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Evaluation of Green Building Technologies (GBTS) By Construction Professionals in Southwest Nigeria

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ABSTRACT
The adoption of Green Building Technologies (GBTs) is increasingly recognized as a promising approach to enhancing the sustainability performance of buildings, generating significant interest in the global construction community. However, barriers such as the lack of local expertise in green building practices and insufficient awareness highlight the need for effective strategies to promote broader adoption of GBTs in building development. This study aims to identify the benefits of adopting GBTs and assess their level of implementation by professionals in Southwest Nigeria. Following a comprehensive literature review on factors hindering GBT adoption in the region, empirical data were collected through a questionnaire survey of 300 green building experts across Nigeria. The analysis confirmed the significance of 12 challenges affecting GBT implementation in Southwest Nigeria. Key benefits identified include reduced energy costs, improved occupant comfort and productivity, enhanced indoor air quality, and lower maintenance costs. These were ranked as the top four benefits driving the adoption of GBTs.
The findings provide valuable insights to help practitioners and policymakers develop effective strategies for promoting GBT adoption, ultimately contributing to the sustainable development of buildings. Future research will explore the economic benefits associated with the adoption of green building technologies in Southwest Nigeria.
Keyword: Sustainable, Practical Strategies, Exploration

I. INTRODUCTION

Green Building Technology (GBT) refers to sustainable construction practices that aim to minimize environmental impact through efficient use of non-renewable resources. Nigeria, like many developing countries, faces the dual challenges of rapid urbanization and significant environmental degradation (Elfeturi, 2015). While the construction sector is an essential driver of economic growth, it has also contributed to serious ecological concerns. Traditional building methods in Nigeria have often disregarded environmental impacts, leading to increasing carbon emissions, resource depletion, and other negative effects on the environment (Akindele et al., 2023). The introduction of Green Building Technologies (GBTs) could mitigate these adverse consequences while supporting economic development, as seen in countries such as China, Jordan, South Africa, and Ghana (Chen et al., 2024; Jaradat et al., 2024; Agbajor & Mewomo, 2024; Anzagira et al., 2024).

GBTs encompass the design, construction, and operation of buildings that prioritize environmental sustainability and resource efficiency. The aim is to reduce the consumption of non-renewable resources and minimize the emission of greenhouse gases from buildings, which are a significant contributor to global warming (U.S. Environmental Protection Agency). Key features of GBT include the use of energy-efficient materials, renewable energy sources, and sustainable construction practices.

One example is the use of locally sourced sustainable materials such as bamboo, recycled concrete, or other eco-friendly building materials. Green buildings also often incorporate rainwater harvesting systems, energy-efficient appliances, and solar power, all of which reduce environmental footprints and support local industries. For instance, in Nigeria, the widespread use of solar panels, LED lighting, and energy-efficient appliances could substantially improve energy efficiency, especially in areas where the power supply is inconsistent, and energy costs are high. With electricity tariffs rising by over 200% for certain users (Samson & Adjekophori, 2018),

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GBTs offer a practical solution to energy challenges in Nigeria (Ijigah & Omeiza, 2024).

The adoption of GBTs in Nigeria could help reduce carbon emissions, mitigate the effects of urbanization on the environment, and enhance energy efficiency. Nigeria's power supply is frequently unreliable, and many households rely on diesel generators or costly alternative sources of energy. Therefore, integrating renewable energy technologies such as solar panels can significantly reduce dependence on the national grid while also cutting electricity costs. The use of energy-efficient construction materials and designs—such as natural lighting, insulation, and advanced cooling systems—further supports sustainable building goals (Samson & Adjekophori, 2018).

However, despite the growing understanding of the benefits of GBTs, Nigeria faces numerous challenges in implementing these practices. The construction industry has been historically reliant on government policies that have not fully embraced sustainable building methods (Akindele et al., 2023). This has resulted in a lack of regulatory enforcement, inadequate support for green building initiatives, and an underdeveloped green building sector in the country (Oke et al., 2024; Babalola & Harinarain, 2024). The lack of clear policies and standards has slowed the adoption of environmentally friendly practices.

The high initial cost of adopting GBTs also presents a significant barrier. For instance, the upfront cost of solar panels, energy-efficient appliances, and sustainable materials can be higher than traditional building methods, making these technologies inaccessible to many developers and homeowners. Furthermore, there is a shortage of trained professionals in Nigeria who are knowledgeable about sustainable construction practices, which impedes the widespread adoption of green technologies.

Despite these challenges, recent developments indicate a positive trend toward sustainable building in Nigeria. The establishment of the Green Building Council of Nigeria and the implementation of the National Building Efficiency Code signal growing recognition of the need for green construction practices (Oke et al., 2024). These initiatives provide guidance on sustainable building practices, set standards for energy efficiency, and encourage the adoption of green technologies in the construction sector.

In addition, the use of locally sourced sustainable materials, such as bamboo and recycled concrete, has gained traction in some regions. Not only do these materials have a lower environmental impact, but they also support local businesses and stimulate the economy. The promotion of these materials, along with the widespread adoption of solar panels and energy-efficient technologies, can significantly reduce Nigeria's environmental footprint and lower energy costs for businesses and households alike.

Green Building Technologies offer significant potential for addressing the environmental and energy challenges facing Nigeria's construction sector. By integrating sustainable building practices into construction projects, Nigeria can reduce carbon emissions, conserve resources, and promote economic development through the use of local materials and renewable energy sources. However, the successful implementation of GBTs requires strong policy support, increased awareness, and investment in capacity-building for professionals in the construction industry.

Recent efforts, such as the formation of the Green Building Council of Nigeria and the enactment of the National Building Efficiency Code, represent positive steps toward encouraging green construction. By addressing the challenges of cost, awareness, and policy enforcement, Nigeria has the opportunity to transition to more sustainable building practices, improving the country's environmental sustainability and boosting its economic development.

This study aims to contribute valuable insights to inform policymakers, construction industry stakeholders, and other interested parties in the promotion of green building practices. By identifying current barriers, assessing the potential for growth, and outlining key opportunities for development, this research seeks to guide efforts toward a more sustainable future in Nigeria's built environment.

Statement of the Research Problems

This research examines the challenges hindering the adoption of environmentally-friendly construction methods. Despite recognized benefits like sustainability, energy efficiency, and economic gains, green building principles remain underused due to limited awareness among the public and experts, lack of educational initiatives, and difficulties in integrating green practices into urban development. Economic concerns, higher initial costs, and limited access to sustainable materials further obstruct adoption. The study aims to explore these barriers and promote green building practices.

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Aim and Objectives of the Study

The primary objective of this study is to evaluate the extent to which green building practices are implemented in building construction projects in Southwest Nigeria, with the goal of promoting the adoption of these sustainable practices.

The specific objectives of the study are to:
1. Identify the benefits of adopting Green Building Technologies (GBTs) among professionals in Southwest Nigeria.
2. Assess the level of implementation of Green Building Technologies (GBTs) by professionals in the region.
3. Examine the impact of GBTs implementation on the performance of building construction projects in Southwest Nigeria.
4. Investigate the factors hindering the implementation of GBTs in Southwest Nigeria.

II. LITERATURE REVIEW

2.1 The Historical Development of Green Building technologies

The historical development of green building technologies can be traced back to ancient civilizations, where rudimentary forms of sustainable construction were employed (Maragh et al., 2019). In ancient Rome, architects utilized principles of passive heating and cooling in the design of buildings, demonstrating an early understanding of environmental considerations (Liu et al., 2018). Moving forward, the 19th and early 20th centuries saw the emergence of architects like Frank Lloyd Wright, who championed organic architecture, emphasizing harmony with the environment Harris, (2007). However, it was not until the latter part of the 20th century that the term "green building" gained prominence. The modern green building movement took root in response to the environmental challenges of the 1960s and 1970s, marked by the oil crisis and increasing awareness of ecological issues. The first Earth Day in 1970 brought environmental concerns to the forefront, prompting a shift in architectural and construction practices towards sustainability. The 1980s and 1990s witnessed the establishment of various green building standards and rating systems, such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) in 1998 (Cao et al., 2022). These frameworks provided guidelines for designing and constructing environmentally responsible buildings, contributing to the global acceptance and adoption of green building practices. In recent decades, international efforts have further propelled green building practices. The United Nations' Sustainable Development Goals (SDGs) and various global environmental initiatives have emphasized the importance of sustainable construction in addressing climate change and resource depletion (Wu et al., 2020). The historical development of green building practices reflects an evolving understanding of the impact of construction on the environment and a commitment to creating buildings that align with ecological principles. Relevance of green buildings practices in the construction industry

Green building technologies encompass a comprehensive approach to construction and design, emphasizing sustainability, environmental responsibility, and energy efficiency (Kruger & Seville, 2013). These technologies aim to reduce the environmental impact of buildings throughout their life cycle, from construction to operation and eventual demolition. The integration of environmentally friendly materials, energy-efficient technologies, and innovative design strategies is at the core of green building, this includes the use of renewable energy sources, energy-efficient lighting and HVAC systems, and the incorporation of recycled and locally sourced materials in construction (Chan et al., 2017).

Green building technologies also prioritize water conservation through efficient plumbing systems, rainwater harvesting, and landscaping designs that reduce the need for irrigation (Adeyeye, 2014). Waste reduction is also crucial, with an emphasis on recycling and responsible disposal methods during both construction and operation phases. Additionally, the concept extends beyond the physical structure to consider the building's impact on the occupants' health and well-being, promoting indoor environments with optimal air quality, natural lighting, and comfortable temperature control (Chan et al., 2017).

Understanding this intricate balance between environmental, economic, and social aspects is essential in comprehending the nature of green building practices. The popularity and acceptance gained by green building practices have led to the development of various green building technologies (GBTs) for enhancing sustainability performance during the construction process (Chan et al., 2017). Overall, green buildings have been shown to improve health and well-being, according to the World Green Building Council. Sustainable design utilizes resources that are environmentally

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friendly and avoid waste and resource depletion which supports biodiversity, natural resource conservation, and minimizes climate change (Kumar et al., 2021).

2.2 Use of recycled and reused materials

The utilization of reclaimed wood, steel, and concrete in construction has been shown to significantly reduce the demand for virgin resources and landfill waste, consequently lowering the embodied carbon and the carbon footprint associated with material extraction, processing, and transportation (Limphitakphong et al., 2020; Nciri et al., 2021).

Reclaimed materials offer short- and long-term social, economic, and environmental advantages, including conserving natural resources, curbing greenhouse gas emissions, minimizing energy consumption, and building sustainable infrastructure (Nciri et al., 2021).

The incorporation of these reclaimed materials aligns with the principles of circular economy, as it involves reusing green and healthy building materials, concrete waste, and wood formwork, thereby promoting resource efficiency and waste reduction (Amudjie et al., 2022). Also, the future of green and energy-efficient construction processes involves the use of reclaimed materials such as wood and reclaimed bricks or glass, indicating a growing trend towards sustainable construction practices (Walenda & Starczyk-Kołbyk, 2022).

2.3 Use of bio-based materials

The use of renewable resources such as bamboo, cork, and mycelium in construction offers sustainable alternatives to traditional materials, contributing to reduced transportation distances, minimized embodied carbon, and support for local economies (Pacheco-Torgal et al., 2020; Amziane & Sonebi, 2022). These materials have been recognized for their excellent thermal and acoustic insulation properties, which can contribute to a healthy indoor environment. Additionally, the utilization of these locally sourced materials aligns with the principles of sustainability and resource efficiency, offering environmental benefits such as conserving natural resources, curbing greenhouse gas emissions, and minimizing energy consumption (Fernandes et al., 2011; ; Pa et al., 2017; Lagorce-Tachon et al., 2017; Perilli et al., 2021; Montalvo et al., 2022; Luciano et al., 2023).

2.4 Energy efficient appliances and systems

The implementation of high-efficiency LED lighting, advanced heating ventilation and air condition (HVAC) systems, have demonstrated a substantial decrease in both energy consumption and utility costs within buildings (Holleron & Tilford, 2012). Additionally, the incorporation of smart building technologies goes a step further by intelligently automating various systems, responding dynamically to occupancy patterns and environmental conditions (Xue & Zhao, 2021; Zhao & Gao, 2022). This synergy of energy-efficient components and intelligent automation not only fosters sustainability but also maximizes operational efficiency, resulting in considerable savings for building owners and occupants alike. The integration of these technologies represents a progressive approach towards creating environmentally conscious and economically viable structures (Moreno-Munoz & Giacomini 2023).

2.7 Strategies to the Implementation of Green building technologies

The strategies to the implementation of green building technologies includes global warming and climate change, government regulatory policies and incentives, client and stakeholder awareness, financial benefit and Improved health and well-being.

2.7.1 Global warming and climate change

Global warming and climate change have become critical global issues, leading to the adoption of sustainable development practices to mitigate environmental degradation and resource depletion (Chophel, 2022). International agreements and standards have played a crucial role in promoting green technologies and raising awareness of green buildings (Chophel, 2022). The issue of climate change and global warming has been extensively publicized at the national and international levels, primarily through media sources and the internet, as a means of raising public awareness (Lee et al., 2015).

This international situation has exerted pressure to address global warming and climate change through sustainable development practices and the adoption of green building standards.

2.7.2 Government regulatory policies and incentives

The Nigerian government has introduced initiatives like the National Building Efficiency Code, Green Building Council of Nigeria (GBCN),

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National Adaptation and Plan (NASPA) and Nigeria Building Code (NBC) to promote sustainable construction (Abisuga & Okuntade, 2019). These programs offer tax breaks, rebates, and other incentives for incorporating green features, making them more attractive to developers and investors. The government's involvement in green building development is crucial for promoting sustainability and driving the adoption of green practices. Government intervention through laws, regulations, tax incentives, and penalties plays a significant role in promoting green buildings and sustainable development (Olanipekun et al., 2016). These measures are essential in mitigating the increased construction expenses associated with green buildings, as favorable regulations and tax concessions considerably lower the cost of green building development, thereby incentivizing contractors to engage in green building projects (Hwang & Tan 2012).

This shows that the government's involvement in green building development is crucial for promoting sustainability and driving the adoption of green practices.

2.7.3 Client and stakeholder awareness

The involvement of developers, contractors, and clients or owners is crucial in sustainable construction. Clients recognizing the advantages of sustainable construction can drive developers to meet their needs, leading to increased spending and the advancement of green building development (Guribie et al., 2021). Business strategies, stakeholder engagement, management control systems, and alternative building materials also contribute to the successful implementation of sustainable construction practices (Marut et al., 2020). These references collectively emphasize the importance of client involvement and satisfaction.

2.7.4 Financial benefit

The financial benefits associated with green buildings are significant, despite the initial higher costs of incorporating green features. Green buildings offer long-term cost savings through lower operating costs, reduced energy consumption, and increased property value (Weerasinghe & Ramachandra, 2018). The reduction in energy usage is particularly crucial, as buildings consume 73% of power, making minimizing energy use and waste a significant way to save expenses. Green buildings achieve energy savings of about 71.1%, significantly less than traditional buildings, and are designed to provide maximum comfort while depending on renewable energy sources to support the lowest possible operational costs (Laude & Firmandhani, 2021; Azmi et al., 2022; Qin, 2023). The economic sustainability of green buildings is therefore evident, as they save 19% of aggregate operational costs, 25% of energy, and 36% of CO2 emissions, while conventional buildings consume a significant portion of global energy and resources (Weerasinghe & Ramachandra, 2018).

2.8 Challenges

There are several challenges that hinder the implementation and awareness of green building practices in southwest, Nigeria. These challenges can be categorized into two types; external and internal challenges. External challenges are factors that are beyond the control of the stakeholders in the construction industry, while internal challenges are factors that can be addressed within the industry itself.

2.8.1 Lack of public awareness and education

The lack of awareness and knowledge regarding green building technologies in Nigeria, particularly in Ekiti and Ondo State,, poses significant barriers to the implementation of sustainable construction technologies. Studies by Komolafe & Oyewole (2018), Samson & Adjekophori (2018), and Oladokun et al. (2020) have examined the level of awareness, perceptions, and implementation of sustainability practices in building construction projects in Nigeria, emphasizing the need for increased awareness and adoption of green building principles. These findings underscore the importance of addressing the lack of awareness and knowledge to drive the adoption of sustainable construction technologies and promote a more environmentally conscious built environment (Barbarossa & Pastore, 2015; Ebekozien et al., 2021; Isang, 2023).

2.8.2 Lack of government support and policies

The Nigerian government has not shown any significant efforts to promote green building practices through legislation and incentives that is why Ebekozien et al. (2021) emphasizes the need for the Nigerian Government to learn from other countries' experiences in promoting green buildings.

This lack of support makes it challenging for stakeholders to implement green building practices in their projects. In addition, the study by Alohan & Oyetunji (2021) evaluated the hindrance

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and benefits to green building implementation, highlighting the need for proper advocacy by policymakers for the adoption of green features in residential buildings.

2.8.3 Inadequate knowledge and skills of construction professionals

In Ekiti and Ondo state, a substantial number of professionals in the construction industry are not adequately equipped with the necessary expertise to effectively implement green building technologies (Samson & Adjekophori, 2018). This deficiency in knowledge presents a significant barrier for stakeholders who are interested in integrating green building technologies into their projects, also the limited availability of information pertaining to green building technologies further complicates the process of implementing and maintaining these practices in their projects (Ebekozien et al., 2021).

2.8.4 Lack of collaboration and communication among stakeholders

The implementation of green building technologies is often impeded by insufficient collaboration and communication among stakeholders (World Economic Forum, 2017). For example, architects and engineers might not have a comprehensive understanding of the advantages of green building practices, which can pose challenges in integrating these practices into their designs (Filipeboni, 2023). Likewise, contractors may lack full awareness of the significance of utilizing eco-friendly materials and equipment, further complicating the adoption of green building technologies. (Illankoon et al., 2017).

2.8.5 Inadequate funding

The scarcity of funding is a major barrier to the adoption of green building practices in Lagos State, this lack of sufficient financial resources impedes the integration of environmentally friendly technologies and materials, which are often associated with higher initial costs. This financial constraint limits the ability of builders and developers to invest in sustainable designs (Lam et al, 2009; Ahn et al, 2013).

2.8.6 Lack of effective regulatory frameworks and standards

The lack of comprehensive regulatory frameworks and standards is a major obstacle to the broad implementation of green building practices (Orsi et al., 2020). In the absence of clear guidelines and mandatory regulations, developers and builders may not be incentivized to prioritize sustainable construction methods (World Economic Forum, 2017). This regulatory void leads to a disjointed approach to green building, preventing the establishment of uniform standards, as a result, the construction industry may find it challenging to adopt eco-friendly practices, affecting the overall incorporation of sustainable building solutions and slowing down progress towards a greener urban landscape in Lagos.

2.8.7 Lack of green building tools and products

The scarcity of suitable green building tools and products significantly impedes the execution of green building practices (Ozolins, 2014). The limited availability and understanding of eco-friendly construction materials and technologies act as barriers to the adoption of sustainable building methods. This issue is further compounded by the absence of specialized tools and products that are adapted to the local context, thereby making it challenging for builders and developers to seamlessly incorporate green practices (Lame et al., 2017; Jusselme et al., 2020). Addressing this challenge necessitates initiatives aimed at improving accessibility, promoting education, and developing a wide array of green building solutions. These efforts would contribute to creating an environment that is more supportive of sustainable construction (Khan, 2020).

2.9 Benefits of Green Building technologies

Green buildings, designed with sustainability in mind, provide a range of benefits that reach far beyond merely lowering our environmental footprint. They favorably benefit the health, well-being, and finance of residents, while also decreasing our negative impact on our surroundings.

2.9.1 Reduced energy consumption

Reducing energy consumption is a significant benefit of green building practices, as it contributes to environmental sustainability and cost savings. Green building practices focus on controlling heating, cooling, ventilation, and lighting loads, which are essential for energy-efficient buildings (Bongtiwon, 2022). Additionally, increasing energy efficiency in buildings is synonymous with reducing energy consumption, aligning with the principles of sustainable construction (Yosef & Damdelen, 2022).

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2.9.2 Conserved water resources

Water-efficient fixtures, rainwater harvesting, and greywater recycling technologies limit water use in green buildings. This helps reduce demand on freshwater resources, especially in drought-prone regions (Hwang et al., 2015; Abdallah et al., 2016).

2.9.3 Minimized pollution and waste

Green buildings incorporate recycled and recyclable materials, lowering dependency on virgin resources and cutting landfill trash. Additionally, construction procedures and materials with minimal emissions help limit air and water pollution (World Green Building Council, 2019).

2.9.4 Lower operating costs

The energy and water efficiency characteristics of green buildings translate to dramatically decrease utility bills over time. This result to cost savings for buildin owners and inhabitants alike (Sun et al., 2019)

2.9.5 Increased property value

Green buildings frequently attract higher rental rates and selling prices due to their better performance, tenant appeal, and potential tax benefits or incentives. (Eichholtz et al., 2013).

2.9.6 Enhanced corporate image

Demonstrating a commitment to sustainability through green construction methods may attract investors, consumers, and talent, enhancing a company's image and brand value (World Green Building Council, 2019).
Occupant benefit

2.9.7 Improved indoor environmental quality

Green buildings focus high air quality, natural lighting, and thermal comfort, resulting to enhanced occupant health, well-being, and productivity (Corgnati et al., 2011).

2.9.8 Enhanced mental and physical health

Access to natural elements and green areas within or surrounding green buildings can decrease stress, increase relaxation, and even boost cognitive performance (Shamseldin, 2018).

2.9.9 Increased comfort and satisfaction

Green buildings often offer greater acoustic management and vibration dampening, producing a more pleasant and comfortable work or living environment. (Isavand et al., 2019; Jalil et al., 2013).

III. METHODOLOGY

This study adopts a quantitative research design using closed-ended questionnaires to assess the use of digital-based quality management systems among building construction stakeholders in Southwest Nigeria. The survey, targeting 300 respondents selected through random sampling, will gather data on awareness, implementation, drivers, challenges, and benefits of Green Building Technologies (GBTs). Data will be collected both online and in-person to maximize response rates, and analyzed to provide a comprehensive understanding of GBTs adoption in the region.

3.1 Study Area

The research will be conducted in Southwest Nigeria, focusing specifically on Ondo and Ekiti States, which are economically significant regions in the country.

Map of Nigeria

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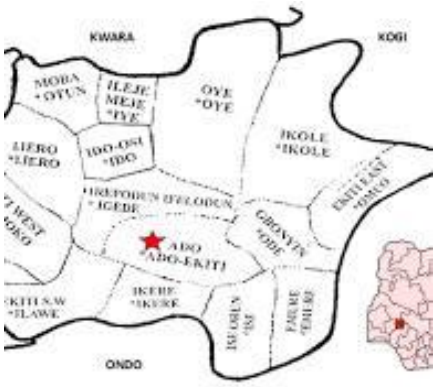
Map of Ondo State



Map of Ekiti State

Figure 1: Map of the Study Area

3.2 Research Population

The population for this study comprises stakeholders in the construction industry in Southwest Nigeria, specifically in Ondo and Ekiti States. This includes professionals such as architects, engineers, builders, and quantity surveyors, who work as contractors, consultants, or clients. The construction sector plays a significant role in the development of residential, commercial, and industrial properties, creating job opportunities for the citizens of these states. A sample letter of introduction was obtained from the Head of the Building Department at the Federal University of Technology, Akure, to approach the respondents, and data collection will be through a research questionnaire.

3.3 Sampling Technique

The study will use a simple random sampling technique, ensuring that participants are randomly selected from the population in the study area. A survey instrument based on the literature review will be developed to gather data on the implementation and awareness of Green Building Technologies (GBTs). The instrument will be pretested for validity and reliability.

3.4 Sample Size

A total of 390 construction professionals in Ondo and Ekiti States will participate. The sample size was calculated using the Yamane formula.

$n = N/1+N(e^2)$
where n = sample size
N= Total population
e= Level of precision which is

$$n = \frac{1,200}{1 + 1,300\ (0.05)^2}$$

$$n = \frac{1,200}{4} = 300$$

300 questionnaires would be shared.

Table 1: Sample Size of the Project Stakeholders

S/No	Professionals	Ondo State	Ekiti State	Total	Sample Size
1	Builders	100	100	200	50
2	Quantity surveyors	100	100	200	50
3	Architects	100	100	200	50
	Engineers				
4	Structural	100	100	200	50
5	Mechanical	100	100	200	50
6	Electrical	100	100	200	50
	TOTAL	600	600	1,200	300

3.5 Method of Data Collection

Data for research is collected from primary and secondary source. The primary source will employ the use of questionnaires. Questionnaire is the research instrument consisting of a series of question and other prompts for the purpose of gathering information from the respondents (Mellenbergh, 2008). This method of data collection is widely used, particularly in case of big number and it was applied in the field of the

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research study and close ended questions was used to get the information from the respondents. The questionnaires would be sent to the respondents selected with a request to answer the questions and return the questionnaire. A questionnaire consists of a number of questions printed in a definite order or set of forms. This method is selected because it is cost-effective and saves time by collecting data from a large sample at once (a short period of time that is required to fill the questionnaire and it is free from bias). This method is mostly used to ensure checks and balances as they complement one another. The use of questionnaires is meant to ensure validity and reliability of the collected data (Loru, 2020).

During the research, a series of questions were formulated to evaluate the awareness, implementation, driving factors, challenges, and benefits of green building practices. Employing a random sampling technique, participants for the study were chosen by disseminating surveys to professionals in both Ekiti and Ondo State, Nigeria. The questionnaires were distributed via email and messages, with participants instructed to complete them within a specified timeframe. The collected data underwent analysis using descriptive statistics, involving measures like mean, median, and mode, along with testing for variable relationships through techniques such as correlation and regression analysis. Based on the results derived from data analysis, conclusions and recommendations for the adoption of green building technologies were formulated. These findings were documented in a written report, encompassing a summary of questionnaire results, a comprehensive data analysis, and conclusions, along with actionable recommendations.

3.6 Method of Data Analysis

The data was analyzed through the statistical package for social sciences (SPSS), utilizing techniques like frequency distribution, percentage, and mean item score. The outcomes were visually represented in tables, and the analysis involved measures such as percentile, mean, standard deviation, and factor analysis. Ranking decisions were determined by the factor with the highest Mean Item Score (MIS), which was positioned as the first rank, followed by subsequent factors in descending order.

Table 2: Research Objectives and Method of Analysis

S/N	Objectives	Method(s) of Analysis	Software
1	Background information of the respondent	Frequency Distribution and Percentage	Ms Excel / SPSS
2	Assessing the level of Awareness and implementation of green building practices	Mean item score (MIS), Standard deviation (SD), and Factor analysis	Ms Excel / SPSS/ Smart PLS 4
3	Determining the drivers and challenges to the implementation of green building practices	Mean item score (MIS), Standard deviation (SD), and Factor analysis	Ms Excel / SPSS/ Smart PLS 4
4	Determining the benefits of adopting green building practices	Mean item score (MIS), Standard deviation (SD), and Factor analysis	Ms Excel / SPSS/ Smart PLS 4

IV. RESEARCH FINDINGS

Three hundred (300) questionnaire were administered based on the age of the respondent, location of the project, gender of the respondents, educational qualification of the respondents, respondent's year of experience, professional group of respondent, type of construction projects executed, position on construction project and involvement in implementation of Green Building technologies (GBTs). One hundred and ninety-six (196) questionnaires were retrieved from the respondent (65.3%) which was considered

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sufficient for this study (Kothari, 2004). The data ranges from 1 to 6. The highest mean was 4.37 while the lowest mean was 1.05. The Standard Deviation (S.D.) of the data ranges from 0.22 to 2.41.

The study firstly assessed benefits of implementing Green Building technologies by construction professionals in Southwest, Nigeria. From the result of the study, Reduces energy cost (MS=4.26), Improved comfort and productivity of occupants (MS=4.26), Improves indoor air quality (MS=4.26), and Reduces maintenance cost (MS=4.09). The least benefits of implementing Green Building technologies are to Reduce dependence on non-renewable resources (MS=4.08), improves image of builders and developers (MS=4.26), creates job opportunities and promote skill development (MS=4.00).

The study also assessed the level of Awareness of Green Building technologies The major Awareness technologies of Green Building are installation of Solar energy systems (MS=4.44), use of Smart building technologies (MS=4.26), use of Water harvesting (MS=4.17), and use of Recycled and reused materials (MS=3.86). The least Awareness Practices of Green Building are the use of Green roof (MS=3.07), use of Low volatile organic (VOC) compounds (MS=3.08), and Daylighting strategies (MS=3.19).

The study also assessed the Implementation of Green Building technologies s by construction professionals in Southwest Nigeria. From the result, Solar energy systems (MS=4.27), Smart building technologies (MS=4.13), Water harvesting (MS=3.96), Recycled and reused materials (MS=3.94). The least Implementation of Green Building technologiesare the use of the use of geothermal heating and cooling, the use of Low Volatile Organic (VOC) compounds (MS=4.13), and the use of Daylighting strategies.

There is a significant different between the paired sample t-test result of Paired Sample Test Between level of Awareness of Green Building technologiesand level of Implementation of Green Building Practicesin Southwest Nigeria indicated a significant relationship (p-value<0.05) as the calculated t-valve is higher than the table values

The result of the Spearman's Correlation carried out onbetween level of Awareness of Green Building technologiesand level of Implementation of Green Building technologiesin Southwest Nigeria indicated a significant relationship at the 0.01 level (2-tailed).

According to the study Drivers of the Implementation of Green Building **technologies** are Client and stakeholder awareness (MS=4.33), Technological advancements (MS=4.30), Resilience to climate change (MS=4.25), and Government regulatory policies and incentives (MS=4.23). The least Drivers of the Implementation of Green Building technologies are Availability of sustainable material (MS=3.89), Cost savings and lifecycle benefits (MS=4.08), and Occupants health and well-being (MS=4.17).

The study also assessed proposed effect of green building technologieson Project Performance. From the result of the study, cost of project (MS= 3.925), time of project (MS= 3.906), and quality of project (MS= 3.899) was ranked most. Functionality of the project (MS= 3.449) and productivity of the project stakeholders was ranked least among the twelve listed performance index in Nigeria. The study lastly assessed the Challenges to the Implementation of Green Buildingtechnologies. From the result of the study, Lack of incentives for promoting green building (MS= 4.39), Low level of awareness (MS= 4.35), Maintenance and operational challenges (MS= 4.21), and Preference towards conventional design (MS= 4.20). The least are Lack of green building tools and products (MS= 4.07), Lack of collaboration and communication among stakeholders in the construction industry (MS= 3.96), and Lack of research and development activities (MS= 3.93).

A reliability test (Kaiser-Meyer-Olkin KMO) was conducted Challenges to the Implementation of Green Building Practices which reduced the twenty-nine (12) challenges into four (4) factor solutions, namely challenge of awareness, founding challenge, and regulation challenge,

The Kaiser- Meyer- Olkin (KMO) value for the 12 items is 0.826 while the (KMO) for each group is 0.804, 0.783, 0.657, and 0.812. The Bartlett's text of sphericity for the three factors loading is significant (p= 0.000). The reliability test was conducted for the three factors and the result ranges from 0.783 to 0.812, which is greater than 0.5.

V. SUMMARY

The study surveyed 300 construction professionals in Southwest Nigeria, with 196 completed questionnaires (65.3%) deemed sufficient for analysis. It explored benefits, awareness, implementation, drivers, project performance effects, and challenges related to Green Building Technologies (GBT). The study found key benefits of GBT include reduced energy and maintenance costs, improved comfort and

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indoor air quality, and enhanced occupant productivity, with the least significant benefits being reduced dependence on non-renewable resources and job creation. In terms of awareness, respondents were most familiar with solar energy systems, smart building technologies, and water harvesting, while knowledge of green roofs and VOC compounds was less prevalent. The implementation of GBT was highest for solar energy systems and smart technologies, with geothermal heating and daylighting strategies being least implemented. A significant relationship between awareness and implementation of GBT was observed.

The primary drivers for GBT implementation were client awareness, technological advancements, resilience to climate change, and government policies. However, challenges included lack of incentives, low awareness, and operational difficulties. The study found significant correlations between these factors. A reliability test revealed that the challenges to GBT implementation were grouped into four factors, with strong reliability (KMO values >0.7). The study provides critical insights into the current state of GBT adoption and its impact on construction projects in the region.

5.1 CONCLUSION

The primary benefits of implementing Green Building Technologies (GBT) by construction professionals in Southwest Nigeria include reduced energy costs, improved occupant comfort and productivity, better indoor air quality, and lower maintenance costs. The most recognized GBT practices include the installation of solar energy systems, use of smart building technologies, water harvesting, and the use of recycled and reused materials. Conversely, awareness of green roofs, low volatile organic compounds (VOC), and daylighting strategies was relatively low.

The study also assessed the implementation of GBT, revealing that solar energy systems, smart building technologies, water harvesting, and the use of recycled materials were effectively adopted. A significant difference was found between the levels of awareness and implementation of GBT, as confirmed by a paired sample t-test (p-value < 0.05). Spearman's correlation analysis also showed a significant relationship (p-value < 0.01) between awareness and implementation.

The key drivers for GBT adoption include client and stakeholder awareness, technological advancements, climate change resilience, and government policies and incentives. The positive impacts of GBT on project performance include cost savings, time efficiency, and enhanced project quality.

Challenges to GBT implementation were identified as a lack of incentives, low awareness, operational difficulties, and preference for conventional designs. A reliability test (Kaiser-Meyer-Olkin, KMO) categorized these challenges into four factors—awareness, funding, and regulatory challenges—yielding a KMO value of 0.826, with values for the individual groups ranging from 0.657 to 0.812, all above the acceptable threshold of 0.5.

5.2 RECOMMENDATIONS

In view of the conclusions that enumerated from this research, the following recommendations are proposed to assess the level of implementation of green building technologies on the performance of building construction projects in Southwest, Nigeria.

i. adopting Green Building technologies (GBTs) by professional in Southwest Nigeria has a lot of benefits like reduction in energy cost, improvement of comfort and productivity of occupants, improvement of indoor air quality, and reduction in maintenance cost should be encouraged.
ii. level of awareness and implementation of Green Building technologies (GBTs) by professional in Southwest, Nigeria should be encouraged.
iii. The effect of green building technologies on Project Performance which are cost saving of construction projects, time saving of project and enhanced quality of construction projects should be encouraged
iv. The Challenges to the Implementation of Green Building technologieslike lack of incentives for promoting green building, Low level of awareness, Maintenance and operational challenges, and Preference towards conventional design should addressed.

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