ASSESSING SUSTAINABLE CONSTRUCTION PRACTICES IN NIGERIA: CHALLENGES, OPPORTUNITIES, AND STRATEGIES FOR ADVANCEMENT

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ABSTRACT

The Nigerian construction industry stands at a critical juncture, facing challenges and opportunities in its journey towards sustainable development. This study aims to investigate the current state of sustainable construction practices and sustainability challenges in Nigeria, with a focus environmental, social and economic domains. Three hundred and fifty questionnaires were distributed to respondents from the construction companies used for the study out which three hundred and thirty seven were utilized for data analyses in Linear Structural Relation (LISREL) using Confirmatory Factor Analyses tool. The result of the data analyses indicates a moderate to weak sustainable construction practices with the factor loadings ranging from 0.55 to 0.65 for the variables across all the constructs. This implies inconsistent practices or lack of commitment to sustainable construction practices by the construction companies. The result also shows high level of sustainability challenges with environmental sustainability challenges emerging the highest of threat followed by social sustainability and economic sustainability challenges. The result reflects a relatively positive scenario where the respondents are aware of and acknowledge sustainability challenges. These findings offer critical insights for policymakers, industry practitioners, and researchers seeking to enhance sustainability efforts within the Nigerian construction sector, guiding strategic interventions and decision-making processes to address sustainability challenges effectively and foster a more sustainable construction industry.

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

1.0 INTRODUCTION

Sustainable construction practices have emerged as a pivotal aspect of the global construction industry, driven by growing concerns over environmental degradation, resource depletion, and social equity. In Nigeria, where rapid urbanization and infrastructure development are ongoing, the adoption of sustainable construction practices is increasingly recognized as essential [1]. Sustainable construction, often referred to as green building or eco-construction, adopts a holistic approach toward the design, construction, operation, and maintenance of buildings and infrastructure. The overarching

goal is to minimize environmental impact, conserve resources, and enhance social well-being [2,3]. This paradigmatic shift toward sustainability is grounded in various principles and strategies aimed at reducing the ecological footprint of the built environment while fostering economic viability and societal equity.

Central to sustainable construction are multifaceted principles that address key environmental concerns. Energy efficiency is a cornerstone, emphasizing the optimization of energy consumption through passive design strategies, the utilization of energy-efficient technologies, and the adoption of renewable energy sources [4,5]. Additionally, water conservation practices are critical, aiming to reduce water consumption, enhance water quality, and manage stormwater runoff through measures such as low-flow fixtures, rainwater harvesting, and water recycling [6]. Waste reduction is also a fundamental tenet, promoting the minimization of construction and demolition waste through recycling, reuse, and responsible material sourcing [4]. Embracing the ethos of sustainability further involves prioritizing the use of renewable materials, such as sustainably sourced timber, bamboo, and recycled aggregates, thereby reducing dependence on finite resources and mitigating environmental damage related to resource extraction [7].

Sustainable construction practices extend beyond environmental concerns to encompass social and economic dimensions. These practices emphasize creating healthy, inclusive, and livable spaces that prioritize occupant well-being and comfort while fostering community engagement and social cohesion [2,5]. At the same time, sustainable construction practices enhance economic resilience and competitiveness by optimizing life-cycle costs, minimizing operational expenses, and unlocking new market opportunities driven by the increasing demand for sustainable built environments [8].

In Nigeria, the construction industry is undergoing a period of rapid expansion, driven by factors such as population growth, urbanization, and ambitious infrastructure development projects [9,10]. While this growth presents opportunities for economic development and improved living standards, it also brings significant challenges, such as environmental degradation, resource depletion, and social disparities [11]. For instance, unchecked construction activities contribute to rising pollution, deforestation, and land degradation [12,13].

The challenges posed by rapid urbanization and unsustainable construction practices have made the adoption of sustainable construction practices a critical priority for Nigeria. Sustainable construction offers a holistic approach to building that prioritizes environmental responsibility, resource efficiency, and social equity [4,3]. By integrating principles such as energy efficiency, waste reduction, and social inclusivity, sustainable practices aim to minimize negative environmental and social impacts while fostering long-term resilience and prosperity [6].

Sustainable construction in Nigeria also aligns with broader national development goals, including sustainable economic growth, infrastructure resilience, and climate change mitigation [9,1]. As Nigeria strives to achieve its sustainable development objectives outlined in frameworks like the Sustainable Development Goals (SDGs) and the Paris Agreement, the integration of sustainable construction practices becomes imperative for aligning the construction sector with national priorities [8,13].

This research seeks to conduct a comprehensive assessment of the current state of sustainable construction practices in Nigeria, while identifying the challenges hindering their widespread adoption. The study aims to examine existing practices within the construction sector, analyze prevailing trends and patterns, and propose strategic interventions to advance sustainable construction practices in Nigeria [12]. By addressing the barriers to adoption and leveraging opportunities, this research will provide actionable recommendations for fostering sustainability within Nigeria's construction industry.

2.0 LITERATURE REVIEW

2.1 Definition and Principles of Sustainable Construction

Sustainable construction, often referred to as green building or eco-construction, is deeply rooted in the principles of environmental stewardship, economic viability, and social equity [2]. It encompasses a holistic approach to the design, construction, operation, and demolition of buildings and infrastructure with the overarching goal of minimizing negative impacts on the environment, conserving natural resources, and enhancing societal well-being [4]. At its core, sustainable construction seeks to create built environments that are environmentally responsible, economically feasible, and socially equitable.

Central to the concept of sustainable construction are several key principles that guide decision-making and practices throughout the building lifecycle [2]. Firstly, energy efficiency is prioritized to reduce energy consumption and minimize greenhouse gas emissions associated with building operations. This involves integrating passive design strategies, high-efficiency HVAC systems, and renewable energy technologies such as solar panels and wind turbines [4]. Secondly, water conservation is a fundamental principle aimed at minimizing water usage and reducing strain on local water resources. Sustainable construction practices include the implementation of water-efficient fixtures, rainwater harvesting systems, and greywater recycling technologies to optimize water usage within buildings and reduce demand on municipal water supplies [2].

Thirdly, waste reduction is emphasized to minimize construction and demolition waste sent to landfills. Strategies for waste reduction include the use of prefabricated and modular construction methods, material reuse and recycling, and construction waste management plans to divert waste from landfill disposal and promote resource conservation [4]. Moreover, the use of renewable and low-impact materials is a key principle of sustainable construction, aiming to reduce the environmental footprint of building materials and minimize embodied carbon emissions. This involves selecting materials with low environmental impact, such as sustainably sourced timber, recycled content materials, and non-toxic finishes, as well as exploring innovative materials with improved environmental performance [2]. Finally, social equity and economic viability are essential considerations in sustainable construction, ensuring that built environments are accessible, safe, and inclusive for all members of society. This includes promoting healthy indoor environments, providing affordable housing options, and fostering community engagement throughout the design and construction process [4].

2.2 Global Trends and Practices in Sustainable Construction

Sustainable construction has emerged as a vital response to global challenges such as climate change, resource depletion, and environmental degradation. This trend has gained significant traction worldwide, with various innovative practices and initiatives being adopted to promote sustainability within the construction industry. One prominent aspect of this global movement is the widespread adoption of green building certification systems, which serve to incentivize and recognize environmentally friendly building practices [14]. Among the most widely recognized certification systems are LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and Green Star. These frameworks provide comprehensive guidelines and benchmarks for sustainable building design, construction, operation, and maintenance, thus driving the integration of sustainable principles into building projects on a global scale.

In addition to certification systems, sustainable construction practices encompass a wide range of strategies aimed at reducing environmental impact and promoting resource efficiency. Passive design strategies, for instance, involve optimizing building orientation, layout, and envelope design to maximize natural lighting, ventilation, and thermal comfort, thereby minimizing the need for mechanical heating, cooling, and lighting [4]. Energy-

efficient HVAC (heating, ventilation, and air conditioning) systems further contribute to energy savings and carbon emissions reduction by utilizing advanced technologies and control strategies to optimize indoor environmental quality while minimizing energy consumption.

Another key aspect of sustainable construction is the utilization of recycled and low-impact materials in building projects. This entails sourcing materials from renewable or sustainable sources, as well as utilizing recycled content wherever feasible to minimize the depletion of natural resources and reduce waste generation [14]. Additionally, the implementation of renewable energy technologies, such as solar photovoltaics, wind turbines, and geothermal heating systems, plays a crucial role in enhancing the energy performance and environmental sustainability of buildings. These technologies harness clean, renewable energy sources to meet building energy needs while reducing reliance on fossil fuels and mitigating greenhouse gas emissions.

2.3 Sustainable Construction in Nigeria

Numerous scholarly investigations have delved into sustainable construction practices in Nigeria, shedding light on the multifaceted challenges and opportunities within the industry. Oluwatobi *et al*. conducted an in-depth assessment of sustainable construction practices, particularly from the perspective of quantity surveyors [9]. Their study identified several barriers impeding the widespread adoption of sustainable construction in Nigeria, including a lack of awareness among stakeholders, high initial costs associated with green building materials and technologies, and regulatory constraints hindering the implementation of sustainable practices. These findings underscore the need for targeted interventions to address these barriers and foster a conducive environment for sustainable construction development. Furthermore, Shen *et al*. offered valuable insights into the policy landscape surrounding green construction in Nigeria [4]. Through their comprehensive review, they highlighted the crucial role of government initiatives and industry collaboration in driving the advancement of sustainable construction practices. Their study emphasized the necessity for robust policy frameworks that incentivize and mandate sustainable building practices while also advocating for enhanced cooperation among various stakeholders to facilitate knowledge sharing and capacity building.

2.4 Challenges Faced in Implementing Sustainable Construction Practices in Nigeria

Implementing sustainable construction practices in Nigeria is hindered by a myriad of challenges. Firstly, inadequate policy frameworks pose a significant barrier, as there is a lack of comprehensive regulations and incentives to encourage the adoption of sustainable building practices [4]. Secondly, limited access to finance for green projects inhibits investment in sustainable construction initiatives, as financial institutions often perceive these projects as risky or unprofitable [12]. Thirdly, the construction industry in Nigeria faces a shortage of skilled labor and technical expertise in sustainable construction methods, hindering the successful implementation of green building projects [4]. Moreover, unreliable supply chains for sustainable materials exacerbate the challenge, as access to environmentally friendly building materials is often limited or inconsistent [12]. Additionally, cultural preferences for traditional construction methods present a barrier to the adoption of sustainable practices, as there is often resistance to change and a lack of awareness about the benefits of green building [4]. Addressing these challenges requires a multifaceted approach, involving collaboration between government agencies, financial institutions, industry stakeholders, and educational institutions to develop supportive policies, improve access to financing, enhance vocational training programs, strengthen supply chains, and raise awareness about the importance of sustainable construction practices [4,12].

2.5 Opportunities for Sustainable Construction in Nigeria

In Nigeria, despite the formidable challenges, there exist substantial opportunities for the advancement of sustainable construction practices. The country's rapid urbanization, driven by population growth and rural-to-urban migration, has resulted in a surge in construction activities, creating a conducive environment for the adoption of sustainable practices [9]. Additionally, there is a growing awareness of environmental issues among both policymakers and the general populace, spurred by global concerns over climate change and environmental degradation. This heightened awareness has led to increased support for sustainability initiatives and policies aimed at promoting environmentally friendly construction practices [12].

Furthermore, Nigeria has made commitments to international agreements such as the Paris Agreement on climate change, signaling the government's intention to mitigate greenhouse gas emissions and promote sustainable development. These commitments have translated into policy interventions and incentives designed to encourage the adoption of sustainable construction methods and technologies [4]. For instance, the Nigerian government has introduced initiatives such as tax breaks and subsidies for green building projects, as well as regulatory frameworks that mandate the incorporation of sustainable design principles in public infrastructure projects.

Moreover, Nigeria's burgeoning renewable energy sector presents significant opportunities for integrating renewable energy solutions into building design and construction. The country boasts abundant renewable resources, including solar and wind, which can be harnessed to power sustainable buildings and reduce reliance on fossil fuels [4]. The declining costs of renewable energy technologies, coupled with government incentives and favorable regulatory frameworks, make it increasingly feasible to incorporate solar panels, wind turbines, and other renewable energy systems into building designs.

In addition to environmental considerations, there are also economic incentives driving the adoption of sustainable construction practices in Nigeria. With growing investor interest in sustainability and corporate social responsibility, there is a rising demand for green buildings and infrastructure projects. Investors are increasingly recognizing the long-term cost savings and market advantages associated with sustainable developments, leading to greater investment in green construction projects [12].

2.6 Strategies and Best Practices for Advancing Sustainable Construction in Nigeria

In order to advance sustainable construction in Nigeria, a multifaceted approach involving various strategies and best practices is essential. Firstly, strengthening policy frameworks and regulatory incentives is crucial to promoting sustainable building practices. Shen *et al*. emphasize the need for robust government initiatives and regulations to drive the adoption of green construction practices [4]. These policies can include mandates for energy efficiency standards, waste management regulations, and incentives for green building certification. Secondly, increasing public awareness and education about the benefits of sustainable construction is imperative. Oluwatobi *et al*. stress the importance of advocacy and capacity-building programs to educate stakeholders, including developers, contractors, and the general public, about the environmental and economic advantages of green building practices [9].

Thirdly, facilitating access to financing mechanisms and incentives is vital for encouraging investment in green building projects. Olajide and Ogunsemi highlight the significance of financial incentives such as tax breaks or subsidies to offset the initial costs of sustainable construction and make it more financially attractive for stakeholders [12]. Moreover, promoting research and development in green building technologies and materials is essential for enhancing efficiency and reducing costs. Goubran *et al*. emphasize the role of innovation in driving sustainable construction forward, with advancements in

materials science, construction techniques, and renewable energy solutions [14]. Lastly, fostering collaboration among stakeholders is critical for driving collective action towards sustainable construction goals. Shen *et al*. underscore the importance of partnerships between government agencies, industry players, academia, and civil society to coordinate efforts, share best practices, and address common challenges in the transition to sustainable construction practices [4]. By implementing these strategies and best practices, Nigeria can overcome barriers and capitalize on opportunities to achieve a more sustainable built environment.

2.7 Review of Related Studies

2.7.1 Studies on Sustainable Construction Practices in Nigeria

[4] conducted a comprehensive review of green construction policy framework development in Nigeria. The authors employed a qualitative research approach to examine the evolution and effectiveness of green construction policies in Nigeria. Their findings shed light on the progress made in policy formulation and implementation to promote sustainable construction practices in the country. However, a potential critique of the study could be the need for more detailed analysis of the challenges encountered in policy implementation and the potential barriers hindering the effectiveness of these policies in achieving sustainable outcomes.

[15] assessed construction waste management practices among building contractors in Lagos State, Nigeria. Using a case study approach, the authors investigated the current waste management practices employed by contractors in Lagos State. Their study reveals significant deficiencies in waste management processes, emphasizing the urgent need for improved regulations, training programs, and infrastructure to address construction waste challenges effectively. However, a potential limitation of the study could be the narrow geographical scope, warranting further research to generalize findings across Nigeria's construction industry.

[16] examined the economic sustainability of green building construction in Nigeria. Employing a quantitative research approach, the authors conducted a cost-benefit analysis of green building projects in Nigeria to assess their economic viability. Their study provides valuable insights into the financial implications of sustainable construction and highlights the potential long-term economic benefits for stakeholders. However, further research could explore additional factors influencing economic sustainability, such as market demand, government incentives, and lifecycle cost considerations.

2.7.2 Studies on Policy and Regulation in Sustainable Construction

[17] investigated the economic implications of sustainable building construction in Lagos, Nigeria. Utilizing a mixed-methods approach, the authors analyzed the cost and benefits of green building projects in Lagos to evaluate their economic feasibility. Their study underscores the importance of considering both short-term costs and long-term benefits in assessing the economic viability of sustainable construction. Nonetheless, future research could explore the specific financial mechanisms and incentives necessary to encourage greater investment in green building projects in Nigeria.

[18] conducted a comparative analysis of sustainable construction practices in Nigeria, focusing on energy efficiency in buildings]. Employing a quantitative research approach, the authors evaluated the energy performance of green buildings compared to conventional structures in Nigeria. Their study highlights the potential energy savings and environmental benefits associated with sustainable construction practices. However, a potential limitation of the study could be the need for more comprehensive data on building energy consumption and performance to generalize findings across different regions and building types in Nigeria.

2.7.3 Studies on Economic Aspects of Sustainable Construction

[19] conducted a comparative analysis of green building certification systems in Nigeria, using a qualitative research approach. The authors compared the criteria, requirements, and effectiveness of various green building certification systems in Nigeria. Their study provides valuable insights into the strengths and weaknesses of different certification systems and their applicability to the Nigerian context. However, further research could explore the perceptions and experiences of stakeholders, such as developers, architects, and building occupants, regarding the benefits and challenges of green building certification in Nigeria.

[20] evaluated green building certification systems in Nigeria, focusing on selected projects. Employing a mixed-methods approach, the authors assessed the performance and effectiveness of green building certification systems in achieving sustainable outcomes. Their study offers practical recommendations for improving the implementation and enforcement of green building standards in Nigeria. However, future research could explore the role of government policies and incentives in promoting greater adoption of green building practices among developers and construction firms in Nigeria.

2.7.4 Studies on Environmental Aspects of Sustainable Construction

[21]. explored the challenges associated with building energy efficiency regulations in Nigeria. Through qualitative research methods, the authors investigated the regulatory landscape governing energy efficiency in the built environment. Their findings reveal significant barriers to the effective implementation of energy efficiency standards, including limited enforcement mechanisms, inadequate institutional capacity, and lack of public awareness. The study highlights the importance of strengthening regulatory frameworks and enhancing stakeholder engagement to overcome these challenges and promote energy-efficient building practices in Nigeria.

[22] investigated the impact of environmental regulations on construction firms in Lagos, Nigeria. Using quantitative research methods, the authors analyzed the compliance costs incurred by construction companies to adhere to environmental regulations. Their study identified various factors influencing firms' compliance behavior, including regulatory complexity, enforcement mechanisms, and perceived business risks. The findings underscore the need for regulatory reforms and support mechanisms to facilitate firms' compliance with environmental standards while minimizing associated costs.

2.7.5 Studies on Social Aspects of Sustainable Construction

[23] examined the nexus between sustainable development and the construction industry in Nigeria. Through a qualitative analysis of industry trends and practices, the authors explored the potential contributions of the construction sector to sustainable development goals in Nigeria. Their study highlights the importance of integrating environmental, social, and economic considerations into construction activities to achieve sustainable outcomes. The findings underscore the need for holistic approaches and multi-stakeholder collaboration to promote sustainable development in the Nigerian construction industry.

[24] investigated waste management practices among building contractors in Lagos State, Nigeria. Through a case study approach, the authors assessed the current waste management strategies employed by contractors and identified challenges and opportunities for improvement. Their study reveals significant gaps in waste segregation, recycling, and disposal practices, highlighting the need for enhanced awareness, training, and infrastructure to address construction waste challenges effectively. The findings contribute to the growing body of literature on sustainable construction practices in Nigeria and underscore the importance of integrating waste management into construction processes.

2.7.6 Studies on Technology and Innovation in Sustainable Construction

[25] investigated the adoption of Building Information Modeling (BIM) technology in Nigeria's construction industry. Through a mixed-methods approach, the authors assessed the prospects and challenges of BIM implementation, drawing insights from industry stakeholders. Their study highlights the potential benefits of BIM, such as improved collaboration, efficiency, and decision-making, while also identifying barriers to adoption, including cost, technical complexity, and resistance to change. The findings contribute to the emerging literature on digital technology adoption in construction and offer practical recommendations for promoting BIM uptake in Nigeria.

In their study, [26]. investigated the adoption of sustainable construction practices in selected building projects in Lagos, Nigeria. Using a case study approach, the authors analyzed the extent to which sustainable practices are integrated into construction projects and identified factors influencing adoption decisions. Their findings revealed both challenges and opportunities for sustainable construction in Lagos, including limited awareness, high initial costs, and the availability of sustainable materials. The study contributes to the understanding of barriers to adoption and underscores the importance of addressing these challenges to promote sustainable development in the Nigerian construction industry.

2.8 Research Gaps

Sustainable construction practices have garnered increasing attention worldwide due to their potential to mitigate environmental degradation and enhance socio-economic development. In the context of Nigeria, a country undergoing rapid urbanization and infrastructure development, the adoption of sustainable construction practices is crucial. While existing literature has provided valuable insights into various aspects of sustainable construction in Nigeria, there remains a notable research gap that necessitates further investigation.

One significant research gap pertains to the lack of comprehensive studies examining the integration of sustainable construction practices across the entire construction lifecycle in Nigeria. While some studies have focused on specific aspects such as green building certification systems [9] or policy frameworks [4], there is a scarcity of research that holistically evaluates the implementation of sustainable practices from design and construction to operation and maintenance phases. This gap hinders a thorough understanding of the challenges and opportunities associated with sustainable construction throughout the entire project lifecycle.

Furthermore, there is limited empirical research exploring the perceptions and attitudes of various stakeholders towards sustainable construction in Nigeria. While quantitative assessments have been conducted to identify barriers to adoption [9], there is a dearth of qualitative studies that delve into the perspectives of key stakeholders such as policymakers, developers, contractors, and end-users. Understanding these stakeholders' motivations, priorities, and concerns is essential for designing effective strategies to promote sustainable construction practices.

Moreover, while previous studies have highlighted challenges faced in implementing sustainable construction practices in Nigeria [4,12], there is limited research on innovative solutions and best practices that have been successfully employed to overcome these challenges. Examining case studies of successful sustainable construction projects and identifying the strategies employed to address barriers could provide valuable insights for replication and scaling up of sustainable practices in the Nigerian construction industry.

Lastly, there is a need for longitudinal studies that track the impact of sustainable construction initiatives over time. While some studies have assessed the immediate outcomes of green building projects [9], longitudinal research can provide insights into the long-term environmental, economic, and social benefits of sustainable construction practices in Nigeria. Understanding the sustained impact of these initiatives is critical for

policymakers, investors, and industry stakeholders to make informed decisions and prioritize investments in sustainable construction.

3.0 METHODOLOGY

3.1 Research Design

The research approach adopted for this study is the quantitative research approach, using a questionnaire as the primary instrument for data collection. Quantitative research involves the collection and analysis of numerical data to identify patterns and trends in a given population. The goal is often to establish cause-and-effect relationships and to test hypotheses [31]. The research strategy adopted is survey research, which entails the collection of data from a sample of respondents using standardized questionnaires [32]. In this study, a structured survey was conducted to gather data used in answering the research questions.

The structured questionnaires were distributed to a sample of construction professionals and stakeholders in Nigeria's construction industry, including contractors and consultants. Participants in this study included professionals such as architects, engineers, project managers, and contractors. A sample was selected using a purposeful sampling technique to target respondents with relevant experience and knowledge.

An alternative research approach is the mixed-methods approach, which integrates both quantitative and qualitative methods [33,34]. However, the quantitative research design was selected for this study due to its ability to generate numerical data suitable for statistical analysis and generalization [31].

3.2 Population and Sample Size

This study focused on a population of 24 construction companies, comprising 645 project management personnel actively involved in construction projects in the North Central Geopolitical Zone of Nigeria, as identified by the *Construction Industry Report* [35].

To determine an appropriate sample size, Yamane's formula was employed. Yamane's formula is a widely used method for calculating sample size when the population is known [36]. The formula is written as:

$$n = N / [1 + N * (e^2)] \quad (3.1)$$

Where:
n = the sample size
N = the population size (645)
e = the level of precision (0.05)
Using a confidence level of 95% and a precision of 5%, the calculation proceeds as follows:

$$n = 645 / [1 + 645 * (0.05)^2]$$
$$n = 645 / [1 + 1.6125]$$
$$n = 645 / 2.6125$$
$$n \approx 248$$

Thus, the sample size for the project management personnel is approximately 248, while the sample size for construction companies is 10. For this study, a purposive sampling technique was employed to select participants. Purposive sampling is a non-probability method in which individuals are intentionally chosen based on their relevance to the research topic [37]. In this case, participants with at least five years of professional experience and direct involvement in construction projects and sustainable practices in Nigeria's construction industry were purposefully selected to ensure informed and context-specific responses.

3.3 Data Collection Procedure

The primary data for this research was collected using a structured survey questionnaire, which was administered manually to the selected participants. The questionnaire was divided into three sections to facilitate the systematic collection of relevant information. The first section gathered demographic information and background data on the respondents and their companies. The second and third sections focused on identifying the key sustainability challenges in Nigeria's construction industry and assessing the current sustainable construction practices adopted by construction companies. These sections were designed to elicit responses based on a five-point Likert scale, where 1 represents "Strongly Disagree," 2 represents "Disagree," 3 stands for "Neutral," 4 indicates "Agree," and 5 denotes "Strongly Agree."

The questionnaire items in Sections 2 and 3 were adapted from established instruments previously validated in the literature. The content was drawn from the works of Chen *et al*. [38], Jallow and Osei-Kyei [39], Poon *et al*. [40], Sun *et al*. [41], and Zuo *et al*. [42], which focused on sustainability assessment and practices in the construction industry. Tables 1 to 4 present the structured data obtained from contractors and consultants, respectively, and provide the basis for subsequent analysis in this study.

Table 1: Questionnaire for contractors on the current sustainability practices in the construction Industry

No.	VARIABLES
	Environmental Sustainability
1	Our construction projects prioritize the use of sustainable and eco-friendly materials.
2	We implement practices to minimize energy consumption during construction.
3	Proper waste management practices are integrated into our construction processes.
4	We take measures to reduce the carbon footprint of our construction projects.
5	Environmental impact assessments are regularly conducted for our construction projects.
6	We actively promote the conservation of natural resources in our construction practices.
	Social Sustainability
7	Health and safety of our workers are a top priority in our construction projects.
8	We engage with local communities and consider their input in our projects.
9	Our construction projects contribute positively to the well-being of nearby residents.
10	We ensure diversity and inclusion in our workforce and project teams.
11	Cultural heritage and historical aspects are respected in our construction projects.
12	Our projects create opportunities for skill development in local communities.
	Economic Sustainability
13	We strive to optimize project costs without compromising quality.
14	Our projects consider life cycle costing for long-term financial viability.
15	We implement efficient resource management to control project expenses.
16	Economic benefits are generated for local economies through our projects.
17	We aim to achieve a balanced return on investment for our construction projects.
18	Financial risks associated with sustainability practices are carefully assessed.

Table 2: Questionnaire for consultants on the current sustainability practices in the construction Industry

No.	VARIABLES
	Environmental Sustainability
1	Our consultancy services emphasize the use of sustainable and eco-friendly materials.
2	We provide guidance to minimize energy consumption during construction processes.
3	Proper waste management practices are integrated into our recommendations.
4	We advise measures to reduce the carbon footprint of construction projects.
5	Environmental impact assessments are part of our consultancy services.
6	We advocate for the conservation of natural resources in our consulting approach.

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No.	VARIABLES
	Social Sustainability
7	Our recommendations prioritize the health and safety of workers during projects.
8	We encourage community engagement and consider public opinions in our advice.
9	Our consultancy contributes to the well-being of communities affected by projects.
10	Diversity and inclusion principles are integrated into our consulting services.
11	Cultural heritage and historical significance are considered in our recommendations.
12	Our guidance supports skill development opportunities in project-adjacent areas.
	Economic Sustainability
13	Our consultancy aims to optimize project costs without compromising quality.
14	We promote life cycle costing analysis for sustainable project financial planning.
15	Efficient resource management advice is part of our strategy to control expenses.
16	Our recommendations contribute to generating economic benefits for local economies.
17	We advocate for a balanced return on investment in our construction project advice.
18	Financial risks related to sustainability practices are included in our assessments.

Table 3: Questionnaire for contractors - key sustainability challenges

No.	Sustainability Challenge Categories and Questions
	Environmental Sustainability Challenges
1	Our projects face challenges in minimizing energy consumption.
2	We encounter difficulties in managing and reducing construction waste.
3	Environmental regulations pose challenges to our construction practices.
4	We struggle with minimizing water usage in construction projects.
5	Climate change adaptation measures are challenging to implement.
6	Challenges are faced in preserving local biodiversity.
7	Minimizing carbon emissions in construction is a complex task.
8	Sustainable transportation options pose challenges in our projects.
9	Energy-efficient technologies are challenging to integrate.
10	We encounter difficulties in managing construction materials sustainably.
	Social Sustainability Challenges
11	We face challenges in ensuring occupational health and safety.
12	Community engagement and relations pose challenges in our projects.
13	Balancing economic benefits with social responsibilities is challenging.
14	Challenges are encountered in promoting diversity and inclusion.
15	Preserving cultural heritage and historical sites poses challenges.
16	Collaboration with stakeholders for social sustainability is challenging.
17	Stakeholder feedback and influence are complex to manage.
18	Meeting social impact goals in projects is a challenging task.
19	Ensuring the well-being of local communities poses challenges.
20	Employee engagement for social sustainability is challenging.
	Economic Sustainability Challenges
21	Achieving cost efficiency in projects is challenging.
22	Life cycle costing considerations pose challenges.
23	Clients face difficulties in managing financial risks.
24	Demonstrating the economic impact of sustainability is challenging.
25	Financial return on investment (ROI) for sustainability is complex.
26	Clients find it challenging to conduct cost-benefit analyses for sustainability.
27	Sourcing sustainable materials at reasonable costs is difficult.
28	Clients face difficulties in budg*et al*location for sustainability initiatives.
29	Balancing economic returns with environmental and social goals is challenging.
30	Clients encounter challenges in managing the economic impact of government regulations.

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Table 4: Questionnaire for consultants - key sustainability challenge

No.	Sustainability Challenge Categories and Questions
	Environmental Sustainability Challenges
1	Our clients face challenges in minimizing energy consumption.
2	Clients encounter difficulties in managing and reducing construction waste.
3	Environmental regulations pose challenges to construction practices.
4	Clients struggle with minimizing water usage in construction projects.
5	Implementing climate change adaptation measures is challenging.
6	Clients face challenges in preserving local biodiversity.
7	Minimizing carbon emissions in construction is a complex task for clients.
8	Sustainable transportation options pose challenges for clients.
9	Integration of energy-efficient technologies is challenging.
10	Clients encounter difficulties in managing construction materials sustainably.
	Social Sustainability Challenges
11	Clients face challenges in ensuring occupational health and safety.
12	Managing community engagement and relations presents challenges for clients.
13	Balancing economic benefits with social responsibilities is challenging for clients.
14	Clients encounter difficulties in promoting diversity and inclusion.
15	Preserving cultural heritage and historical sites poses challenges for clients.
16	Facilitating collaboration with stakeholders for social sustainability is challenging for clients.
17	Managing stakeholder feedback and influence is complex for clients.
18	Clients find it challenging to meet social impact goals in projects.
19	Ensuring the well-being of local communities poses challenges for clients.
20	Employee engagement for social sustainability is challenging for clients.
	Economic Sustainability Challenges
21	Achieving cost efficiency in projects is challenging for clients.
22	Clients find it challenging to consider life cycle costing.
23	Managing financial risks presents difficulties for clients.
24	Demonstrating the economic impact of sustainability is complex for clients.
25	Clients find it challenging to realize financial ROI for sustainability.
26	Clients struggle with conducting cost-benefit analyses for sustainability.
27	Sourcing sustainable materials at reasonable costs is difficult for clients.
28	Clients encounter challenges in budg*et al*location for sustainability initiatives.
29	Balancing economic returns with environmental and social goals is challenging for clients.
30	Clients face difficulties in managing the economic impact of government regulations.

3.4 Method of Data Analysis

The data collected for this study underwent preliminary screening to identify and eliminate outliers and ensure the integrity of the dataset. Following this, the data were subjected to tests for reliability and validity. Reliability was assessed using the Composite Reliability (CR) index, while validity was evaluated through the Average Variance Extracted (AVE), both of which are widely accepted measures in structural equation modeling.

The analysis of the data was carried out in two distinct phases. The first phase involved examining the demographic characteristics of the respondents and their respective construction companies. This analysis was conducted using descriptive statistics through the Statistical Package for the Social Sciences (SPSS). The descriptive statistics helped to establish the background context of the participants, providing insight into the distribution of responses across key demographic variables.

The second phase focused on evaluating the sustainability challenges and current sustainable construction practices in Nigeria. This phase was executed using Confirmatory Factor Analysis (CFA) within the Linear Structural Relationship (LISREL) framework. CFA was employed to test the measurement models and assess the relationships among observed and latent variables, ensuring construct validity and model fitness.

A summary of the research methodology, including the data analysis procedure, is presented in Figure 1 to provide a visual representation of the step-by-step process followed in the study.

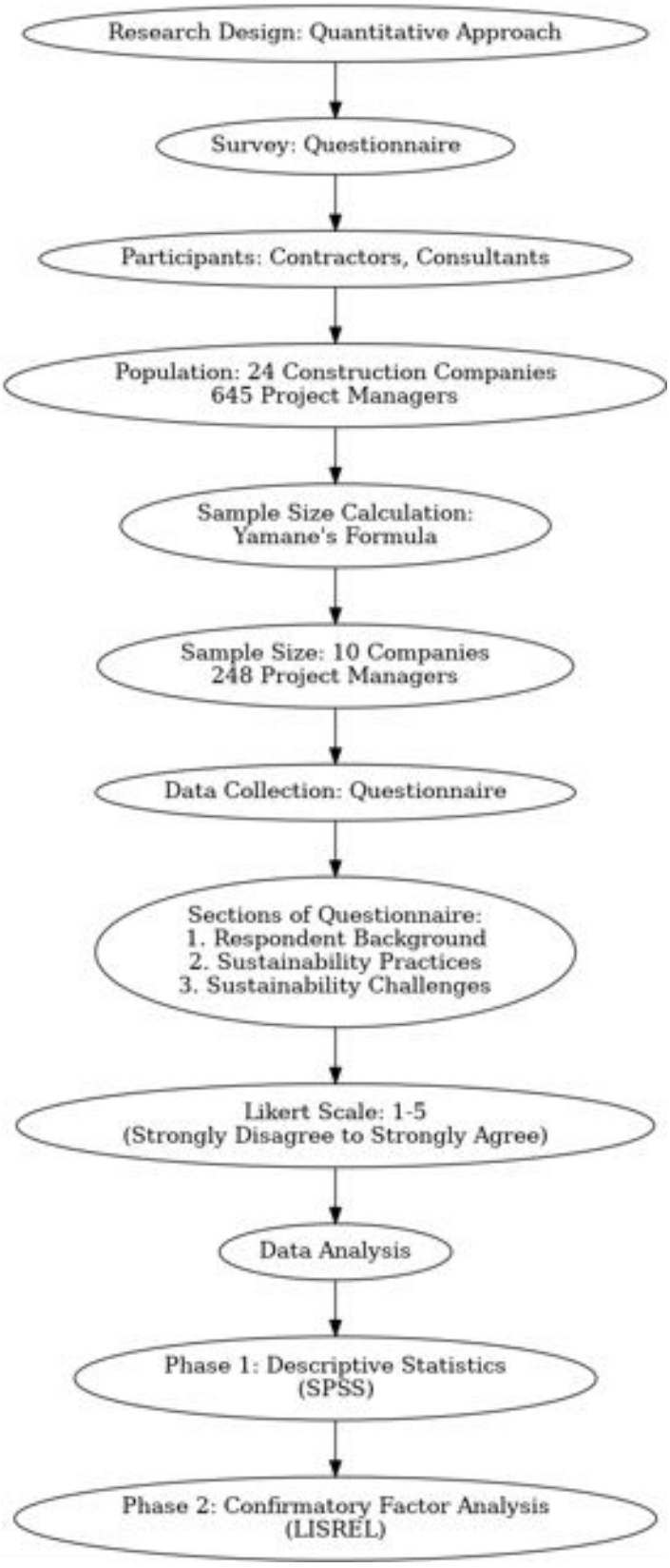

Figure 1: Flowchart for the research methodology

4.0 RESULTS AND DISCUSSION

4.1 Response Rate

A total of 237 valid responses were obtained from survey participants, yielding a response rate of 95.6%. This response rate is considered highly satisfactory for a survey-based study and aligns with the standards established by [43], who emphasized that response rates above 70% are generally acceptable for quantitative research in the construction industry. The disciplinary composition of the respondents revealed that 67.5% were from the Civil and Structural Engineering field, which corresponds with the findings of [44], who noted that professionals from these disciplines are often deeply involved in construction project execution and are well-positioned to provide informed responses on sustainability-related issues.

In terms of professional experience, 76.4% of the respondents reported having over five years of work experience. This level of experience is regarded as sufficient to allow for meaningful and informed assessments of sustainability variables. This view is supported by [45], who asserted that industry experience of five years or more significantly enhances the accuracy and depth of survey-based evaluations in construction-related research.

4.2 Preliminary Data Analyses

The initial stage of data analysis involved subjecting the collected data to various statistical tests to evaluate the adequacy of the sample size, relationships among variables, and the reliability of the constructs measured. These assessments included tests such as Average Variance Extracted (AVE), Composite Reliability (CR), and Cronbach's Alpha (α), which are essential for validating the measurement model by confirming that the indicators reflect the latent constructs accurately.

4.2.1 Average Variance Extracted (AVE)

The Average Variance Extracted (AVE) measures the amount of variance captured by the latent construct in relation to the variance due to measurement error. It assesses the convergent validity of the construct. The formula for AVE is as follows:

$$AVE = (\Sigma \text{ Squared Loadings of Indicators on Latent Construct}) / (\Sigma \text{ Variance of Latent Construct}) \quad (4.1)$$

Where:

Squared Loadings = the squared correlation of each indicator with the latent construct.

Variance of Latent Construct = the total variance explained by the latent construct.

A rule of thumb is that an AVE of at least 0.50 indicates that the construct explains a sufficient amount of variance in its indicators, ensuring acceptable convergent validity.

4.2.2 Composite Reliability (CR)

The Composite Reliability (CR) is used to measure the internal consistency of the indicators in assessing the latent construct. CR is considered a more precise reliability measure than Cronbach's Alpha and is less affected by the number of items in the construct. The formula for CR is given by:

$$CR = (\Sigma \text{ Squared Loadings of Indicators on Latent Construct}) / (\Sigma \text{ Squared Loadings of Indicators on Latent Construct} + \Sigma \text{ Measurement Error}) \quad (4.2)$$

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Where:

Squared Loadings = the squared correlation of each indicator with the latent construct.

Measurement Error = the variance not explained by the latent construct.

A CR value of 0.60 or higher is typically indicative of good internal consistency among the indicators.

4.2.3 Cronbach's Alpha (α)

Cronbach's Alpha (α) is a commonly used measure of reliability, indicating the internal consistency of a set of indicators. It measures how well a set of items measure a single latent construct. The formula for Cronbach's Alpha is:

$$\alpha = [N / (N - 1)] * [1 - (\Sigma \text{ Variance of Measurement Error}) / (\Sigma \text{ Total Variance})] \quad (4.3)$$

Where:

N = the number of items in the construct.

Variance of Measurement Error = the amount of variance in the construct attributed to measurement error.

Total Variance = the total variance observed in the construct.

A Cronbach's Alpha value of 0.60 or above is generally considered acceptable, indicating good internal consistency.

The results of AVE, CR, and Cronbach's Alpha tests, as shown in Table 5, demonstrate that all constructs met the required thresholds, confirming their adequacy for use in the subsequent Confirmatory Factor Analysis (CFA). These tests ensure that the measurement model is valid and reliable, allowing for accurate interpretation of the relationships between the latent variables in the study. This result confirms that the constructs possess the necessary convergent validity and internal consistency, as indicated by the AVE, CR, and Cronbach's Alpha values. This provides a solid foundation for the subsequent CFA, ensuring that the latent variables are accurately represented by their respective indicators.

Table 5: preliminary data analyses

SN	CONSTRUCTS	CR	AVE	(α)
1	Environmental Sustainability (ENS)	0.66	0.76	0.64
2	Social Sustainability (SS)	0.72	0.68	0.63
3	Economic Sustainability (ES)	0.67	0.83	0.75
4	Environmental Sustainability Challenges (ENSC)	0.85	0.77	0.81
5	Social Sustainability Challenges (SSC)	0.78	0.82	0.75
6	Economic Sustainability Challenges (ESC)	0.71	0.80	0.69

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:

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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:

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

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

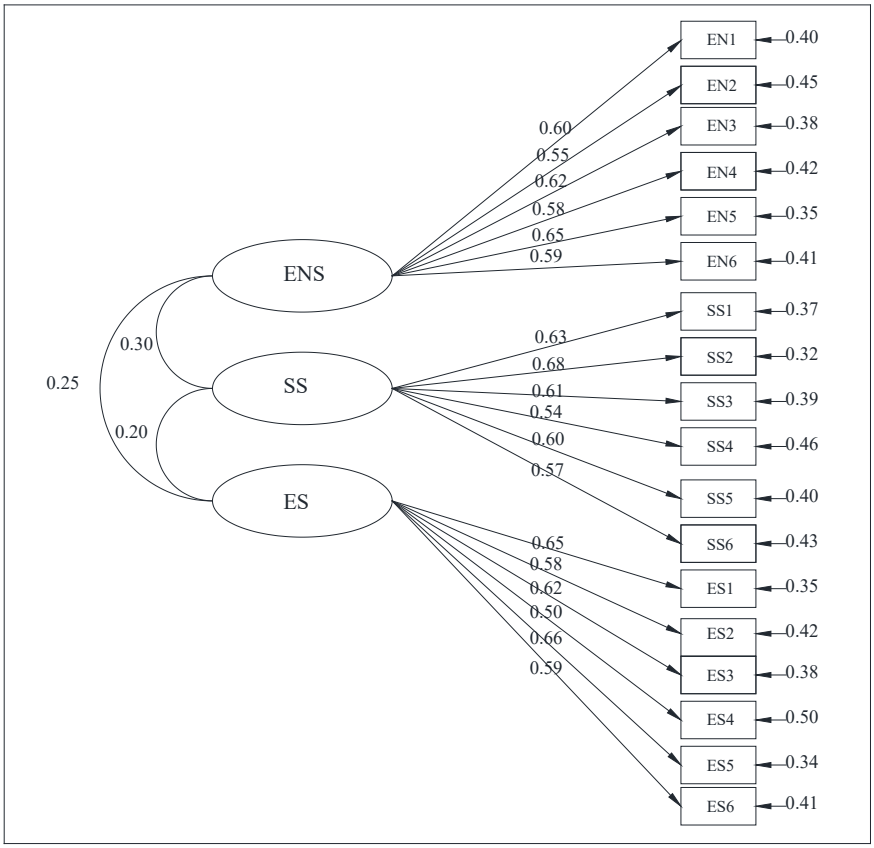

Figure 2: CFA for current sustainable construction practices in Nigeria

The results of the Confirmatory Factor Analysis (CFA), which assess the current sustainability practices in the Nigerian construction industry, offer valuable insights into the environmental, social, and economic dimensions of sustainability. These findings are consistent with recent literature on sustainable construction, suggesting both areas of progress and significant room for improvement.

For the environmental sustainability dimension, factor loadings for the observed variables (EN1–EN6) ranged from 0.55 to 0.65, indicating moderate to weak associations. This suggests that while certain environmental practices are in place, the overall emphasis remains inadequate across the sampled construction companies. This result reflects previous findings by Aghimien *et al*. [46], who reported that the adoption of environmentally sustainable practices in sub-Saharan Africa is often limited by infrastructural deficiencies and weak regulatory enforcement. Similarly, Chileshe *et al*. [47]

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emphasized that, despite increased awareness, the implementation of green construction in Nigeria is inconsistent due to limited technical expertise and financial support.

Regarding social sustainability, the factor loadings for variables SS1–SS6 ranged from 0.54 to 0.68, also representing moderate to weak correlations. This implies that social dimensions—such as occupational health and safety, community engagement, and equitable labor practices—are not uniformly prioritized. High measurement error rates further suggest challenges in consistent application. These observations correspond with the work of Osunsanmi *et al*. [48], who found that social sustainability in Nigerian construction faces obstacles related to stakeholder inclusivity and institutional engagement. Ofori and Toor [49] also noted that variability in resource availability and organizational policies contributes to inconsistency in addressing social issues.

In terms of economic sustainability, the factor loadings (ES1–ES6) were between 0.50 and 0.66, revealing a similarly weak to moderate association. This inconsistency reflects limited application of tools like life-cycle costing, cost-benefit analysis, and risk assessment. Elevated measurement errors, ranging from 0.34 to 0.50, further point to uneven application. These results support Olanipekun *et al*. [50], who found that financial limitations and the high cost of sustainable technologies hinder consistent integration of economic sustainability practices in Nigerian construction.

This analysis contributes to a more nuanced understanding of sustainability practices in Nigeria's construction sector. It highlights the pressing need for improved regulatory structures, increased financial incentives, and strengthened technical capacity. Addressing these barriers will enhance the adoption and implementation of sustainable construction practices [51,52].

4.4 Sustainability Challenges of Construction Projects in Nigeria

The Confirmatory Factor Analysis (CFA) model developed to assess sustainability challenges in Nigerian construction projects is shown in Figure 3. In refining the model, 12 variables (E3, E5, E7, E8, S15, S16, S17, S19, E23, E25, E27, and E28) were removed to enhance factor loadings and improve model reliability. The final model demonstrated strong associations between the observed variables and their respective latent sustainability constructs.

Within the Environmental Sustainability Challenges construct, key variables such as "Minimizing energy consumption" and "Minimizing carbon emissions" had loadings of 0.80 and 0.72, respectively. These strong correlations highlight the growing significance of energy efficiency and carbon reduction in Nigerian construction, aligning with the global movement toward low-carbon technologies [50,51]. These findings reaffirm Olanipekun *et al*. [50] and Badu *et al*. [51], who highlighted the urgency of addressing energy use and emissions in construction processes across developing nations.

Similarly, robust factor loadings were found for Social and Economic Sustainability Challenges. For instance, the variable "Ensuring occupational health and safety" recorded a loading of 0.75, while "Challenges in conducting cost-benefit analyses for sustainability" had a loading of 0.78. These figures emphasize the persistent difficulties encountered in safeguarding worker welfare and conducting financial assessments for sustainable practices. This is consistent with the observations of Olawumi and Chan [53] and Ofori and Toor [49], who underscored the impact of limited regulatory oversight and financial constraints in these domains.

Overall, factor loadings across constructs ranged from 0.72 to 0.85, signifying strong model fit and highlighting key sustainability challenges—particularly in areas such as water management and long-term financial planning. These results are consistent with studies by Aghimien *et al*. [46] and Akinradewo *et al*. [52], who noted that sustainable water usage and cost management are two of the most critical hurdles for construction firms in Nigeria and across sub-Saharan Africa.

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Importantly, the findings reflect a growing awareness among contractors of the complexities involved in integrating sustainability into construction processes. This awareness forms a vital foundation for developing responsive policies and industry strategies. High loadings on variables related to energy, social responsibility, and economic impact suggest that practitioners increasingly recognize the interconnected nature of sustainability dimensions [48]. As such, the results underscore the importance of holistic, cross-sectoral approaches in addressing Nigeria's sustainability challenges in construction.

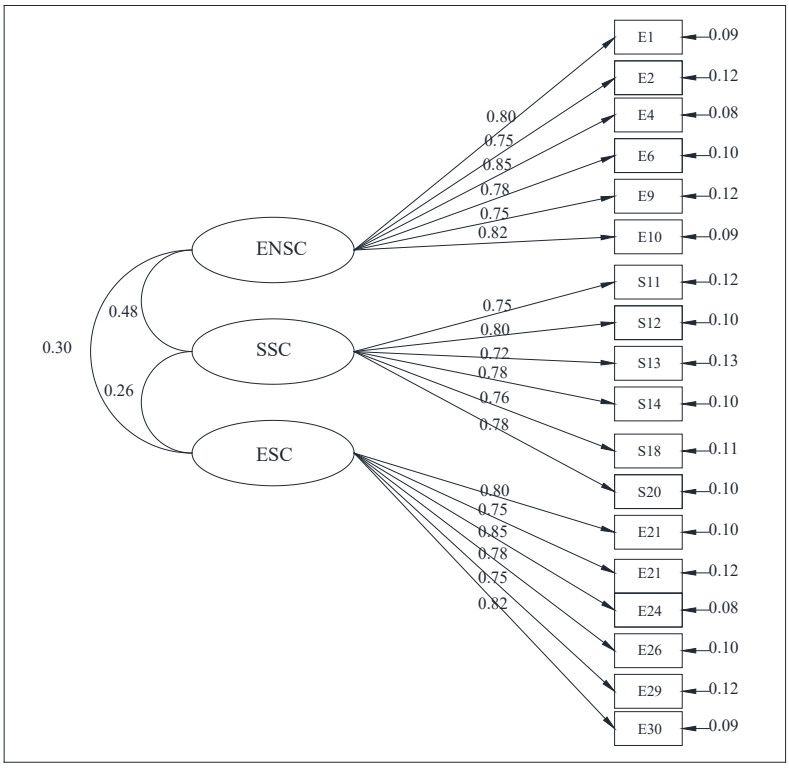

Figure 3: CFA for sustainability challenges of construction projects

5 CONCLUSION

The CFA conducted on the current sustainable construction practices in Nigeria unveils nuanced insights into environmental, social, and economic sustainability within the construction industry. The analysis reveals moderate to weak associations between observed variables and their respective sustainability constructs, indicating varying degrees of emphasis and challenges across these dimensions. Notably, environmental sustainability practices exhibit a less pronounced focus, while social sustainability practices demonstrate varied strengths, and economic sustainability practices lack uniform emphasis among sampled construction companies. Elevated measurement errors further highlight potential inconsistencies in sustainability implementation. These findings underscore the multifaceted nature of sustainability challenges within the Nigerian construction sector and emphasize the necessity for targeted interventions to address these challenges effectively.

Based on the findings, it is recommended that policymakers and industry stakeholders implement comprehensive sustainability initiatives tailored to address the identified challenges and enhance sustainability practices within the Nigerian construction industry. This may involve the development of robust regulatory frameworks, capacity-building programs, and incentives to promote environmental, social, and economic sustainability. Additionally, fostering collaboration among stakeholders and investing in

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research and development initiatives can facilitate innovation and knowledge-sharing to drive sustainable construction practices forward.

Future research endeavors could build upon this study by employing longitudinal research designs to examine the evolution of sustainability practices over time and assess the effectiveness of interventions aimed at enhancing sustainability within the Nigerian construction industry. Furthermore, conducting comparative studies across different regions or countries can provide valuable insights into contextual factors influencing sustainability practices. Additionally, qualitative research methods such as interviews and focus groups could complement quantitative analyses to gain a deeper understanding of the socio-cultural and institutional dynamics shaping sustainability practices in Nigeria's construction sector.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper.

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