakeholders from investing in green building practices (Olaniyan et al., 2018; Agboola & Emmanuel, 2016).

In contrast, examples from countries like South Africa illustrate how locally adapted certification systems can achieve higher adoption rates through government incentives and regional customization (Green Building Council South Africa, 2020). For instance, South Africa's Green Star rating system has successfully promoted sustainable construction by integrating local priorities and providing financial support for green initiatives. Such comparisons highlight the need for systemic reforms in Nigeria to overcome barriers to green building certification.

Despite these challenges, there is growing recognition of the need for sustainable construction practices in Nigeria. Rising energy costs, the visible impacts of climate change, and the country's alignment with international commitments, such as the United Nations Sustainable Development Goals (SDGs), drive this shift (UNEP, 2021). The potential benefits of green buildings, including reduced operational costs, improved occupant health, and enhanced building longevity, underscore their importance in advancing Nigeria's environmental and economic goals (Darko et al., 2017; Adedeji et al., 2020).

This study addresses a significant knowledge gap by critically evaluating the adoption of green building certifications in Nigeria's construction industry. Specifically, it examines their economic, environmental, and regulatory impacts, identifies key barriers to adoption, and explores actionable strategies to overcome these obstacles. By synthesizing evidence from global and local contexts, this research contributes to the broader understanding of sustainable construction in developing countries, offering practical recommendations for policymakers, construction professionals, and industry stakeholders.

1.1 Overview of Green Building Certification Systems

Green building certification systems play a critical role in promoting sustainable construction practices by providing standardized frameworks to evaluate and enhance the environmental performance of buildings throughout their lifecycle. These systems assess various sustainability dimensions, including energy efficiency, water conservation, material selection, and indoor air quality (Vaidya et al., 2022). Widely recognized certification systems, such as Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), and Green Star, have established themselves as global benchmarks for measuring sustainability in construction (Tan et al., 2023).

LEED, developed by the U.S. Green Building Council (USGBC), focuses on energy efficiency, water usage, materials selection, and indoor air quality and has become a global standard in over 160 countries (USGBC, 2023). BREEAM, originating in the UK, offers a broader scope by evaluating the lifecycle impact of buildings and adapting to regional environmental conditions (O'Meara et al., 2022). Green Star, recognized primarily in Australia and New Zealand, integrates both environmental and social sustainability considerations, emphasizing community well-being alongside resource efficiency (Green Building Council of Australia, 2023). Other systems, such as the Living Building Challenge, known for its stringent standards, and the WELL Building Standard, prioritizing occupant health and well-being, reflect the evolving focus of green certifications beyond environmental metrics (Zuo et al., 2021). While these systems have driven global advancements in sustainable construction, their adaptability and relevance to developing countries, particularly Nigeria, remain underexplored. Tailoring these frameworks to Nigeria's socio-economic and environmental conditions is essential for their effective implementation.

1.2 Evolution and Global Adoption of Green Building Certifications

The evolution of green building certifications has been shaped by the growing need to address global environmental challenges, particularly climate change and rapid urbanization. Initially focused on improving energy efficiency, these certifications have expanded to encompass a broader range of sustainability goals, including carbon emissions reduction, water conservation, and enhanced occupant health (Guerra et al., 2023). For instance, since its launch in 1998, LEED has certified more than 100,000 projects in over 160 countries, becoming a cornerstone of global sustainable construction (USGBC, 2023).

BREEAM, introduced in 1990, pioneered the use of a formal rating system for building sustainability and has significantly influenced other certification systems worldwide (Gou, 2022). Its emphasis on regional adaptation has made it particularly effective in Europe. The adoption of these systems has expanded to developing countries, with region-specific certifications such as the China Green Building Label (GBL) and South Africa's Green Star certification demonstrating the adaptability of global frameworks to unique socio-economic and environmental contexts (Zhao et al., 2021; GBCSA, 2023). In emerging economies, certifications like Brazil's AQUA and India's GRIHA have been designed to address local construction challenges while promoting sustainable practices (Pinheiro et al., 2023). South Africa's Green Star rating system, in particular, demonstrates the importance of financial incentives, government support, and regional customization in overcoming adoption barriers. These successful models provide valuable insights for Nigeria, where systemic challenges such as high costs, limited technical expertise, and weak policy frameworks have hindered the widespread adoption of green certifications. This underscores the need for localized adaptations of certification systems to address Nigeria's specific economic and environmental conditions.

1.3 Green Building Practices in Nigeria: Current Trends and Challenges

The adoption of green building practices in Nigeria is still in its infancy but is gaining traction as awareness of sustainable development increases. The Nigerian Green Building Council (NGBC) has actively promoted green practices by offering educational resources and raising awareness among developers, architects, and policymakers (Olubayo et al., 2020). However, implementation remains limited due to systemic barriers,

including high initial costs, limited access to sustainable technologies, and insufficient government incentives (Bamgbade et al., 2020). A significant challenge is the high upfront investment required for green buildings, including energy-efficient systems, sustainable materials, and certification fees, which deters private sector developers (Akinmoladun et al., 2020). Furthermore, the absence of robust government policies and incentives, such as tax breaks or subsidies, exacerbates the financial constraints faced by stakeholders (Ugochukwu et al., 2022). Comparatively, South Africa's Green Star rating system has successfully addressed similar challenges by implementing government-backed incentives and training programs, highlighting the potential for similar initiatives in Nigeria.

Despite these barriers, there have been promising developments, particularly in commercial sectors. For example, multinational companies and developers in urban centers like Lagos and Abuja are increasingly integrating green features such as renewable energy systems, water recycling, and sustainable landscaping into their projects (Igbokwe et al., 2020). Collaborative efforts between the NGBC and international organizations like the World Green Building Council (WGBC) are also fostering progress. However, achieving widespread adoption in Nigeria will require systemic reforms, including stronger regulatory frameworks, financial incentives, and enhanced technical capacity.

1.4 Environmental, Economic, and Social Impacts of Green Building Certifications

Green building certifications offer substantial environmental, economic, and social benefits, which underscore their importance in advancing global and local sustainability goals. Environmentally, green-certified buildings significantly reduce energy consumption, water usage, and carbon emissions. For example, LEED-certified buildings consume 30% to 50% less energy and reduce carbon emissions by approximately 34% compared to conventional buildings (Baker et al., 2023; Kats, 2022). Water conservation measures, including efficient fixtures and rainwater harvesting, further enhance environmental sustainability. Economically, although green buildings require higher initial investments, these costs are offset by long-term operational savings. Certified buildings have lower utility costs, higher rental values, and longer lease terms, making them economically viable in the long run (Azhar et al., 2020; Deng et al., 2023). The green building sector also drives economic growth by creating jobs in design, construction, and maintenance, providing opportunities for innovation and skill development (Kats, 2022).

Socially, the impact of green buildings extends beyond environmental and economic considerations. Improved indoor air quality, natural lighting, and thermal comfort contribute to better occupant health, reducing respiratory illnesses and enhancing overall well-being (Jones et al., 2022). Green-certified offices have been shown to increase employee productivity by up to 20%, demonstrating the potential for broader societal benefits through sustainable design (Jones et al., 2022). These impacts emphasize the transformative potential of green building certifications for sustainable development. However, maximizing these benefits in Nigeria requires addressing the systemic challenges limiting their adoption.

1.5 Barriers and Opportunities for Green Certification Adoption in Developing Countries

The adoption of green building certifications in developing countries faces significant challenges, particularly in sub-Saharan Africa, South Asia, and parts of Latin America. Economic pressures in these regions often prioritize cost-saving measures over environmental sustainability, compounded by limited access to capital, underdeveloped infrastructure, and a general lack of awareness about sustainable construction practices. These constraints result in green building certifications being perceived as costly and unattainable for many stakeholders.

One of the most prominent barriers is the high upfront cost of green building technologies and certification fees. Energy-efficient systems, renewable energy installations, and eco-friendly construction materials require significant initial investments, which are frequently beyond the financial capacity of developers in developing economies (Madhusree et al., 2023). Certification fees themselves are seen as additional financial burdens,

particularly for small and medium-sized enterprises (SMEs), which play a critical role in these regions' construction sectors but often operate with limited budgets (Akinmoladun et al., 2021). Developers may prioritize short-term cost savings over long-term benefits, especially in markets where the financial returns on sustainable investments are not immediately evident. This financial constraint is especially pronounced in sub-Saharan Africa, where high capital costs often render green building projects infeasible.

A lack of awareness and technical knowledge among developers, contractors, and building professionals further hinders the adoption of green certifications. In many developing countries, the construction industry remains unfamiliar with sustainable building concepts and lacks the expertise to incorporate green technologies effectively (Bamgbade et al., 2020). This knowledge gap is exacerbated by limited access to training programs and a shortage of skilled labor in sustainable construction methods. Without the requisite expertise, even projects aspiring to green certification may fail to meet the required standards, diminishing the perceived value of certification and hindering broader adoption (Madhusree et al., 2023).

Regulatory frameworks in developing countries often do not support green building initiatives. The absence of clear policies, building codes, and incentives that promote sustainability makes it challenging for developers to justify the additional costs of certification (Li et al., 2021). Outdated urban planning regulations in some countries prevent the incorporation of features like green roofs, passive solar designs, and advanced energy systems into new buildings. Furthermore, international certification systems like LEED and BREEAM are often not well-suited to local contexts, making compliance difficult and deterring developers (Tan et al., 2023).

Despite these barriers, there are significant opportunities to advance the adoption of green certifications in developing countries. One key strategy is the introduction of government incentives, such as subsidies, tax breaks, and low-interest loans, which can offset the high initial costs of green technologies and certification fees. For example, providing financial incentives for developers could make green buildings more economically feasible and attractive, especially in regions where access to capital is limited (Sharma & Kumar, 2022). Public-private partnerships (PPPs) also offer substantial potential to drive green building initiatives. Through these collaborations, the public sector can provide a favorable policy environment and financial support, while the private sector contributes technical expertise and innovation. This model has been successful in several emerging economies, demonstrating its effectiveness in scaling sustainable construction practices (Li et al., 2021).

Developing localized green certification systems tailored to regional contexts represents another opportunity. While international frameworks like LEED and BREEAM have set global benchmarks, they often fail to consider the specific environmental, economic, and cultural realities of developing nations. Regional systems like India's GRIHA and South Africa's Green Star certifications have proven more effective in addressing local challenges by focusing on locally available materials, climatic conditions, and socio-economic considerations (Bamgbade et al., 2020). Such localized frameworks could help reduce costs and make certifications more accessible to developers in these regions.

International collaboration also plays a critical role in overcoming barriers to green certification adoption. Through platforms like the World Green Building Council (WGBC) and global funding mechanisms, developing nations can access technical expertise, financial support, and best practices from more developed markets (Pinheiro et al., 2023). Collaborative efforts facilitate knowledge-sharing, technology transfer, and capacity-building, empowering local stakeholders to adopt sustainable construction practices effectively. By addressing these challenges and leveraging these opportunities, developing countries can align their construction sectors with global sustainability goals while addressing local environmental and economic needs.

1.6 Emerging Trends and Future Directions for Research

The field of green building certification is rapidly evolving, influenced by technological advancements, growing environmental awareness, and the urgent need to address climate change. Emerging trends include the

integration of smart technologies, a heightened focus on climate resilience, and an emphasis on sustainable materials. These developments are shaping the future of certification systems and enhancing their relevance to both global and local contexts.

Smart technologies are increasingly incorporated into green-certified buildings, enabling real-time monitoring and optimization of performance metrics such as energy consumption, water usage, and indoor air quality (Tan et al., 2023). Internet of Things (IoT) devices, sensors, and artificial intelligence (AI) systems are transforming how buildings interact with their environments. For instance, smart thermostats and automated energy management systems can dynamically adjust energy usage based on occupancy and external conditions, significantly improving efficiency. These technologies not only enhance the environmental performance of buildings but also make them more adaptive to changing conditions, reinforcing their value in the face of growing environmental challenges.

Another critical trend is the integration of climate resilience into green building certifications. With the intensification of climate change, certification systems are placing greater emphasis on strategies to mitigate and adapt to extreme weather events such as floods, heatwaves, and storms (Jones et al., 2022). Features like green roofs, reflective surfaces, and advanced insulation are increasingly being incorporated to help buildings withstand these events. This shift reflects a broader recognition of the need for buildings to be both environmentally efficient and resilient to long-term climate impacts, such as rising temperatures and sea levels. The construction industry's role in carbon emissions and resource depletion has also driven a growing focus on sustainable materials. Certification systems are promoting the use of bio-based and low-carbon materials such as bamboo, hempcrete, and recycled timber as alternatives to traditional materials like concrete and steel (Zuo & Zhao, 2021). Research into recycling and repurposing construction waste is gaining traction, further supporting efforts to reduce the environmental impact of new buildings (Tan et al., 2023). These material innovations are critical for reducing the overall carbon footprint of the construction sector.

Future research must explore the integration of advanced digital technologies into green certification systems. Building Information Modeling (BIM), artificial intelligence, and blockchain have the potential to transform how certification processes are conducted, improving efficiency and transparency. BIM enables the simulation of building performance before construction, identifying energy-saving opportunities and optimizing design. AI can facilitate ongoing performance monitoring and predictive maintenance, while blockchain ensures secure and transparent records of sustainability metrics (Li et al., 2021). Research in this area could revolutionize green certifications by streamlining processes and enhancing the accuracy of assessments.

Social impacts represent another key area for future exploration. While much attention has been given to the environmental and economic benefits of green certifications, the social outcomes, such as improved health, equity, and community well-being, remain under-researched. Studies show that green-certified buildings improve indoor air quality and occupant comfort, reducing respiratory illnesses and enhancing productivity (Jones et al., 2022). However, further research is needed to understand the broader social implications, particularly in developing countries, where green buildings could address critical issues like affordable housing and urban equity.

Finally, there is a pressing need for localized adaptations of international certification systems to better suit developing countries. Frameworks like LEED and BREEAM often fail to account for regional differences in materials, climate, and economic realities. Research should focus on tailoring these systems to local contexts, ensuring their relevance and feasibility. By addressing these gaps, developing countries can maximize the benefits of green building certifications and contribute to a more inclusive global movement toward sustainability (Madhusree et al., 2023).

2. Methods

2.1 Research Design

This study employed a systematic review methodology to evaluate the adoption and impacts of green building certifications in Nigeria's construction sector. Systematic reviews provide a rigorous and unbiased approach to synthesizing existing research, offering a comprehensive analysis of the evidence base (Liberati et al., 2009; Moher et al., 2015). The methodology combined descriptive and analytical approaches. The descriptive approach focused on summarizing the current state of research on green building certifications, while the analytical approach critically assessed factors influencing their adoption in Nigeria (Gough et al., 2012). The PRISMA 2020 guidelines were strictly followed to enhance transparency, reproducibility, and methodological rigor (Page et al., 2021).

2.2 Method of Data Collection

The literature search was conducted across multiple academic databases, including Google Scholar, ScienceDirect, JSTOR, and IEEE Xplore, to ensure comprehensive coverage of peer-reviewed studies, technical reports, and industry publications. This multi-database strategy was designed to capture insights from both qualitative and quantitative research on green building certifications. The search terms included combinations of keywords such as "green building certifications," "LEED," "BREEAM," "sustainable construction," and "Nigeria." The publication timeframe was restricted to studies published between 2020 and 2024 to reflect the most recent trends and developments in the field (Zuo et al., 2017).

To maintain the relevance and quality of the review, strict inclusion and exclusion criteria were applied. The inclusion criteria focused on studies published in peer-reviewed journals, conference proceedings, and reputable industry reports that addressed green building certifications in Nigeria or similar contexts in sub-Saharan Africa. Priority was given to studies that examined the economic, environmental, or social impacts of these certifications or explored factors influencing their adoption. Studies that were not directly related to green certifications, published in languages other than English, or lacked sufficient methodological detail were excluded.

The selection process involved a two-phase screening procedure. In the first phase, studies were assessed based on their titles, abstracts, and keywords to determine preliminary eligibility. In the second phase, full-text screening was conducted to confirm the inclusion of studies that met the established criteria. The process was documented using a PRISMA flow diagram (Figure 1), which provided a clear visual representation of the stages involved in identifying, screening, and including studies in the review. A discrepancy was identified during the review process regarding the classification of qualitative and quantitative studies. An audit revealed that 11 studies were misclassified, necessitating a re-evaluation of these studies to align their categorization with their methodologies. This correction was reflected in the updated PRISMA diagram to ensure transparency and methodological accuracy.

The quality of the included studies was assessed using the Critical Appraisal Skills Programme (CASP) checklist. This tool evaluated aspects such as study design, data collection methods, sample sizes, and the reliability of findings (Munn et al., 2022). High-quality studies were prioritized in the synthesis to ensure that the conclusions drawn were robust and credible. Additionally, a strength of evidence grading system was employed to assess the confidence level in the findings, considering study quality and consistency across the literature base (Moher et al., 2015).

Efforts were made to minimize bias during the review process. A double-screening method was employed, with two independent reviewers assessing each study for eligibility. Disagreements were resolved through consensus or consultation with a third reviewer, reducing the potential for selection bias (Whiting et al., 2021). An objective data extraction form was developed and used consistently across all studies to standardize the

collection of information, addressing the risk of information bias. These measures ensured that the selection and evaluation processes were both rigorous and impartial.

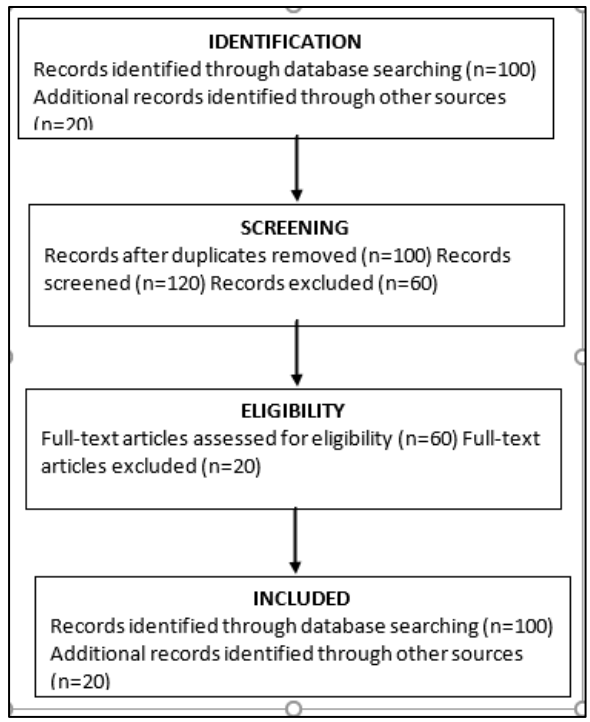

Figure 1. PRISMA diagram

2.2.1 Quality Assessment

The methodological quality of the studies was assessed using the Critical Appraisal Skills Programme (CASP) checklist. This checklist evaluates aspects such as study design**,** sample size**,** data collection methods, and the reliability of findings. Studies with higher quality scores were prioritized in the review to ensure the robustness and validity of the conclusions drawn (Munn et al., 2022). Additionally, a strength of evidence grading system was applied to assess the level of confidence in the findings based on study quality and consistency across studies (Moher et al., 2015).

2.2.2 Management of Bias

To minimize potential biases during the selection process, a double-screening method was employed, where two independent reviewers assessed each study for eligibility. Disagreements were resolved through consensus or by consulting a third reviewer. This process helped manage selection bias and ensured that studies were included based on clearly defined, standardized criteria (Whiting et al., 2021). To address information bias, an objective data extraction form was developed and used consistently across all studies.

2.3 Data Analysis Techniques

Data analysis combined qualitative and quantitative techniques to provide a comprehensive synthesis of findings. Thematic analysis was conducted to identify recurring themes related to the environmental, economic, and social impacts of green building certifications, as well as barriers to their adoption. This approach enabled the identification of trends and patterns across the studies, offering insights into the multifaceted nature of green certifications in Nigeria (Braun & Clarke, 2022). Quantitative data analysis focused on summarizing key metrics

such as adoption rates, economic benefits, and return on investment (ROI) for certified buildings. These metrics were presented in tables and graphs to provide a clear, data-driven overview of the financial and practical implications of adopting green certifications (Goh et al., 2020).

2.4 Study Limitations

Several limitations were identified during the review process. The restriction to English-language publications may have excluded valuable studies published in other languages, introducing a potential language bias (Polanin et al., 2021). The reliance on secondary data posed another limitation, as rapidly evolving developments in green building certifications may not have been fully captured (Rothstein et al., 2020). The exclusion of grey literature, such as unpublished reports and industry case studies, could also have introduced a publication bias, given that studies with positive findings are more likely to be published (Rothstein et al., 2020).

Another limitation was the dynamic nature of green building standards and policies in Nigeria. As these standards evolve, some findings may not fully reflect the most current practices. To address this, the study emphasizes the importance of ongoing monitoring and further research into the development of green certifications in Nigeria. Despite these limitations, the methodological rigor applied in this review ensures that the findings provide a robust and credible foundation for understanding the state of green building certifications in the Nigerian context.

3. Results and Discussion

3.1 Overview of Key Findings

This section outlines the key findings of the study on the adoption of green building certifications in Nigeria, providing insights into the adoption rates, driving forces, barriers to growth, and opportunities for acceleration. Despite the increasing interest in sustainable construction, Nigeria remains significantly behind global leaders in green building certifications. However, the review also identifies promising areas for enhancing adoption, including policy reform, technological advancements, and international collaboration.

3.1.1 Adoption of Green Building Certifications in Nigeria

As illustrated in Figure 2, by 2023, Nigeria had achieved certification for 32 green building projects, primarily through the LEED, EDGE, and BREEAM systems. A notable concentration of these projects is observed in Lagos, Nigeria's commercial hub. The trend toward energy-efficient buildings, particularly in the commercial real estate sector, reflects a growing desire among developers to meet global sustainability standards and attract international investments. However, despite this progress, Nigeria remains far behind in comparison to other nations. For example, the United States, with over 40,000 LEED-certified buildings (USGBC, 2023), and China, with over 15,000 LEED projects, significantly outpace Nigeria's growth (Zhang et al., 2021). This discrepancy underscores the gap in Nigeria's green building sector and highlights both challenges and untapped potential.

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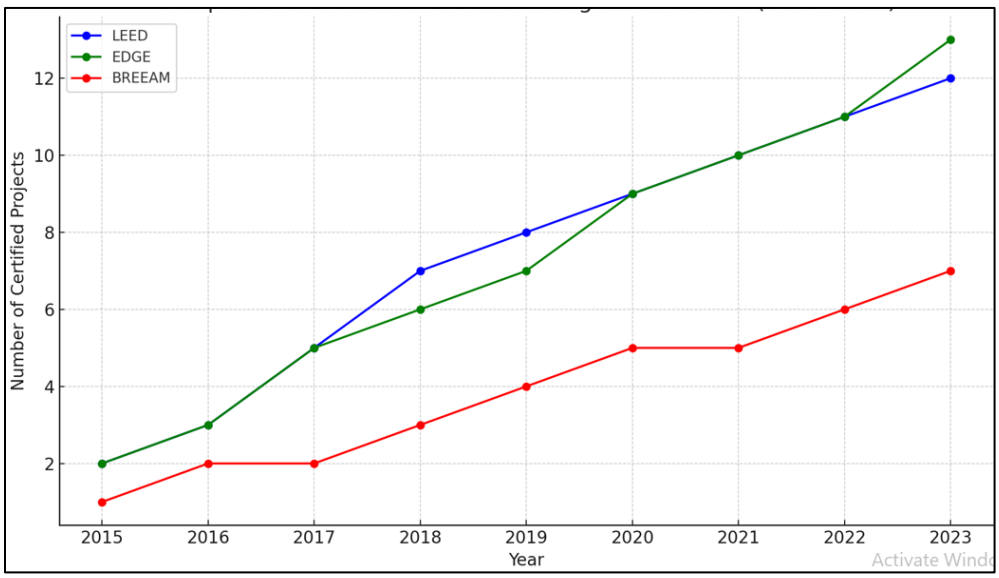

Figure 2. Growth of certified green building projects in Nigeria (2015-2023)

Despite the modest growth, the adoption rate from five certified projects in 2015 to 32 in 2023 demonstrates positive momentum. This trend indicates that while the green building sector in Nigeria is nascent, there is significant potential for further growth if the underlying barriers are addressed.

3.1.2 Global Comparison and Contextualization

The global landscape for green building adoption is shaped by strong governmental support, public awareness, and substantial financial incentives. Countries such as the United States, China, and Germany have led the way in green building certification, thanks to comprehensive policies and market-driven demands for energy-efficient infrastructure (Berardi, 2017). The U.S., for instance, has invested heavily in green building initiatives, with tax incentives, energy-efficient building codes, and a robust certification system (USGBC, 2023). In contrast, Nigeria's adoption remains limited due to several key challenges, including a lack of policies to incentivize green building certifications, high capital costs, and limited technical expertise in sustainable construction.

Figure 3 further highlights the stark contrast between Nigeria's adoption rate of green building certifications and global leaders. The comparison reveals a significant gap, but also suggests that Nigeria could rapidly close this gap by leveraging global best practices and adopting relevant policies. The implementation of incentives, such as tax rebates for green projects, as seen in the U.S. and China, could foster accelerated growth in Nigeria’s green building market (Hwang & Ng, 2013).

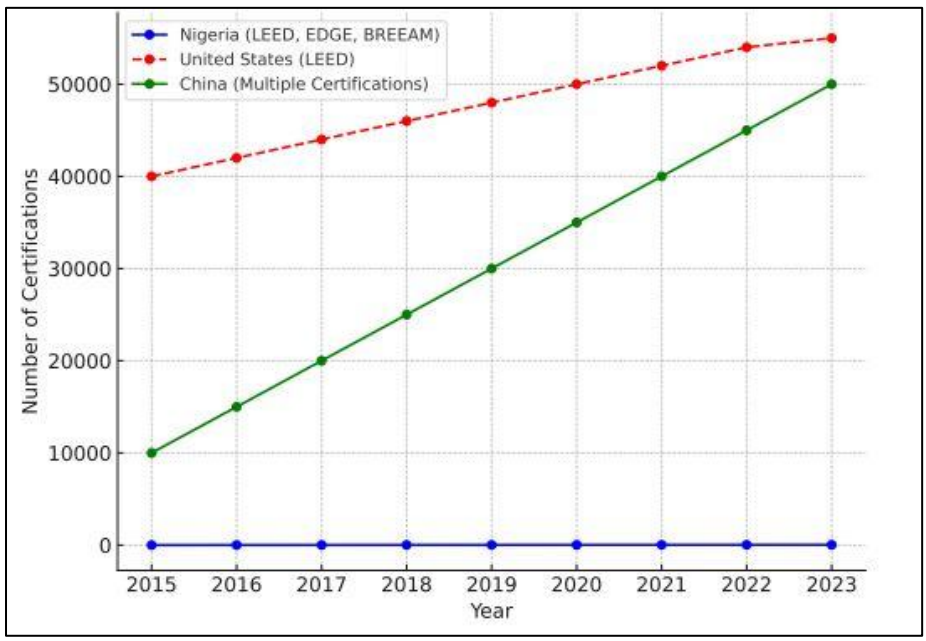

Figure 3. Comparative growth of green building certifications

3.2 Material and Technological Innovations

The integration of sustainable materials and technological advancements in green buildings is an area that has seen some positive developments in Nigeria. However, these innovations are not yet widely adopted, largely due to high costs and limited availability of locally sourced materials.

3.2.1 Use of Sustainable Materials

The use of sustainable building materials, such as high-performance glass, insulating concrete forms (ICFs), and eco-friendly finishes, has become increasingly prevalent in green building projects in Nigeria. However, the high cost of these materials remains a significant challenge, as they typically add 15%-30% to the construction budget (Jiao et al., 2020). Furthermore, the lack of local suppliers for sustainable materials further exacerbates the problem, as many of these materials need to be imported, raising costs even more. To mitigate this issue, a strategy to foster local production of green building materials, such as the development of regional suppliers and manufacturers, is essential to reduce costs and improve the accessibility of sustainable materials (Ogunbiyi et al., 2021).

3.2.2 Technological Advancements

Technological innovations, such as the integration of solar power, rainwater harvesting systems, and advanced HVAC systems, are fundamental to improving the sustainability of buildings. These technologies are particularly important in Nigeria, where the national grid is often unreliable. Solar energy, for instance, provides an effective solution to the country's energy deficit, reducing reliance on the national grid and helping mitigate high energy costs (Alhassan et al., 2022). Furthermore, rainwater harvesting systems contribute to water conservation, addressing Nigeria's growing water scarcity issues. These advancements in building technologies not only support environmental sustainability but also enhance the cost-effectiveness of green buildings in the long term.

3.3 Economic and Environmental Outcomes

Green buildings in Nigeria have demonstrated substantial economic and environmental benefits, despite the high initial investment required for certification. Studies have shown that while the capital costs of green buildings are generally higher, long-term operational savings make them a more cost-effective choice in the long run (Kats, 2003). These savings come primarily from reduced energy consumption and water use, as well as lower maintenance costs.

3.3.1 Economic Benefits

The economic benefits of green buildings in Nigeria are significant. Research suggests that green buildings can reduce energy costs by up to 30% and water consumption by 25%, resulting in operational savings of approximately 10%-15% over the life cycle of the building (USGBC, 2023). These savings are particularly valuable in Nigeria, where energy costs are high and water resources are limited. Moreover, green buildings tend to have higher resale values and attract higher rental premiums, making them an attractive investment for developers.

3.3.2 Environmental Benefits

From an environmental standpoint, green buildings in Nigeria help to mitigate climate change and reduce the country's carbon footprint. For example, LEED-certified buildings in Nigeria have demonstrated a 30% reduction in energy consumption compared to conventional buildings (EIA, 2021). This reduction is particularly important in a country where the building sector is one of the largest contributors to greenhouse gas emissions. Moreover, green buildings are contributing to water conservation, reducing water consumption by up to 25%, and enhancing indoor air quality, which is crucial in urban centers with high pollution levels (Alhassan et al., 2022).

Table 1 presents a comparison of the environmental benefits of various green building certifications in Nigeria. These figures underline the positive environmental impact of green buildings, which contribute to energy and water conservation, as well as waste reduction.

Table 1. Comparison of environmental benefits for certified green buildings in Nigeria

Certification Type	Energy Reduction (%)	Water Usage Reduction (%)	Waste Reduction (%)
LEED	30%	25%	20%
EDGE	28%	20%	15%
BREEAM	25%	22%	18%

3.4 Challenges and Opportunities

The adoption of green building certifications in Nigeria faces several challenges, primarily economic, technical, and regulatory. However, by addressing these barriers, there is significant potential for Nigeria to become a leader in sustainable construction in Africa.

3.4.1 Barriers to Adoption

One of the most significant barriers to the widespread adoption of green buildings in Nigeria is the high initial capital cost associated with certification and the use of sustainable materials. These higher upfront costs, which can be up to 30% more than conventional buildings, deter many developers from pursuing green certification (Ogunbiyi et al., 2021). Additionally, there is a lack of skilled professionals in the construction industry, which

limits the ability to meet green certification standards and implement sustainable construction practices effectively. The absence of adequate government incentives further exacerbates the situation. Unlike in countries such as the United States, where tax rebates and financial incentives encourage developers to build sustainably (Wong et al., 2020), Nigeria lacks policies that directly support green building projects. Moreover, regulatory gaps and the poor enforcement of environmental laws in the construction sector create an environment where developers may not feel compelled to adopt green building practices (Fadare et al., 2021). Finally, a public awareness deficit regarding the benefits of green buildings means that many stakeholders, including developers and potential occupants, are not fully aware of the long-term economic and environmental advantages of sustainable construction.

3.4.2 Strategies for Improvement

To overcome these barriers and accelerate the adoption of green building certifications, several strategies can be implemented. First, the introduction of financial incentives and subsidies would significantly reduce the financial burden on developers. Programs such as tax rebates for green building certifications, low-interest loans, and subsidies for the purchase of sustainable materials would encourage developers to embrace sustainable construction practices (Kats, 2003).

Second, Nigeria needs to establish mandatory green building standards for public sector buildings. These standards should be incorporated into national building codes and extended to the private sector through incentives. The development of green building task forces or committees could streamline the certification process and promote policy compliance (Hwang & Ng, 2013).

Third, capacity building is crucial. A concerted effort is needed to train more professionals in sustainable building practices. Collaboration between universities, vocational training centers, and industry stakeholders can enhance the availability of skilled professionals in the green building sector (Jiao et al., 2020). Additionally, industry associations like the Nigerian Institute of Architects (NIA) and the Nigerian Society of Engineers (NSE) can establish certification programs for professionals in the green building sector.

Fourth, public awareness campaigns should be intensified to educate both developers and the general public about the long-term economic and environmental benefits of green buildings. Collaborations with the media, environmental NGOs, and professional associations can help disseminate information about the positive impacts of sustainable construction. Educational programs targeting the private sector, government agencies, and the general public will be essential for fostering a broader understanding and acceptance of green building certifications in Nigeria.

Finally, international collaboration should be encouraged. Nigeria can benefit from knowledge exchange programs with countries that have successfully implemented green building initiatives, such as the United States, China, and the United Kingdom. These partnerships can provide valuable insights into best practices, policy frameworks, and financial mechanisms that have proven effective in promoting green building adoption in other countries. Moreover, global certification systems like LEED and EDGE can play a crucial role in establishing a standardized framework for green building practices in Nigeria. As part of this collaboration, international stakeholders can also offer technical and financial support for developing sustainable building materials, improving local capacity, and reducing the cost of green construction.

3.5 Policy and Regulatory Recommendations

One of the most effective ways to support the expansion of green building adoption in Nigeria is through the implementation of robust policies and regulations. Currently, the lack of strong regulatory frameworks is a major obstacle to widespread adoption. By establishing comprehensive policies that mandate green building certifications for both public and private sector projects, the Nigerian government can create an environment conducive to sustainability in the construction industry. A green building code should be developed that outlines

specific requirements for energy performance, water use, waste management, and other sustainability criteria. This code should be enforced across both public and private developments to ensure uniformity in construction practices.

The government should also create green public procurement policies that prioritize environmentally sustainable buildings in public sector projects. This would not only serve as an example for private developers but also stimulate demand for green building materials and technologies. Additionally, financial incentives such as tax reductions, grants for research and development, and subsidies for green building technologies would further encourage developers to pursue sustainable construction practices.

As seen in other countries, the integration of green building incentives into the broader national economic strategy is key to fostering growth in the sector. The Nigerian government can collaborate with international development agencies and financial institutions to secure funding for green infrastructure projects, particularly in the affordable housing sector, where demand is high but financial resources are limited. Establishing a national green building fund could also facilitate the financing of green building projects, offering loans with favorable terms to developers who commit to sustainability standards.

The adoption of green building certifications in Nigeria is still in its early stages but shows promise, particularly in urban centers like Lagos. While the barriers to adoption are substantial, they are not insurmountable. Addressing the financial, technical, and regulatory challenges through targeted policies, capacity building, and public awareness campaigns can significantly accelerate the growth of green buildings in Nigeria. With the right mix of incentives, training, and regulatory frameworks, Nigeria has the potential to become a regional leader in sustainable construction, promoting energy efficiency, reducing environmental impact, and contributing to the global fight against climate change.

Furthermore, by leveraging international partnerships and drawing on the experiences of countries that have successfully integrated green building practices, Nigeria can position itself as a key player in the global transition to sustainable development. With the proper investments in both human and capital resources, the country can transform its built environment to be more sustainable, resilient, and future-proof.

4. Conclusion

This study has undertaken a detailed evaluation of the adoption and impacts of green building certifications on Nigeria's construction practices. While there has been a steady increase in certified projects, particularly through LEED, EDGE, and BREEAM, the progress remains modest compared to leading global markets. The adoption of certifications has yielded measurable improvements in energy efficiency, water conservation, and waste reduction in certified buildings, signaling growing awareness of sustainability within the Nigerian construction sector. However, systemic barriers continue to restrict broader adoption, limiting the potential of green building practices to drive sustainable development in Nigeria.

Key challenges include the high initial capital costs of green construction, exacerbated by the reliance on imported sustainable materials, which raises costs further. This financial burden often deters developers from pursuing green certifications. The critical shortage of trained professionals in sustainable building practices further compounds this issue, as the industry struggles to meet the stringent standards required by green certification systems. Additionally, the absence of a robust regulatory framework, coupled with insufficient governmental incentives such as tax rebates and subsidies, limits the economic feasibility of green construction projects. The lack of public awareness regarding the long-term benefits of green buildings further inhibits demand for sustainable practices, stalling progress in both public and private sectors.

Addressing these barriers requires coordinated efforts from policymakers, industry stakeholders, and international collaborators. The Nigerian government must prioritize the establishment and enforcement of comprehensive regulatory frameworks that mandate minimum energy efficiency and sustainability standards

for new construction projects. Implementing policy interventions such as tax incentives, grants, and subsidies would alleviate the financial burden on developers and encourage investment in green building projects. Furthermore, integrating green standards into public procurement policies would stimulate demand for sustainable construction, setting an example for the private sector to follow. These measures must be complemented by public awareness campaigns aimed at educating stakeholders and the broader public about the economic, environmental, and social benefits of green buildings. Greater awareness would foster acceptance of sustainable construction practices and create a market-driven demand for green certifications.

Industry stakeholders, including architects, engineers, and developers, have a crucial role to play in advancing sustainable construction practices. Emphasizing the use of locally sourced sustainable materials would reduce dependency on imports, lower costs, and stimulate economic growth in the manufacturing sector. Collaborative efforts among construction professionals, training institutions, and policymakers are needed to build capacity and equip the workforce with the skills required to meet green certification standards. Incorporating innovative and cost-effective sustainable design solutions into projects can further reduce construction costs and enhance environmental performance.

Future research must focus on quantifying the long-term economic benefits of green buildings in Nigeria, particularly regarding energy and water cost savings. A robust understanding of these savings could justify the higher upfront costs and incentivize developers and investors to adopt green certifications. Additionally, research addressing the specific barriers faced by the Nigerian construction sector, such as supply chain inefficiencies and workforce shortages, is essential for tailoring solutions to the local context. Comparative studies of green building adoption in other developing countries could provide valuable lessons and best practices for Nigeria to adapt and implement.

By addressing these challenges and capitalizing on the opportunities identified, Nigeria has the potential to become a regional leader in sustainable construction. The widespread adoption of green building certifications would contribute significantly to environmental conservation, economic development, and an improved quality of life for Nigerian citizens. Moreover, such progress would position Nigeria as a global leader in green development, setting a precedent for other emerging economies. With strategic investments in policy reforms, capacity building, and international collaboration, Nigeria can transform its construction sector into a model of sustainability and resilience, aligning with global efforts to combat climate change and achieve sustainable development goals.

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All authors declare that they have no conflicts of interest.

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