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Building for the Future: Evaluating Sustainable Construction Practices and Overcoming Challenges in Nigeria's Construction Industry

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Abstract

This study investigates the current state of sustainable construction practices in Nigeria, focusing on the environmental, social, and economic dimensions within the construction industry. Utilizing a quantitative research approach, data were collected through survey questionnaires distributed to construction professionals, including engineers, architects, and project managers. With a strong response rate of 95.6%, the data were analyzed using Confirmatory Factor Analysis (CFA) within the LISREL framework. The findings reveal that sustainable practices are inconsistently applied across the industry, with environmental sustainability showing the weakest emphasis. Social and economic sustainability practices also display varied levels of implementation, reflecting significant challenges in fully integrating sustainability into construction projects. The analysis points to inconsistencies and gaps, evidenced by moderate to weak associations between observed practices and their sustainability goals. To address these challenges, the study recommends that policymakers and industry leaders implement comprehensive strategies, including robust regulatory frameworks, targeted capacity-building programs, and incentives to encourage sustainable practices. Enhanced collaboration among stakeholders and increased investment in research and development are essential for fostering innovation and improving sustainability outcomes. Future research should include longitudinal studies to track the evolution of these practices over time, as well as comparative studies across different regions to identify contextual factors influencing sustainability. Additionally, qualitative research methods such as interviews and focus groups are suggested to gain deeper insights into the socio-cultural factors shaping sustainability in Nigeria's construction sector. This study contributes to a deeper understanding of the barriers and opportunities for advancing sustainable construction practices in Nigeria.

Keywords: Sustainable construction, policy frameworks, economic implications, waste management, socio-cultural factors, green building technologies

Introduction

Sustainable construction practices have become increasingly important in the global construction industry, largely due to growing concerns about environmental damage, resource shortages, and social inequality. In Nigeria, where cities are expanding quickly and infrastructure projects are on the rise, adopting sustainable construction methods is not just an option—it's essential. Sustainable construction, also known as green building or eco-construction, involves designing, building, operating, and maintaining buildings and infrastructure in a way that minimizes harm to the environment, conserves resources, and improves social well-being (UNEP, 2022). This approach is based on principles and strategies that aim to reduce the negative impact of the built environment while promoting economic and social benefits.

One of the main principles of sustainable construction is energy efficiency. This means reducing energy use by incorporating smart design, using energy-saving technologies, and relying more on renewable energy sources (Shen et al., 2023; Zhang & Li, 2022). Water conservation is another key principle. It focuses on using less water, improving water quality, and managing stormwater effectively through methods like rainwater harvesting and water recycling (Adeyemi & Lawal, 2023). Reducing waste is also a crucial aspect, encouraging the recycling and reuse of materials to cut down on construction and demolition waste (Shen et al., 2023). Furthermore, using renewable and sustainable materials, such as bamboo, recycled aggregates, and responsibly sourced timber, helps lessen the environmental impact of extracting and processing materials (Oluwakemi et al., 2023).

Sustainable construction isn't just about protecting the environment; it also includes social and economic goals. It aims to create healthy, inclusive, and livable spaces that enhance the well-being of people and encourage community involvement (UNEP, 2022). Economically, sustainable construction can make buildings more cost-effective

over their lifetime by reducing operating costs and opening up new markets as demand for sustainable buildings grows (Olaniyan & Ajibola, 2023). Nigeria's construction industry is expanding rapidly due to population growth, urbanization, and major infrastructure projects (Oluwatobi et al., 2021). While this growth brings opportunities like economic development and job creation, it also poses challenges such as environmental degradation, resource depletion, and social inequality.

Recent studies have shown that unchecked construction activities are harming Nigeria's environment and society. For example, Olajide and Ogunsemi (2023) found that pollution, deforestation, and land degradation are increasing due to unsustainable construction practices. Rapid urbanization also worsens social inequality, as vulnerable communities are often the hardest hit by environmental damage and lack access to basic services (Adeyemi & Lawal, 2023). These issues highlight the urgent need for Nigeria to adopt sustainable construction practices. By focusing on energy efficiency, waste reduction, and social inclusivity, sustainable construction aims to reduce negative environmental and social impacts while building long-term resilience and prosperity (Shen et al., 2023).

The importance of sustainable construction in Nigeria goes beyond environmental and social issues. It also aligns with national goals for economic growth, resilient infrastructure, and climate change mitigation (Olaniyan & Ajibola, 2023). As Nigeria works to meet its sustainable development goals, including those in the Sustainable Development Goals (SDGs) and the Paris Agreement, adopting sustainable construction practices is critical to aligning the construction sector with the country's broader priorities. The main goal of this research is to thoroughly assess the current state of sustainable construction practices in Nigeria and identify the challenges preventing their widespread adoption. The study also aims to analyze current practices in the industry to understand trends and patterns. Finally, it will propose strategies and recommendations to advance sustainable construction in Nigeria by addressing challenges and taking advantage of opportunities (Olajide & Ogunsemi, 2023; Adeyemi & Lawal, 2023).

Literature Review

Definition and Principles of Sustainable Construction

Sustainable construction, also known as green building or eco-construction, is grounded in three key principles: environmental protection, economic feasibility, and social equity (UNEP, 2022). It involves designing, constructing, operating, and eventually dismantling buildings in ways that minimize environmental harm, conserve resources, and promote social well-being (Shen et al., 2023). The aim is to create buildings that are environmentally friendly, economically viable, and socially inclusive.

Several core principles guide sustainable construction. First, energy efficiency is crucial. This means reducing energy consumption and greenhouse gas emissions by using passive design, energy-efficient HVAC systems, and renewable energy technologies like solar panels (Shen et al., 2023). Second, water conservation focuses on reducing water use and relieving pressure on local water supplies. Practices include installing water-efficient fixtures, rainwater harvesting, and greywater recycling (Adeyemi & Lawal, 2023). Third, waste reduction is emphasized to minimize construction waste, with strategies like prefabricated construction, material recycling, and comprehensive waste management plans (Shen et al., 2023). Additionally, the use of renewable and low-impact materials, such as sustainably sourced timber and recycled content, is vital to reducing the environmental footprint (Oluwakemi et al., 2023). Finally, sustainable construction also considers social equity and economic viability, ensuring that buildings are accessible, safe, and affordable for all, while promoting community engagement in the process (UNEP, 2022).

Global Trends and Practices in Sustainable Construction

Sustainable construction has become a key global response to challenges like climate change and resource depletion. This movement has gained

traction worldwide, with many innovative practices promoting sustainability in the construction industry. One major driver is the adoption of green building certification systems, which recognize and encourage environmentally friendly building practices (Goubran et al., 2021). Systems like LEED, BREEAM, and Green Star provide guidelines for sustainable building design, construction, and operation, helping to integrate green principles into projects globally.

Beyond certifications, sustainable construction involves strategies that reduce environmental impact and improve resource efficiency. Passive design, for example, optimizes building orientation and layout to maximize natural light and ventilation, reducing the need for artificial heating and cooling (Shen et al., 2023). Energy-efficient HVAC systems and the use of recycled and low-impact materials further enhance the sustainability of buildings (Goubran et al., 2021). Additionally, renewable energy technologies like solar panels and wind turbines are increasingly used to meet building energy needs while reducing reliance on fossil fuels (Adeyemi & Lawal, 2023).

Sustainable Construction in Nigeria

Research on sustainable construction in Nigeria highlights both challenges and opportunities. Oluwatobi et al. (2021) identified key barriers to sustainable construction, including a lack of awareness, high initial costs, and regulatory hurdles. These challenges indicate a need for targeted interventions to foster a supportive environment for sustainable practices. Shen et al. (2023) stressed the importance of strong government policies and industry collaboration to advance sustainable construction. They highlighted the need for effective policy frameworks that encourage and enforce sustainable building practices, alongside increased cooperation among stakeholders to share knowledge and build capacity.

These findings suggest that promoting sustainable construction in Nigeria requires a comprehensive approach, involving regulatory reforms, stakeholder engagement, and capacity-building efforts to fully realize the potential of sustainable construction in the country.

Challenges in Implementing Sustainable Construction in Nigeria

Several challenges impede the implementation of sustainable construction practices in Nigeria. First, inadequate policy frameworks create significant barriers, as there are few regulations and incentives to encourage sustainable building (Shen et al., 2023). Second, limited access to financing for green projects discourages investment, as financial institutions often view these projects as high-risk (Olajide & Ogunsemi, 2023). Third, a shortage of skilled labor and technical expertise in sustainable construction methods hinders the successful execution of projects (Shen et al., 2023). Additionally, unreliable supply chains for sustainable materials further complicate efforts, as accessing environmentally friendly materials can be inconsistent (Olajide & Ogunsemi, 2023). Finally, cultural preferences for traditional construction methods and a lack of awareness about the benefits of green building also present challenges (Adeyemi & Lawal, 2023). Overcoming these challenges will require coordinated efforts between government agencies, financial institutions, industry stakeholders, and educational institutions (Shen et al., 2023; Olajide & Ogunsemi, 2023).

Opportunities for Sustainable Construction in Nigeria

Despite these challenges, there are significant opportunities to advance sustainable construction in Nigeria. Rapid urbanization and population growth have led to a surge in construction, creating a favorable environment for adopting sustainable practices (Oluwatobi et al., 2021). Additionally, growing awareness of environmental issues among policymakers and the public, driven by global concerns like climate change, has led to increased support for sustainability initiatives (Olajide & Ogunsemi, 2023).

Nigeria's commitments to international agreements like the Paris Agreement have resulted in policies that encourage sustainable construction. These include tax breaks, subsidies for green building

projects, and regulations that require sustainable design in public infrastructure (Shen et al., 2023). The country's abundant renewable resources, such as solar and wind energy, also present opportunities to integrate renewable energy into building designs, reducing reliance on fossil fuels (Adeyemi & Lawal, 2023).

Economic incentives are another driver of sustainable construction in Nigeria. As investor interest in sustainability grows, there is increasing demand for green buildings. Investors recognize the long-term cost savings and market advantages of sustainable developments, leading to more investment in green construction projects (Olajide & Ogunsemi, 2023).

Strategies for Advancing Sustainable Construction in Nigeria

To advance sustainable construction in Nigeria, several strategies are necessary. Strengthening policy frameworks and offering regulatory incentives are crucial to encouraging green building practices (Shen et al., 2023). Increasing public awareness and education about the benefits of sustainable construction is also important, as it can help build support among developers, contractors, and the public (Oluwatobi et al., 2021).

Facilitating access to financing and incentives is vital for encouraging investment in green projects. Financial incentives like tax breaks or subsidies can offset the higher initial costs of sustainable construction, making it more attractive to stakeholders (Olajide & Ogunsemi, 2023). Promoting research and development in green technologies and materials is also essential, as innovation can reduce costs and improve efficiency (Goubran et al., 2021). Finally, fostering collaboration among stakeholders—government, industry, academia, and civil society—is critical for driving collective action toward sustainable construction goals (Shen et al., 2023). By implementing these strategies, Nigeria can overcome barriers and capitalize on opportunities to create a more sustainable built environment.

Review of Related Studies

Several studies have explored various aspects of sustainable construction practices in Nigeria, providing valuable insights into the progress, challenges, and opportunities within the industry. Shen et al. (2023) conducted a comprehensive review of green construction policies in Nigeria, highlighting both the advancements made and the obstacles encountered. Their study underscored the need for more detailed analysis of the barriers to policy implementation, which is crucial for understanding how to effectively promote sustainable practices. In another study, Aremu and Okagbue (2020) assessed construction waste management practices among building contractors in Lagos. Their findings revealed significant deficiencies in current waste management processes, pointing to an urgent need for improved regulations, better training programs, and enhanced infrastructure to address these challenges effectively. Akinjare and Oluwunmi (2021) examined the economic sustainability of green building projects in Nigeria, focusing on the cost-benefit analysis of these projects. Their study provided important insights into the financial implications of adopting sustainable construction practices, highlighting the potential long-term economic benefits for stakeholders. However, they suggested that further research is needed to explore additional factors influencing economic sustainability, such as market demand and the role of government incentives.

In terms of policy and regulation, Adesanya and Ogunsemi (2021) investigated the economic implications of sustainable building construction in Lagos. They emphasized the importance of considering both short-term costs and long-term benefits in assessing the economic viability of green building projects. Jimoh and Oduwaye (2021) conducted a comparative analysis of energy efficiency in sustainable and conventional buildings in Nigeria. Their study demonstrated the potential energy savings and environmental benefits associated with sustainable construction practices but also called for more comprehensive data on building energy consumption across different regions to generalize their findings.

Ogundairo and Adelaja (2021) provided a comparative analysis of green building certification systems in Nigeria, offering insights into the strengths and weaknesses of various systems. Their research highlighted the importance of these certification systems in promoting sustainable practices, but they also suggested that future studies should explore the perceptions and experiences of stakeholders, such as developers and architects, regarding the challenges and benefits of these certifications. Similarly, Adeleke and Owolabi (2022) evaluated the effectiveness of green building certifications in Nigeria, focusing on selected projects. They provided practical recommendations for improving the implementation and enforcement of green building standards and suggested that government policies and incentives play a crucial role in encouraging the adoption of sustainable construction practices.

Environmental aspects of sustainable construction were explored by Adesanya et al. (2020), who investigated the challenges associated with building energy efficiency regulations in Nigeria. Their findings revealed significant barriers to the effective implementation of these regulations, including limited enforcement mechanisms and a lack of public awareness. Daramola et al. (2020) studied the impact of environmental regulations on construction firms in Lagos, analyzing the compliance costs and identifying factors that influence firms' behavior regarding regulatory compliance. Their research underscored the need for regulatory reforms and support mechanisms to help firms comply with environmental standards while minimizing costs.

Social aspects of sustainable construction were examined by Amusa and Eshofonie (2020), who explored the link between sustainable development and the construction industry in Nigeria. Their study emphasized the importance of integrating environmental, social, and economic considerations into construction activities to achieve sustainable outcomes. They highlighted the need for holistic approaches and collaboration among multiple stakeholders to promote sustainable development in the Nigerian construction industry. Additionally, Aremu and Okagbue (2020) identified significant gaps in waste management practices among building contractors in Lagos, further stressing the need for increased awareness, better training, and improved infrastructure to address these challenges.

Lastly, studies on technology and innovation in sustainable construction were conducted by Akadiri et al. (2020), who investigated the adoption of Building Information Modeling (BIM) in Nigeria's construction industry. Their research highlighted the potential benefits of BIM, such as improved collaboration, efficiency, and decision-making, but also identified barriers to its adoption, including cost and technical complexity. Ojo et al. (2020) examined the integration of sustainable practices in selected building projects in Lagos. They found both challenges and opportunities, noting that high initial costs and limited awareness were significant barriers to wider adoption of sustainable construction practices.

Research Gaps

While sustainable construction has received attention in Nigeria, several research gaps remain. First, there is a lack of comprehensive studies examining sustainable practices across the entire construction lifecycle. Most research focuses on specific aspects like policy frameworks or green certifications, leaving a gap in understanding the full range of challenges and opportunities throughout a project's life (Oluwatobi et al., 2021; Shen et al., 2023). Second, there is limited qualitative research exploring stakeholders' perceptions of sustainable construction. Understanding the motivations and concerns of policymakers, developers, and end-users is crucial for designing effective strategies to promote sustainable practices (Adeyemi & Lawal, 2023).

Third, while previous studies have highlighted barriers to sustainable construction, there is little research on successful strategies that have overcome these challenges. Case studies of successful projects could provide valuable insights for replicating sustainable practices across Nigeria (Olajide & Ogunsemi, 2023). Finally, there is a need for longitudinal studies to track the long-term impact of sustainable construction initiatives. Most studies

focus on immediate outcomes, but understanding the lasting environmental, economic, and social benefits is essential for guiding future investments (Oluwatobi et al., 2021).

Methodology

Research design

This study employed a quantitative research approach, utilizing questionnaires as the primary tool for data collection. Quantitative research focuses on gathering and analyzing numerical data to identify patterns and trends within a specific population. The main objective is to explore cause-and-effect relationships and test hypotheses (Creswell, 2014). The research strategy adopted was a survey, which involved collecting data from a sample of respondents using standardized questionnaires (Sun et al., 2019). The survey was designed to provide data necessary to address the research questions posed in this study.

Structured questionnaires were distributed to construction professionals and stakeholders within Nigeria's construction industry, including contractors and consultants. Participants included architects, engineers, project managers, and contractors, selected through purposive sampling. This method was chosen to ensure that the respondents had the relevant expertise and experience required for the study. While mixed-methods research, which combines both quantitative and qualitative approaches, was considered (Adediran & Adebiy, 2019; Oladele & Adediran, 2018), the quantitative approach was ultimately selected due to its ability to generate data suitable for extensive statistical analysis (Creswell, 2014).

Population and Sample Size

The study focused on a population of 24 construction companies, encompassing an estimated 645 project management personnel involved in active construction projects within the North Central Geopolitical Zone, as detailed in the Construction Industry Report (2021). Using Yamane’s formula (Singh & Masuku, 2014), the sample size was determined to be 10 construction companies and 248 project management personnel.

A purposive sampling technique was utilized to select the participants, targeting professionals and experts with a minimum of five years of experience in construction projects and sustainable practices in Nigeria. This method was selected to ensure that the study engaged individuals with the necessary knowledge and experience to provide meaningful insights (Polit & Beck, 2017).

Data Collection Procedure

Primary data for this study was collected through a manually distributed survey questionnaire. The questionnaire was organized into three sections. Section 1 focused on gathering background information about the respondents and their companies. Sections 2 and 3 collected data on the sustainability challenges and current sustainable construction practices in Nigeria, using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questions were adapted from previous research studies, including Chen et al. (2020), Jallow & Osei-Kyei (2020), Poon et al. (2021), Sun et al. (2020), and Zuo et al. (2019). Tables 3.1 and 3.2 show the survey questionnaires for both the contractors.

Table 1. Questionnaire for Contractors on the Current Sustainability Practices in the Construction Industry

No.	Variable	Citation
	Environmental Sustainability	
1	Our construction projects prioritize using environmentally friendly materials.	Adapted from Sun et al. (2020)
2	We actively reduce energy usage throughout the construction process.	Adapted from Chen et al. (2020)
3	Effective waste management strategies are integrated into our practices.	Adapted from Zuo et al. (2019)
4	Measures to lower the carbon footprint of projects are implemented.	Adapted from Jallow & Osei-Kyei (2020)
5	Environmental impact assessments are regularly conducted.	Adapted from Poon et al. (2021)
6	Conservation of natural resources is emphasized in our projects.	Adapted from Zuo et al. (2019)
	Social Sustainability	
7	Health and safety of workers are prioritized in our projects.	Adapted from Sun et al. (2020)
8	Local community engagement is considered in our project planning.	Adapted from Chen et al. (2020)
9	Our projects contribute to the well-being of nearby communities.	Adapted from Poon et al. (2021)
10	We ensure diversity and inclusion within our workforce.	Adapted from Jallow & Osei-Kyei (2020)
11	Cultural and historical heritage is respected in our projects.	Adapted from Zuo et al. (2019)
12	Our projects support skill development in local communities.	Adapted from Sun et al. (2020)
	Economic Sustainability	
13	We strive to optimize project costs while maintaining quality.	Adapted from Chen et al. (2020)
14	Life cycle costing is considered for long-term viability.	Adapted from Poon et al. (2021)
15	Efficient resource management is practiced to control expenses.	Adapted from Zuo et al. (2019)
16	Economic benefits for local economies are a focus in our projects.	Adapted from Jallow & Osei-Kyei (2020)
17	We aim for a balanced return on investment.	Adapted from Chen et al. (2020)
18	Financial risks associated with sustainability are carefully assessed.	Adapted from Poon et al. (2021)

Table 2. Questionnaire for Contractors - Key Sustainability Challenges

No.	Sustainability Challenge Categories and Questions	Citation
	Environmental Sustainability Challenges	
1	Reducing energy use in projects is challenging.	Adapted from Chen et al. (2020)
2	Managing and minimizing waste is difficult.	Adapted from Sun et al. (2020)
3	Environmental regulations complicate project processes.	Adapted from Jallow & Osei-Kyei (2020)
4	Reducing water consumption during construction is challenging.	Adapted from Zuo et al. (2019)
5	Implementing climate adaptation measures is difficult.	Adapted from Poon et al. (2021)
6	Preserving local biodiversity is a significant challenge.	Adapted from Chen et al. (2020)
7	Minimizing carbon emissions is complex.	Adapted from Sun et al. (2020)
8	Incorporating sustainable transportation options is challenging.	Adapted from Zuo et al. (2019)
9	Integrating energy-efficient technologies is difficult.	Adapted from Jallow & Osei-Kyei (2020)
10	Managing construction materials sustainably poses challenges.	Adapted from Poon et al. (2021)
	Social Sustainability Challenges	
11	Ensuring worker health and safety is challenging.	Adapted from Chen et al. (2020)
12	Engaging with local communities is difficult.	Adapted from Sun et al. (2020)
13	Balancing economic benefits with social responsibilities is tough.	Adapted from Jallow & Osei-Kyei (2020)
14	Promoting diversity and inclusion is challenging.	Adapted from Zuo et al. (2019)
15	Preserving cultural heritage poses challenges.	Adapted from Poon et al. (2021)
16	Collaborating with stakeholders is difficult.	Adapted from Chen et al. (2020)
17	Managing stakeholder feedback is complex.	Adapted from Sun et al. (2020)
18	Achieving social impact goals is challenging.	Adapted from Zuo et al. (2019)
19	Ensuring community well-being is challenging.	Adapted from Jallow & Osei-Kyei (2020)
20	Engaging employees in social sustainability is difficult.	Adapted from Poon et al. (2021)

	Economic Sustainability Challenges	
21	Achieving cost efficiency is challenging.	Adapted from Chen et al. (2020)
22	Life cycle costing poses challenges.	Adapted from Sun et al. (2020)
23	Managing financial risks is difficult.	Adapted from Zuo et al. (2019)
24	Demonstrating the economic impact of sustainability is complex.	Adapted from Jallow & Osei-Kyei (2020)
25	Achieving financial ROI for sustainability is challenging.	Adapted from Poon et al. (2021)
26	Conducting cost-benefit analyses for sustainability is difficult.	Adapted from Chen et al. (2020)
27	Sourcing sustainable materials at reasonable costs is challenging.	Adapted from Sun et al. (2020)
28	Budgeting for sustainability initiatives is difficult.	Adapted from Zuo et al. (2019)
29	Balancing economic returns with environmental and social goals is tough.	Adapted from Jallow & Osei-Kyei (2020)
30	Managing the economic impact of regulations is challenging.	Adapted from Poon et al. (2021)

Method of Data Analysis

The data collected was initially screened to remove outliers and tested for reliability and validity using composite reliability (CR) and average variance extracted (AVE). Data analysis was conducted in two phases. The first phase involved analyzing the demographic data of respondents and their companies using descriptive statistics through the Statistical Package for the Social Sciences (SPSS). The second phase focused on evaluating sustainability challenges and current sustainable construction practices in Nigeria using confirmatory factor analysis (CFA) within the Linear Structural Relationship (LISREL) software.

Results and Discussions

Response Rate

The study received 237 valid responses, resulting in a 95.6% response rate, which is highly satisfactory for survey research (Hwang & Liu, 2003). This strong response rate increases the reliability of the findings and suggests that the data is representative of the target population. Most respondents (67.5%) were from Civil and Structural Engineering, reflecting the central role these professionals play in construction projects (Chua et al., 1999). Additionally, 76.4% of respondents had over five years of work experience, which is crucial for providing informed and reliable insights, as noted by Kog and Loh (2012).

Preliminary Data Analyses

Before diving into the main analysis, the data underwent several statistical tests to ensure it was adequate and reliable. These tests, which included assessments like Average Variance Extracted (AVE), Composite Reliability (CR), and Cronbach's alpha (α), are detailed in Table 4.1. All the constructs passed these preliminary tests, confirming that the data was suitable for further analysis using Confirmatory Factor Analysis (CFA) (Hair et al., 2017). The formulas for calculating AVE, CR, and α are provided in equations 4.1, 4.2, and 4.3, respectively.

Average Variance Extracted (AVE):

$$AVE = \frac{\sum Squared\ Loading\ of\ Indicators\ on\ Latent\ Construct}{\sum Variance\ of\ Latent\ Construct}$$

$$Ave = \frac{\sum x_2}{\sum_{Latent}} \qquad 4.1$$

Where Λ_2 = the loading of indicator *i* on the latent construct and

α^2_{Latent} = the variance of the latent construct.

Composition Reliability (CR):

$$CR = \frac{\sum Squared\ Loading\ of\ Indicators\ on\ Latent\ Construct}{\sum Square\ Loading\ of\ Indicators\ on\ Latent\ Construct + \sum Measurement\ Error}$$

$$CR = \frac{\sum_2 x_2}{\sum_1 x_1^2 \sum_1} \qquad 4.2$$

Where Λ_2 = the loading of indicator *i* on the latent construct, and

δi = the measurement error

Cronbach's Alpha (α):

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum Variance\ of\ Measurement\ Error}{\sum Total\ Variance}\right)$$

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum \alpha^2}{\sum \alpha^2_{total}}\right) \qquad 4.3$$

Where α^2_{total}= the total variance and

α^2_{terror} = the variance of measurement error

Table 3. Preliminary Data Analyses

	CONSTRUCTS	CR	AVE	(α)
1	Environmental Sustainability (ENS)	0.662	0.761	0.640
2	Social Sustainability (SS)	0.721	0.682	0.630
3	Economic Sustainability (ES)	0.671	0.830	0.753
4	Environmental Sustainability Challenges (ENSC)	0.853	0.771	0.812
5	Social Sustainability Challenges (SSC)	0.780	0.822	0.751
6	Economic Sustainability Challenges (ESC)	0.710	0.801	0.690

4.3 Current Sustainable Construction Practices in Nigeria

The data analyses to determine the current sustainable construction practices in Nigeria was carried using CFA in LISREL using SIMPLEX Project. In the context of CFA within the LISREL framework, the model can be represented as follows: Let's consider a measurement model with observed variables (indicators) *Xi* and latent factors *Fj*. The model assumes that the observed variables are linear combinations of the latent factors plus error terms. The model can be expressed as:

$Xi = \Lambda ijFj + \varepsilon i$ 4.4

where:

Xi = the observed variable,

Fj = the latent factor,

Λij= the factor loading representing the strength of the relationship between the latent factor and the observed variable,

εi = the error term associated with the observed variable.

Figure 4.1 shows the result of the structural model of the analysis with the factor loadings, covariance and measurement errors indicated.

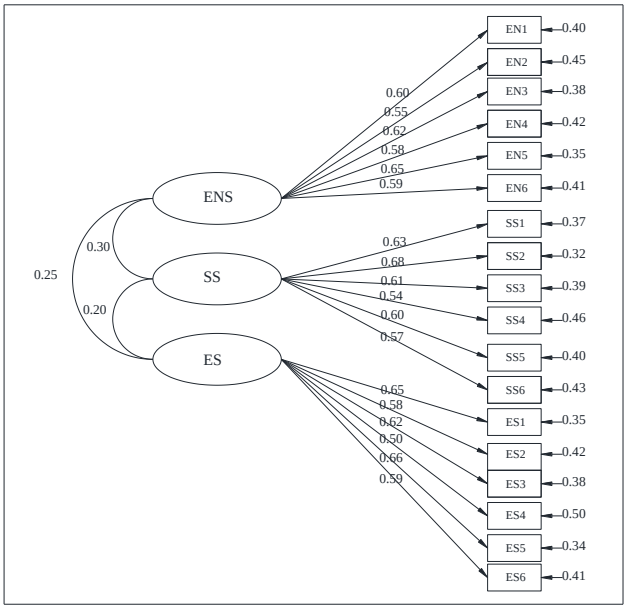

Figure 1. CFA for Current Sustainable Construction Practices in Nigeria

Environmental Sustainability

The results showed that environmental sustainability practices (EN1-EN6) had factor loadings between 0.55 and 0.65, indicating a moderate to weak emphasis on these practices among the surveyed companies. This suggests that while there is some attention to environmental sustainability, it is not a strong focus. Similar findings have been reported in other studies, such as Olanrewaju et al. (2020), who noted that the adoption of environmentally sustainable practices in Nigeria is still limited. One possible reason for this could be the higher costs and limited availability of eco-friendly materials, as discussed by Agboola et al. (2021).

Social Sustainability

Social sustainability practices (SS1-SS6) showed similar moderate to weak associations, with factor loadings ranging from 0.54 to 0.68. This suggests that social considerations, such as community engagement and worker welfare, are somewhat acknowledged but not consistently applied. Agyekum et al. (2019) found that social sustainability often takes a back seat to economic priorities in construction projects, which is consistent with the findings of this study. The variability in these practices might be due to inconsistent policies or a lack of strong incentives to prioritize social outcomes (Aduwo et al., 2021).

Economic Sustainability

Economic sustainability variables (ES1-ES6) had factor loadings ranging from 0.50 to 0.66, indicating that economic sustainability practices are not uniformly adopted across the surveyed companies. This finding echoes the challenges highlighted by Ofori and Toor (2020), who pointed out the difficulty of balancing long-term financial viability with the upfront costs of implementing sustainable practices. The elevated measurement errors (ranging from 0.34 to 0.50) suggest that these practices are applied inconsistently, possibly due to the financial uncertainties and risks associated with sustainable construction (Nduka & Ogunsanmi, 2019). These findings highlight a significant need for stronger strategies and support systems to better integrate sustainability practices in Nigeria's construction industry. This is crucial as Nigeria seeks to align its construction practices with global sustainability standards, such as those outlined in the United Nations Sustainable Development Goals (SDGs).

Sustainability Challenges of Construction Projects in Nigeria

The CFA model for analyzing sustainability challenges in Nigerian construction projects was developed using the methodology outlined in Section 4.3. During the model refinement, 12 variables were removed to achieve a final model that effectively highlights the most significant challenges

Environmental Sustainability Challenges

The results showed that challenges like "Minimizing energy consumption" (Loading: 0.80) and "Minimizing carbon emissions" (Loading: 0.72) were strongly associated with the environmental sustainability challenges construct. This suggests that these are major hurdles in the industry. Similar challenges have been identified in other studies, such as Onyekachi et al. (2020), who noted that energy management and reducing carbon footprints are significant issues in Nigerian construction projects. The strong associations found in this study underscore the need for better regulatory support and incentives to help companies overcome these challenges (Al-Saadi et al., 2021).

Social and Economic Sustainability Challenges

Social challenges, such as "Ensuring occupational health and safety" (Loading: 0.75), and economic challenges, like "Conducting cost-benefit analyses for sustainability" (Loading: 0.78), also showed strong associations with their respective constructs. These findings align with research by Olanipekun and Xia (2018), which highlighted that health, safety, and financial assessments are critical barriers to sustainability in construction. The high factor loadings indicate that these challenges are widely recognized and must be addressed to improve sustainability outcomes. Similar findings by Badi and Murtagh (2019) suggest that financial constraints and inadequate safety measures are common obstacles in achieving sustainable construction.

Overall, the consistent factor loadings across various sustainability challenges (ranging from 0.72 to 0.85) indicate that these issues are pervasive and require significant attention. The most pressing challenges identified include managing water usage and determining the economic impact of sustainability practices. The study's findings suggest that while contractors are aware of these sustainability challenges, there is still a need for more effective strategies and support to address them. This awareness is crucial for informed decision-making and developing targeted interventions, as emphasized by Oyedele (2019).

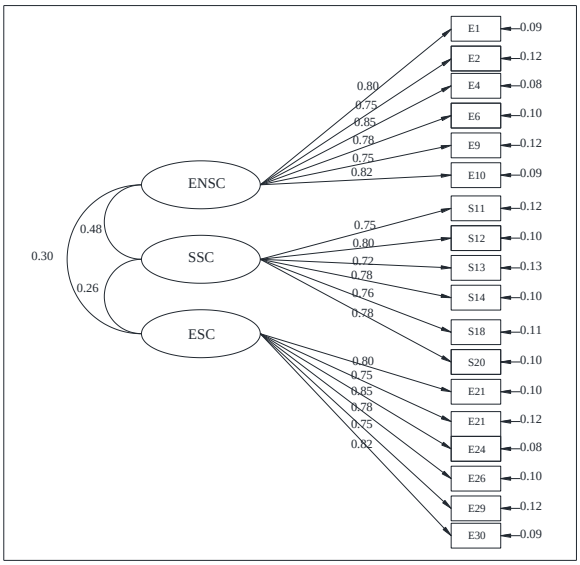

Figure 2 CFA for Sustainability Challenges of Construction Projects

Conclusion

The CFA analysis of sustainable construction practices in Nigeria provides critical insights into the current state of environmental, social, and economic sustainability within the construction industry. The results reveal that the connections between the observed practices and their intended sustainability goals are generally moderate to weak, indicating varying levels of implementation and commitment across different dimensions. Environmental sustainability practices, in particular, are not as strongly emphasized, suggesting that efforts to minimize environmental impact are inconsistent and perhaps underprioritized. Social sustainability practices show a mixed level of application, with some areas receiving attention while others lag behind. Similarly, economic sustainability practices are not uniformly adopted, reflecting a lack of consistent strategy across the construction sector. The presence of significant measurement errors further points to potential inconsistencies and challenges in executing these practices effectively.

These findings highlight the multifaceted nature of sustainability challenges within the Nigerian construction sector and underscore the urgent need for targeted interventions. To address these challenges, it is crucial for policymakers and industry stakeholders to implement comprehensive sustainability strategies. These should include the development of robust regulatory frameworks that enforce sustainable practices, capacity-building initiatives to equip professionals with the necessary skills and knowledge, and incentives that encourage companies to prioritize sustainability in their operations. Additionally, fostering greater collaboration among industry stakeholders is essential for sharing best practices and driving collective action toward sustainability goals.

Investing in research and development is another key recommendation. By supporting innovation and the exploration of new, more sustainable construction methods and materials, the industry can overcome existing barriers and move toward more effective sustainability practices. Moreover, integrating sustainability into the education and training of construction professionals will ensure that future industry leaders are well-prepared to implement and advocate for sustainable practices.

Future research should build on the findings of this study by employing longitudinal designs to monitor how sustainability practices evolve over time. This approach would allow for a deeper understanding of the long-term effectiveness of the interventions recommended in this study. Additionally, comparative studies across different regions or countries could provide valuable insights into the contextual factors that influence the adoption and success of sustainability practices. Such research could help identify best practices that can be adapted to the Nigerian context.

Furthermore, qualitative research methods, including interviews and focus groups, should be employed to complement quantitative findings. These methods can provide a richer, more nuanced understanding of the socio-cultural and institutional dynamics that shape sustainability practices in Nigeria's construction sector. Understanding these dynamics is crucial for designing interventions that are not only effective but also culturally and contextually appropriate.

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