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Critical Factors Affecting the Implementation of Green Building Technologies Adoption in Nigeria

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Abstract

The rapid population growth and increased housing demand have exacerbated environmental challenges, such as excessive waste generation and high energy consumption. The aim of the study is to investigate the barriers hindering the widespread adoption of green building technologies in Nigeria's construction sector. Random sampling method was used to collect information from the respondents. A sample size of three hundred and eighty-four (384) questionnaires were distributed through an online link and three hundred and eighty-four (384), which equates to a hundred (100%) percent of questionnaires distributed. The mean score and sum were employed in for ranking the professionals experience in the field with various barriers and their severity. From the results, positive ratings concerning client satisfaction (4.22), building functionality (4.19), clarifications of technical specifications (3.78), and stakeholders' satisfaction (4.06) were uncovered in the field. High ratings for technology awareness amongst professionals (3.53), and availability of a skilled workforce (3.22) were revealed. To facilitate sustainable construction practices, it is essential to bolster awareness (3.19), ensure the availability of a skilled workforce (3.22), encourage public engagement (3.09), expand financing options (3.03), and enhance government support (3.00). Crucially, addressing project management, compliance, and quality control barriers is vital. By prioritizing these factors and overcoming barriers, Nigeria's construction industry can champion green building, preserve resources, and achieve sustainable outcomes.

Keywords: Adoption, Green building technologies, Barriers, Nigeria's construction sector, Sustainability

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1. Introduction

The rising population in Nigeria has led to an increased demand for housing, putting pressure on the construction sector. Conventional building methods, on the other hand, have accelerated the deterioration and depletion of already limited resources. Nigeria's conventional construction has contributed to further environmental degradation in the nation (Chukwu *et al.,* 2019). The construction sector has greatly improved and is still seeing further improvement. Advancements in construction technologies are currently being put in place and construction industries are putting more consideration into the state of our environment. Construction of energy-efficient buildings, the use of recycled or recyclable materials, and improvements to building longevity and occupant health have resulted from this (Berhad, 2010). This relatively new innovation is known as Green Building Technology (GBT). Green Building technology is a branch of engineering that applies environmentally friendly ideas to building. GBT entails applying eco-friendly design, building, and maintenance practices (Swarnkar & Singh, 2016). The principles of green building technologies also cover the effective use of water through water harvesting and recycling, the use of solar and photovoltaic systems for renewable energy, and the use of recyclable or recycled materials in buildings. While many advanced and developing countries have embraced green building practices, Nigeria lags behind due to various barriers (Idris *et al.,* 2020).

The concept of green building has existed for a little over forty years, starting from the late 1980s. Green building has become increasingly vital in the recent years due to the rising effect of global warming and climate change. The idea behind this subject first became popular in the 1970s when the building industry started to design and build more sustainable buildings. This was done in an effort to apply sustainable development ideas to construction projects. Since then, the popularity of green building technology has been growing due to the assistance of globally regulated building-rating systems (Chew *et al.,* 2016).

The building industry makes has championed many significant contributions to the economic development of many countries. However, the building industry's operations have negative impacts on society and the environment in Nigeria (Ijigah *et al.,* 2013; Saroop and Allopi, 2014). The construction industry's waste production and energy use are both world-wide occurrences. 40% of the energy generated, 25% of raw materials, 16% of wood, 40% of total water usage, and 35% of natural resources mined in industrialized countries are used by the construction

sector. Additionally, it is in charge of 40% of the world's energy, 35% of the carbon dioxide (CO2) emissions, and more than 40% of the greenhouse gases discharged into the atmosphere (Sirkeck, 2017; Omuh *et al.,* 2018).

In addition, Windapo (2014) said that 50% of all world resources are used by the construction industry. Infrastructure construction and its associated activities also contribute significantly to harmful emissions, accounting for over 30% of the ozone-harming substances transported globally. This is all due to the tasks that frequently occur during the development process. Comparatively, the transportation and handling of materials associated with it cause 18% of discharges. Environmentally friendly construction practices and preventive actions are required due reduce the negative consequences of construction industry and its activities on the environment. In response to this request, building experts must incorporate green technology concepts into their processes in order to lessen the adverse effects on the environment. The green building technology concepts will enhance performance and productivity of the construction industry which will in turn enhances the living standard of the populace (Swarnkar & Singh, 2016; Ahn *et al.,* 2016; Omuh *et al.,* 2018).

Singh (2018) stated that "the benefits and advantages of green buildings are enormous, as they come in the form of lower development costs which lower operating costs, increase comforts, ensure healthier indoor environment quality, enhance durability and ensure lower maintenance costs". The United States of America's Green Building Council (2015) noted that developed countries have a long history of green building policies that Nigeria does not. Traditional construction methods, inadequate attention to energy and land conservation, and poor-quality materials prevail in the country's construction industry. Despite the existence of awareness and occasional seminars on green technology, the implementation of sustainable principles remains limited. The absence of robust green building policies, political and cultural context, and insufficient efforts to promote green construction further hinder progress. The idea of "green building technology" has thus emerged as an innovative solution to these problems, advocating sustainable materials, renewable energy sources, and energy-efficient design and construction techniques.

According to a study made by Onuoha and Okeahialam (2018), Nigeria was creating its green building policy framework (WSP, 2014). Nigeria registered the Green Building Council of Nigeria (GBCN) with the World Green Building Council (WGBC) in 2014 as a first step toward promoting green building (WSP, 2014; Nduka & Ogunsamni, 2015). While GBCN is responsible for creating the rating system for the evaluation of sustainable buildings in Nigeria, it is currently developing a policy system for green buildings. However, Nigeria has not yet created a green building grading system that might be used to projects for offices, retail, multi-unit housing, public buildings, and educational institutions. The Green Building Council of South Africa (GBCSA) is currently authorized by the Nigerian government to certify green structures for her. It is referred to as Green Star South Africa-Nigeria (Green Star SA-Nigeria).

There are several flaws apparent in the Green Star SA-Nigeria, which included weighting of standards and specification focused on energy efficiency management and innovations. it is therefore unclear whether Nigeria Green Building Council (GBC) intends to enact further regulations to promote green building in the country (Nduka & Ogunsamni, 2015).

According to Nduka & Ogunsamni, (2015), the nine main categories of the Green Star SA rating system management includes, indoor environmental quality management, energy management, assessable transportation system, distribution of quality water , renewable materials management system, land use ecology, emissions control and innovations and technology advancement are the foundation of the system. The Green Building Council of Nigeria (GBCN) and the Green Building Council of South Africa (GBCSA) have agreed to use the Green Star SA grading system until the GBCN rating system is developed. According to Nduka & Ogunsamni, (2015), to assess and certify green buildings in Nigeria, professionals in built environment needs to undergoing training on the 2014 Green Building guideline to become "Green Star SA-Nigeria assessors". The assessors will join the GBCSA Star SA authorized professionals from south Africa and other countries to implement green building standards in Nigeria. Also, the Green Star SA-Nigeria has been modified and recommendations have been made for the Nigerian context in collaboration with the GBCN academics, business and industry experts. This relates to laws, regulations, and sustainable business practices. Nigerians, meanwhile, has not yet felt the effects (Nduka & Ogunsamni, 2015). This is due to the fact that the average Nigerian, especially those working in the built environment, are either not completely aware of or even less certain of the advantages of green building.

The fact that Nigeria has not created its own national Green Building Rating is another significant setback. However, in an effort to guarantee environmental sustainability, Nigeria has formed a variety of institutions and laws designed to encourage sustainability. The National Policy on the Environment (NPE), the Environmental Protection Agency Act (1988), the National Council on the Environment (NCE), the National Policy on Climate Change and Response Strategy, and the National Environmental Standards and Regulations Enforcement Agency

(NESREA) are a few examples of these (Nwokoro & Onukwube, 2011). Even though Nigeria has registered about 317,039 gross square feet of green buildings, it is a serious problem that it has not made any significant environmental rating scheme policy. As a result, the nation has not taken a pre-determined role in pursuing green building policies, establishment and programs that will control the real estate construction industry (United States of America's Green Building Council, 2015). Worth mentioning is the Green Housing Estate that the FCMB (First City Monumental Bank) wanted to build in Lagos. The project was started in 2012 and was expected to cost $500 million, but it has essentially been abandoned because of the nation's economic problems and other limiting factors (Oyefusi *et al.,* 2019).

Conventional construction still dominates Nigeria and will do so for years to come. The construction sector is still more concerned with creating traditional buildings. However, very few buildings make an effort to incorporate some aspect of green design during construction. This involves the use of solar panels as a replacement for an electric power supply to provide energy for cooling, lighting, and powering their equipment, including the installation of other energy-efficient fixtures to improve the building's insulation. With technological improvements, existing structures can be modified to improve efficiency, environmental responsibility, and occupant well-being. The use of high-quality, long-lasting, aesthetically pleasing, and low-maintenance materials must be taken into account by those who work in the building construction industry. Bredenoord (2017) asserts that a structure must be able to shield occupants from adverse weather conditions as heat, wind, cold, rain, etc. But according to the research done by Onyegiri & Ugochukwu (2016), buildings made of natural materials have concerns with acceptability, low strength, high maintenance requirements, and deforestation, among other things. (Adeniyi *et al.,* 2020). However, it should be taken into consideration that many building materials and methods have roles they are best suited for. This is the same for conventional materials where when used improperly and in the wrong quantities, will ultimately produce poor building conditions, enabling the structure to have these same problems. Therefore, building professionals should take into account other elements like the weather, topography, etc. and which green materials work best for construction in certain regions.

In addition, when compared to the use of traditional materials, potential green materials can generate buildings at a lower cost, making them cost-effective for building construction (Adeniyi & Mohamed, 2020).

The degree of the Nigerian society's exposure to the green building idea was meticulously outlined in a study conducted by Dahiru *et al.* (2014). According to the study, the research was based on the responses to structured questionnaires distributed to various respondent categories. These categories included developers, public and private organizations, construction professionals, artisans, and the general public. Despite the fact that approximately 70% of respondents who were developers and professionals were familiar with the concept of green building, it was found that only a small percentage of respondents—5%—had worked with or were planning to adopt the design due to some obvious limitations that will be discussed in this paper. While the craftspeople and the general public displayed and admitted their ignorance of the design and its corresponding advantages and benefits, they neglected to take into account the limitations that would be encountered. These survey covered several challenges to the implementation of green buildings technology like lack of proper green rating systems, technical and technological obstacles, costs associated with green building, lack of awareness and incentives to promote green building technology, unavailability of green building technology, perception of risks, expectations, cultural and social resistance. The paper has also come up with possible solutions to eliminate these barriers, starting with the creation and implementation of a Nigerian green building rating system.

Construction practices and technologies have negatively impacted the environment by degrading water quality at various levels and causing environmental disruptions. Inefficient and uneconomical construction techniques, high expenses, the use of subpar Portland cement, and other construction materials all have a negative impact on the environment. In addition, the environment has been negatively impacted by the aggressive impact of chemical agents, the effects of mineral admixtures, the leaching of construction materials, the disposal of materials, and the lack of recyclable resources. The burden of construction practices on the Nigerian built environment has also been increased by the absence of standards in the construction processes in urban centers. Such examples include the use of localized openings and trenches in the development and maintenance of urban infrastructure, and the improper disposal of primary and secondary aggregates (Elmasry & Haggag, 2011). Therefore, for these problems to be solved and for the country to work towards a better and healthy environment, green building technology isn’t just needed, but is a necessity for the country’s development.

2.Materials and Methods

This research involved the use of structural questionnaires administered online to various green building professionals. The primary study population is a list of green building professionals active in the field. These professionals involve individuals in the Green Building Council of Nigeria, which is a non-governmental organization. The professionals who filled the questionnaires mostly consisted of project managers, engineers, builders, and architects. As there was little to no information on the detailed number of green building professionals in the country's construction industry, the population size of this research was based on the responses received. Three hundred and eighty four (384) copies of well-structured questionnaire was distributed online to green building professionals by the use of proportional random sampling technique. Three hundred and eighty-four (384) questionnaires were retrieved from the respondents, giving it a response rate of 100%. The collected data were presented and examined with Statistical Package for Social Science (SPSS) version 23 and Excel 2013. The Mean Score (MS) were used to determine the convergence and divergent views of the stakeholders as they assessed the barriers preventing the adoption of green building technology in the country. Factor analysis as data reduction method via principal component extraction was used to classify these barriers into various categories.

Table 1: Descriptive Result of Respondent Responses to Questionnaire Administration

Administered	Retrieved	Percentage
384	384	100

3.Results and Discussion

Background information of the respondents

Table 2 shows the background information of the respondents. From the result of the survey in Table 2, 81.0% of the respondents are males while 19.0% of the respondents are female. These respondents have carried out green building construction projects in various regions of the country with 37.5% in the North-West, 28.2% in the South-West, 25.1% in the North East, 3.1% in the North-Central, and finally 3.0% in the South-East. However, 3.1% of respondents carried out green building projects in South-South region of the country. The age distribution of the respondents reveals 43.8% to be in their forties, 31.3% in their fifties, 21.9% in their thirties, and 3.0% in their sixties and above. Regarding the academic qualification category, it is evident that there is a small percentage of respondents (12.1%) with Ph.D., and that the overwhelming majority are M.Sc holders with 75.8%. The occupational status of the respondents reveal that 40.6% work in the private sector of the green building field which includes non-governmental organizations, schools, and agencies, 37.5% are shown to be working under the government, either state or federal and are civil servants, and lastly, 21.9% are self-employed, neither being affiliated with a private nor public sector of the green building industry. In terms of respondents' professional qualification, it was shown from Table 2 that architects have the highest representation with 81.3%, project managers with a representation of 9.4%, builders with a representation of 6.3%, and the least represented was engineers with a percentage of 3.0%. Based on the forgoing, the information provided by these green building professionals, having worked on various green building projects was considered adequate and reliable for further analysis upon which inferences was drawn.

Table 2: Background Information of the Respondents

S/No	Categories	Classification	Freq.	Percentage
I	**Gender**	Male	311	81.0
		Female	73	19.0
			384	**100**
Ii	**Green building project regions**	North-West	144	37.5
		South-West	108	28.2
		North-East	97	25.1
		North-Central	12	3.1
		South- South	12	3.1
		South-East	11	3.0
			384	**100**
iii	**Age**	40 – 49yrs	168	43.8
		50 – 59yrs	120	31.3
		30 – 39yrs	84	21.9
		Above 60yrs	12	3.0
			384	**100**
Iv	**Highest educational qualification**	M.Sc.	291	75.8
		Ph.D.	46	12.1
		BSc	12	3.0
		HND	12	3.0
			361	**93.9**
v	**Occupational status**	Private Sector	156	40.6
		Civil Servant	144	37.5
		Self Employed	84	21.9
			384	**100**
vi	**Professional group of respondents**	Architect	312	81.3
		Project Manager	36	9.4
		Builder	24	6.3
		Engineers	12	3.0
			384	**100**

Table 3 indicates the measures or factors that have to be met before a green building can be deemed successful. In the table, respondents reveal how their experience has been with these factors on a range of 1 to 5. Various measures from literature were presented in the questionnaire for respondents to identify and rate, and the Mean Score was used to analyze and identify the level of each factor that the respondents have experienced in their green building projects. The table suggests that while adherence to safety practices, construction cost predictability, design safety, construction time predictability, and project risk avoidance or reduction, are generally satisfactory, there is room for improvement in terms of reducing the number of defects encountered during construction projects with a mean score of 3.75, 3.75, 3.72, and 2.88 respectively. Additionally, there is variation in the level of variation in design change and order with a mean score of 3.47, which may require further attention to ensure smoother construction processes.

Table 3: Green building measures

Factors	5	4	3	2	1	Sum	Mean	Rank
Client satisfaction with the project	156	180	24	24	-	1620	4.22	1
Building functionality	132	192	60	-	-	1608	4.19	2
Stakeholders satisfaction with the project	132	168	60	24	-	1560	4.06	3
Building comfortability	108	204	48	24	-	1548	4.03	4
Quality of coordination by construction team members	132	132	108	12	-	1536	4.00	5
Efficient waste reduction and disposal	132	144	84	12	12	1524	3.97	6
Efficient energy utilization	144	120	72	48	-	1512	3.94	7
Level of material ordering, handling and management on Site	96	168	108	12	-	1500	3.91	8
Building surveying and inspection	120	168	36	36	24	1476	3.84	9
Adherence and compliance to specifications	96	180	48	48	12	1452	3.78	10
Adherence to safety practices	60	216	60	48	-	1440	3.75	11
Construction cost predictability	96	132	120	36	-	1440	3.75	12
Design safety	72	156	132	24	-	1428	3.72	13
Construction time predictability	36	192	156	-	-	1416	3.69	14
Project risk avoidance or reduction	60	132	144	48	-	1356	3.53	15
Variation in design change and order	60	144	108	60	12	1332	3.47	16
Number of defects	24	48	204	72	36	1104	2.88	17

**Note that: 5= Very High, 4= High; 3= Medium; 2= Low, 1= Very Low*

Table 3, further portrays the data behind the top three factors; client satisfaction with the project, building functionality, and stakeholders satisfaction with the project. The ratings for client satisfaction range from 156 to 24, with an overall mean score of 4.22. The majority of the ratings fall into the "very high" category, indicating a high level of client satisfaction with the project. The ratings for building functionality range from 192 to 60, with an overall mean score of 4.19. The majority of the ratings fall into the "very high" category, suggesting that the building's functionality is rated highly by stakeholders. The ratings for stakeholders' satisfaction range from 168 to 24, with an overall mean score of 4.06. The ratings mostly fall into the "high" category, indicating a positive level of satisfaction among stakeholders. This table has shown the professionals experiences with these factors in the field and how frequently these factors influence the progress of green building technology adoption in the country.

Table 4: Green building measures II

Factors	5	4	3	2	1	Sum	Mean	Rank
Awareness of the technology to professionals like architects, engineers, builders, etc.	84	108	132	48	12	1356	3.53	1
Availability of a skilled workforce with knowledge and experience of the technology	60	84	156	48	36	1236	3.22	2
Public awareness of green building technologies	72	48	168	72	24	1224	3.19	3
Policies and incentives that encourage green building	48	96	120	84	36	1188	3.09	4
Availability and accessibility of financing	60	72	84	156	12	1164	3.03	5
Government support and investment	60	60	120	108	36	1152	3.00	6

**Note that: 5= Very High, 4= High; 3= Medium; 2= Low, 1= Very Low*

Table 4 indicates the measures or factors that have to be met before a green building can be deemed successful

which is another extension of the previous table. In the table, respondents also reveal how their experience has been with these factors, specifically the awareness and support provided to the green building projects. Various measures from literature were presented in the questionnaire for respondents to identify and rate, and the Mean Score was used to analyze and identify the level of each factor that the respondents have experienced in their green building projects. The table notes that while there is a relatively high level of awareness of green building technologies among professionals, there is room for improvement in public awareness, availability of financing, and government support and investment with a mean score of 3.53, 3.19, 3.03, 3.00 respectively. Alongside that, the availability of a skilled workforce is moderately satisfactory with a mean score of 3.22, but further efforts may be needed to enhance its availability and ensure a well-equipped workforce for green building projects.

Table 5: Barriers in Green Technology Implementation Green building measures

Barriers	5	4	3	2	1	Sum	Mean	Rank
Clarification of technical specifications	72	192	84	36	-	1452	3.78	1
Client satisfaction with project	108	132	84	60	-	1440	3.75	2
Building functionality	60	192	96	36	-	1428	3.72	3
Level of resistance to change among stakeholders	96	120	132	36	-	1428	3.72	4
Non-compliance to green building codes and regulations	60	168	120	36	-	1404	3.66	5
Quality of coordination by construction team members	60	168	120	26	-	1404	3.66	6
Climate and weather influence	72	108	192	12	-	1392	3.63	7
Limited access to available materials	72	120	144	48	-	1368	3.56	8
Efficient waste reduction and disposal	72	108	156	36	12	1344	3.50	9
Delay of tasks	36	132	192	24	-	1332	3.47	10
Uncertainty in project outcome	72	84	180	36	12	1320	3.44	11
Poor communication between teams	60	84	204	36	-	1320	3.44	12
Wrong selection of construction method	36	144	120	72	12	1272	3.31	13
Misinterpretation of project information	24	144	144	60	12	1260	3.28	14
Poor supervision	24	120	168	60	12	1236	3.22	15
Building code restrictions	36	96	180	36	36	1212	3.16	16
Number of defects	120	168	84	12	-	1164	3.03	17

**Note that: 5= Always occurs, 4= Often occurs; 3= Sometimes occurs; 2= Rarely occurs, 1= Never occurs*

Table 5 analyzes the barriers in green building construction projects. Here, respondents assess the severity of various barriers they have encountered during green building projects on a range of 1 to 5. The Mean Score was used to analyze and identify the level of each barrier that the respondents have experienced in their green building projects. Clarification of technical specifications is the barrier with the highest mean score of 3.78, suggesting that technical specification issues pose the most significant challenge in green building construction projects. Client satisfaction with project is the barrier ranked second with a mean score of 3.75, indicating that ensuring client satisfaction is a crucial challenge. Building functionality ranks third with a mean score of 3.72, indicating that achieving the desired functionality of the building is a significant concern. The remaining barriers follow in descending order of mean score, with "Poor supervision" and "Building code restrictions" having the lowest mean scores of 3.22 and 3.16, respectively. Overall, the data suggests that addressing technical specification issues, ensuring client satisfaction, and achieving building functionality are among the top priorities in the construction project. Additionally, managing resistance to change and complying with green building codes are significant challenges that need attention. The analysis of these tables emphasized the importance of enhancing awareness, availability of skilled workforce, public engagement, financing options, government support, and addressing barriers related to project management, communication, compliance, and quality control. By addressing these factors and barriers, the construction industry can further promote green building practices and ensure successful

project outcomes.

4.Conclusions

The main aim of this study was to comprehensively examine and evaluate the factors that hinder the widespread practice of green building technologies in Nigeria. The research aimed to identify and analyze the key barriers, including socio-cultural, economic, regulatory, and technological factors that impede the successful practice, implementation and integration of green building technologies in Nigerian building construction sub sector. The research study found out that out of several barriers and factors affecting green technology advancement, there were a few that posed serious barriers while other aspects needed more improvement to be effective. Therefore, according to the analysis and interpretation of data collected through the questionnaire from respondents in Nigeria, observation and questionnaire survey, the study has been able to assess the respondents experience with certain green building measures, the barriers encountered during green building construction projects, and how frequently these barriers appear before, during, and after construction.

Based on the findings from the study, it is concluded that:

i. Construction time predictability, project risk avoidance or reduction, and variation in design change and order are factors in green building projects that need to be properly tackled in order to enhance the quality of green building construction projects should be encouraged.

ii. Many green building projects have a number of defects, making it a very crucial barrier along with poor supervision and building code restrictions.

iii. The Nigerian government and other relevant authoritative bodies should provide strong financial programs for the growth of green building technology, and awareness should be made through such programs and campaigns to promote the awareness of green building technology not just to professionals but also to the general public. This will prompt a steady push from the public to strive towards adopting green technology in construction.

iv. Rather than importing green materials that could easily be procured in Nigeria, local businesses should be encouraged to produce green construction products and materials necessary for construction according to each climatic region of the country.

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