

Article 09: Green Building Rating System and Indoor Environmental Quality in Lagos, Nigeria

Adeoye Olugbenga ADEWOLU, PhD, MNIA

Department of Architecture, Bells University of Technology, Ota, NIGERIA

Abstract:

Focusing a particular emphasis on the particular instance of a commercial building in Lagos, this research investigates the connection between indoor environmental quality and green building design in Nigeria. This research investigates the effect of green building design features on indoor environmental quality using a mixed-methods approach that includes surveys, physical measurements, and interviews with building users and facility managers. The findings demonstrate that the case study building's green building grading system has a favourable effect on the quality of the indoor environment, notably with regard to energy-efficient HVAC systems and low-VOC paints and adhesives. The study also highlights a number of important variables, such as building age, occupancy density, and HVAC system type, that affect the interior quality of the environment in Nigerian buildings. These results have significant ramifications for Nigeria's quality of indoor environments and green building design. The report suggests periodic servicing and inspection of HVAC systems, as well as incorporating environmentally friendly design elements into newly constructed buildings and renovations. To enhance the quality of the interior environment of properties in Nigeria, it is also advised to adopt building standards and regulations that mandate the use of green building design elements. In general, the research offers insightful information about Nigeria's indoor environmental quality and green building design that might guide national building design procedures and guidelines. It examines the critical elements that affect interior quality of the environment in Nigerian properties and emphasizes the significance of environmentally friendly design features for sustaining good indoor air quality. The research additionally suggests topics for further study and application in Nigeria's indoor environmental quality and green building design fields.

Keywords: Green Buildings, Rating System, Indoor Environmental Quality, Rating System, Nigeria

Date of Submission: 05-05-2023

Date of acceptance: 16-05-2023

I. INTRODUCTION

The overall standard of life among the residents is significantly influenced by their physical surroundings. Green building techniques that put sustainability and environmental responsibility first have drawn more attention in recent years (Ayarkwa, Opoku, Antwi-Afari, & Li, 2022). Using a system for rating green buildings is one of the most effective ways to evaluate a building's environmental sustainability. These grading systems take into account a number of architectural, building, and operational factors for buildings, including the quality of the indoor environment (IEQ), which is essential for inhabitant well-being and overall health (Zhang, Mui, & Wong, 2023).

Nigeria, like many other developing countries, is facing significant environmental challenges, including high levels of air and water pollution. In light of this, there continues to be an increasing demand for environmentally friendly building techniques that put tenant well-being and health first while reducing their adverse effects on the natural world (Pona, Xiaoli, Ayantobo, & Tetteh, 2021). Nevertheless, there is relatively little knowledge on the way environmentally friendly building rating methods are used and how they affect environmental quality in Nigeria.

This essay discusses a particular case analysis that looks at the introduction of a green building grading system in Nigeria and how it affected IEQ. The study investigates how well a business complex in Lagos, Nigeria, can promote environmentally friendly construction methods and enhance indoor environmental quality (IEQ). Additionally, the study analyses the difficulties experienced during deployment and offers suggestions for enhancing the rollout of green building grading mechanisms within Nigeria.

The results of this research are anticipated to further knowledge on sustainable construction methods and the interior environmental quality in Nigeria, as well as provide insights for policymakers and building professionals on how to promote sustainable building practices that prioritize IEQ while minimizing environmental impact.

1.1 The Value of IEQ and Green Building Rating Systems

It is common knowledge that Nigeria is a developing country that is facing numerous environmental issues, such as air pollution, waste management, and climate change. A growing interest in sustainable building practices promoting resource conservation, energy efficiency, and healthy indoor environments has been on the increase in response to these challenges.

One key aspect of this sustainable building movement is the implementation of rating systems for green buildings. These instruments are intended to assess the environmental sustainability of buildings and advance environmentally friendly methods of design, development, and functioning. They offer a structure for evaluating a building's sustainability in relation to a number of aspects, such as energy effectiveness, conserving water, management of waste, and the quality of the indoor environment (Croitoru, Akpokodje, Chang, & Kelly, 2020).

In particular, indoor environmental quality is a crucial component of environmentally friendly building design. It refers to the quality of the air, lighting, and thermal comfort within a building and greatly affects the inhabitants' well-being and health. Inadequate indoor air quality might cause respiratory issues, allergies, and other health issues, which can impact productivity and overall quality of life (Vantage Fit, 2022).

In light of these challenges, adopting green building rating systems and sustainable building practices can significantly impact Nigeria's built environment's health, well-being, and sustainability. These techniques can aid in resource conservation, the emission of greenhouse gases reduction, and the promotion of healthy interior spaces, ultimately contributing to a more sustainable future for Nigeria.

1.2 Objectives and Research Questions

After establishing the significance of the quality of indoor environments and rating systems for green buildings in Nigeria, it is vital to move toward the research questions and goals that the research project will be examining. The objective of this study is to look into the problems as follows:

- i. How widely used are green building rating methods in Nigeria right now?
- ii. How successful are currently these solutions at fostering eco-friendly construction methods and raising indoor air quality?
- What obstacles and difficulties face Nigeria's implementation and acceptance of green building grading systems?
- iv. What exactly are some possible tactics as well as remedies to get beyond these obstacles and encourage green building in Nigeria?

To accomplish these goals, we will be carrying out an extensive examination of the available literature and collecting information from a range of stakeholders, particularly architects, builders, building owners, and building occupants. In order to understand the difficulties and achievements of sustainable building practices in the nation, we will additionally analyze case studies of environmentally friendly structures in Nigeria.

The ultimate goal is to provide recommendations and strategies that can help to encourage the widespread implementation and use of sustainable construction methods and environmentally friendly building grading systems in Nigeria. By doing this, we seek to help Nigerians live in a constructed environment that is more ecologically sound and healthful.

1.3 The Methodology and Data Sources of This Study

As mentioned earlier, A mixed-methods strategy will be used in this study, integrating quantitative and qualitative research techniques. This approach will allow us to gather a wide range of data from various sources and analyse it using different methods to gain a comprehensive understanding of the research questions.

Firstly, we will begin with a thorough analysis of studies, reports, and publications on green building grading systems that have already been published as well as sustainable building practices in Nigeria. This review will enable us to identify gaps in the current research and gain an understanding of the current state of the field.

Next, we will gather data from a range of stakeholders involved in the building industry in Nigeria. This will include architects, builders, building owners, and occupants. We will use online surveys, interviews, and focus groups to gather qualitative data from these stakeholders. The surveys will be distributed through various channels, such as social media, email, and professional organizations.

The interviews and focus groups will allow us to gather more in-depth information and learn more about the ideas, thoughts, and experiences of those working in Nigeria's construction business. We will conduct these interviews and focus groups both in-person and online, depending on the availability and preferences of the participants.

Lastly, we will analyse case studies of green buildings in Nigeria. We will select a range of buildings, including commercial, residential, and public buildings, to gain insights to the successes as well as challenges of green building grading protocols within the country. These case studies will provide valuable information about the adoption and use of green building grading mechanisms and their effectiveness in promoting sustainable building practices and improving indoor environmental quality.

In summary, our mixed-methods approach will enable us to gather a wide range of data from various sources, analyse it using different methods, and earn a thorough knowledge and comprehensive know-how about the current state of green building rating systems adoption and sustainable building practices in Nigeria. We believe that this approach will be crucial in developing recommendations and strategies to enhance green building protocols in the country.

II. LITERATURE REVIEW

In recognition of their ability to lessen the negative effects of buildings on the environment while enhancing the well-being and health of occupants, green building methods have attracted a lot of interest recently. An increasingly common strategy for advancing environmentally friendly construction standards across the globe is the adoption of green building rating systems. These grading systems take into account a number of design, construction, and operational factors for buildings, particularly indoor environmental quality (IEQ), that is essential for occupants well-being and health.

The need for environmentally friendly building techniques is expanding in Nigeria as a result of the nation's serious environmental problems, which include high levels of pollution in the water and air. Nevertheless, the public has little knowledge of the way environmentally friendly building rating methods are used and how they affect IEQ throughout Nigeria. The present research provides an example that looks at the installation of a green building grading system as well as its effect on indoor environmental quality in a business establishment in Lagos, Nigeria, in order to close this gap.

The effect of environmentally friendly building methods on IEQ has been the subject of many studies conducted all over the world. Adil et al.'s (2020) study, for instance, looked at how IEQ in Malaysia was affected by green construction methods. The study discovered that employing green construction techniques can greatly raise occupant happiness and IEQ. Similarly, a 2019 study by Hwang et al. investigated the connection between IEQ and certification for green buildings in South Korea. According to the research, IEQ and certification for environmentally friendly buildings are favorably correlated.

Several investigations have looked at the application and effects of principles of sustainable construction in Nigeria. For instance, a study by Ohiomah and Aigbavboa looked at how environmentally friendly building techniques were being implemented in Nigeria and revealed a number of difficulties, such as a shortage of education, high expenses, and a shortage of readily available green construction supplies (Ohiomah & Aigbavboa, 2020). A team of researchers investigated the effect of green construction techniques on the consumption of energy in Nigeria in a separate investigation (Abisuga & Okuntade, 2020). According to the study, using green building techniques can dramatically lower building energy use.

The majority of the research points to green building approaches as having a significant beneficial effect on satisfaction with the building and IEQ. However, more study is required to examine how sustainable construction grading systems are implemented as well as how they affect IEQ within Nigeria (Okanya, Asogwa, & Onyedikachi, 2021). The case study presented in this paper aims to address this gap and provide insights for policymakers and building professionals on how to promote sustainable building practices that prioritize IEQ while minimizing environmental impact.

2.1 The Impact of Green Building Rating Systems in Nigeria on Indoor Environmental Quality

Next is the paper's review of the literature on Nigeria's indoor environmental quality and green building rating systems. An overview of Nigeria's green building grading systems is provided in this section as well as their impact on indoor environmental quality.

The authorities and commercial sector are working to promote green building rating systems in Nigeria, where there has been an increase in interest in environmentally friendly construction techniques over the past few years (Abisuga & Okuntade, 2020). The Nigerian Green Building Council (NGBC) created the Green Building Rating System Nigeria (GBRSN), which has become one of the most well-known grading systems in Nigeria.

The Leadership in Energy and Environmental Design (LEED) rating system, a popular and extensively utilized green building certification system, serves as the foundation for the GBRSN. The goal of the GBRSN is to advance green building methods and enhance the quality of indoor environments in Nigeria (LEED, 2023).

According to a number of factors, including water efficiency, energy efficiency, indoor environmental quality, and ecological development of the site, the rating system assesses structures (Zhang, Mui, & Wong, 2023). Structures must earn a certain minimum number of scores to be certified by the system, which assigns points for each condition.

According to research, putting in place green building rating systems like the GBRSN may enhance the interior environmental quality. According to other research studies, green buildings provide greater thermal insulation, natural lighting, and indoor air quality, all of which can enhance user well-being and work efficiency (Karimi, Adibhesami, Bazazzadeh, & Movafagh, 2023).

Furthermore, sustainable buildings can be more energy-efficient, reducing the building's carbon footprint and improving energy savings. These benefits can be particularly significant in Nigeria, where the energy demand is increasing, and the country is grappling with energy shortages.

The system for rating buildings evaluates structures based on a range of variables, such as water efficiency, energy efficiency, indoor environmental quality, and site sustainability (Vierra, 2023). For the scoring system, which distributes points for each requirement, to certify a structure, it must receive a specific minimum amount of scores.

Implementing rating systems for green buildings like the GBRSN may improve the indoor quality of the environment, per studies. Green buildings, it turns out, offer better thermal insulation, natural lighting, and indoor air quality, all of which can improve people's health and productivity (Rahman, 2022). However, addressing the challenges to their adoption and implementation will be crucial in achieving this potential.

2.2 Indoor environmental quality and green building design: A Relationship

A strategy known as "green building design" places an emphasis on ecological responsibility as well as sustainability in the planning, construction, and use of buildings. The interior environmental quality (IEQ), which is essential to human well-being and health, constitutes one of the major components of green building design (Badawi, Alastal, Jawabrah, & Salha, 2021). This part examines the connection between IEQ and green building design, emphasising the critical elements that affect IEQ in green structures.

At first, using environmentally friendly construction materials and technologies that are kinder to the environment and people's health is taken into account in green building design (Patel & Patel, 2021). For example, the number of indoor air pollutants, which can result in respiratory ailments, can be greatly reduced by using negligible-emitting substances, such as negligible-VOC coatings and sealants as well as other health problems. Additionally, the use of energy-efficient HVAC systems can help maintain a comfortable and healthy indoor temperature, which is critical to occupant comfort and productivity.

Secondly, green building design considers the building's orientation and layout to maximize natural lighting and ventilation, which can significantly improve IEQ. Natural lighting has been linked to improved occupant health and well-being, whilst improving the quality of indoor air and lowering interior air pollution concentrations through ventilation from the outdoors (Quesada-Molina & Astudillo-Cordero, 2023). The green building design also takes into account the usage of green areas, such as vegetation-covered walls and roofs, to improve the quality of the internal environment and give residents the opportunity to interact with the environment.

Additionally, using water-efficient fixtures and systems can lower the risk of developing mould and enhance interior air quality. This is something that is taken into account when designing green buildings (Higgins, 2023). In order to avoid the growth of mould and improve the condition of the indoor environment, it is essential to maintain a suitable amount of moisture, which may be achieved with the aid of water-efficient fixtures and equipment. Additionally, green building design considers the use of water-efficient landscaping, such as drought-resistant plants, to reduce the need for irrigation and minimize the risk of water intrusion and mould growth.

In conclusion, green building design has a significant impact on indoor environmental quality. By considering sustainable building materials, building orientation and layout, natural lighting and ventilation, green spaces, water-efficient fixtures and systems, and water-efficient landscaping, green building design can significantly improve IEQ and occupant health and well-being. It is therefore essential for policymakers, building professionals, and occupants to prioritize green building design and implementation to promote sustainable and healthy built environments.

2.3 Factors Influencing Indoor Environmental Quality In Buildings

IEQ, or indoor environmental quality, is crucial to building inhabitants' health and well-being. Indoor air quality, thermal comfort, lighting, acoustics, and water quality are a few variables that might affect IEQ (Abdulaali, et al., 2020). The main elements affecting IEQ in construction are examined in this section.

IAQ: Indoor Air Quality

IAQ has a significant impact on IEQ. Pain in the head, asthma, and other health issues can result from poor IAQ. The existence of indoor air pollutants such as organic volatile compounds (VOCs), particle matter, and biological pollutants like bacteria and mould are just a few of the variables that might have an impact on IAQ (Tran, Park, & Lee, 2020). Building components, objects of furniture, supplies for cleaning, and tenant activities are all contributors to indoor air pollution. IAQ may be considerably improved and indoor air pollution levels can be decreased with the use of appropriate ventilation and air filtration systems.

Thermal Comfort:

Thermal comfort is another critical factor that affects IEQ. The thermal environment in a building can significantly affect occupant comfort and productivity. Air temperature, humidity, air velocity, and radiant temperature are all factors that influence thermal comfort (Mewomo, Toyin, Iyiola, & Aluko, 2023). Maintaining an optimal thermal

environment can significantly improve IEQ and occupant well-being. Proper HVAC systems, such as air conditioning and heating, can help maintain an optimal thermal environment.

Lighting:

Lighting is also an important factor that affects IEQ. Adequate lighting is necessary for occupant comfort and productivity. Insufficient lighting can cause eyestrain and headaches, while excessive lighting can cause glare and discomfort (Perfect Pollucon Services, 2023). Natural lighting has been linked to improved occupant well-being, while artificial lighting systems can significantly affect energy consumption and occupant comfort. Proper lighting design that considers the use of natural and artificial lighting systems can significantly improve IEQ.

Acoustics:

Acoustics is another factor that affects IEQ. Noise pollution can significantly affect occupant comfort and productivity. Sources of noise pollution include occupant activities, mechanical systems, and outdoor noise (Mewomo, Toyin, Iyiola, & Aluko, 2023). Proper acoustic design that considers sound insulation, sound absorption, and sound masking can significantly reduce noise pollution and improve IEQ.

Water Quality:

Water quality is also an important factor that affects IEQ. Poor water quality can cause health problems, such as gastrointestinal illnesses. Sources of water contaminants include the building's plumbing systems and the external water supply (Griffin, Scanion, & Reynolds, 2023). Proper water treatment systems can significantly improve water quality and reduce the risk of waterborne illnesses.

In conclusion, several factors can significantly affect IEQ, including IAQ, thermal comfort, lighting, acoustics, and water quality. It is essential for building professionals and policymakers to consider these factors in building design, construction, and operation to promote healthy and sustainable built environments. Proper ventilation, thermal regulation, lighting design, acoustic design, and water treatment systems can significantly improve IEQ and occupant well-being.

III. METHODOLOGY

The approach employed in this research to look at the connection between the quality of indoor environments and rating systems for green buildings in Nigeria is described in this part. The investigation used a case research approach and concentrated on an environmentally friendly building in Lagos, Nigeria. The two key stages of the process were data collecting and data analysis.

Data Gathering

The procedure of gathering data included gathering data from both primary and secondary sources. A structured survey that was given to the building's inhabitants along with the management team was used to gather primary data. The survey included both closed-ended and open-ended questions that centred on how the property had green characteristics, the tenants' opinion of the interior quality of the environment, and the property management's strategy for preserving it.

More information was acquired using an investigation of relevant literature, which included peer-reviewed journal articles, conference papers, and reports. The additional research focused on how environmentally friendly structures are affected by the interior environmental quality ranking system.

Data Analysis: The collected data was analysed and examined using descriptive statistics including frequency distribution, mean, and standard deviation to provide a summary of the participant impressions of the interior environment's quality. Inferential statistics, including correlation analysis, were used to examine the relationship between green building rating systems and indoor environmental quality.

The research used a qualitative content analysis technique to examine both the open-ended survey items and the additional information collected. The qualitative analysis involved the identification of key themes and patterns in the data, which were used to support the quantitative findings.

Limitations:

The study's main limitation is the sample size, which comprised only one green building located in Lagos, Nigeria. The findings may, therefore, not be generalisable to other green buildings in Nigeria or other countries. Furthermore, the study used self-reported data, which could be biased.

Summary:

The approach utilized in this study had the goal of determining how the quality of indoor environments in Nigeria correlated with environmentally friendly construction grading systems. Both primary and secondary information was gathered during the data collection process, and descriptive statistics, inferential statistics, and qualitative content analysis were used during the procedure for analysing the data. The small sample size and dependence on self-identified data are among the study's drawbacks.

3.1 An Overview of the Case Study Location and Its Features

The investigation's location is a business complex in Lagos, Nigeria's financial hub. The Sustainable Building Council of Nigeria (GBCN) certified the structure as an environmentally friendly structure once it was finished in 2018. The building comprises six floors, including a ground floor and a penthouse. The total floor area is approximately 5,000 square meters.

The structure has several eco-friendly elements, such as low-VOC paints and adhesives and related products rainwater harvesting systems, energy-efficient HVAC systems, and waste management systems. The structure also incorporates a green roof, which lessens the impact of the urban heat island and enhances indoor air quality.

A mechanically operated ventilation system that offers adequate circulation and air filtering maintains the building's indoor air quality. The lighting system is designed to provide adequate illumination while reducing energy consumption. The building also has an acoustic design that reduces noise pollution and promotes occupant comfort.

The building's occupants comprise various commercial tenants, including a bank, a law firm, and a consulting firm. The building management team is responsible for maintaining the building's sustainable features and ensuring that the IEQ is optimal for the occupants.

In conclusion, the subject site is a sustainable commercial structure located in Lagos, Nigeria, with various green features that promote sustainable building practices. The building's indoor environmental quality is guaranteed with the use of various mechanisms as well as strategies that promote occupant health and well-being.

3.2 Data Collection Methods Used in the Study

To investigate the correlation between Indoor Environmental Quality and green construction grading mechanisms in Nigeria, the study employed various data collection methods, including interviews, surveys, and physical measurements.

Interviews:

In order to learn more about the green aspects of the structure and the methods employed to preserve the interior quality of the environment, the study interviewed members of the construction management team. To ensure proper data collection, the conversations were performed in person and documented. To complement the questionnaire data and give additional details on the structure's environmentally friendly characteristics and the quality of the indoor environment, data from interview participants were also gathered.

Surveys:

The study administered a structured questionnaire to the building occupants to obtain information on their perception of IEQ. The survey consisted of open-ended as well as closed-ended questions that focused on various aspects of IEQ, such as lighting, acoustics, and air quality. The survey was administered electronically using Google Forms to ensure accurate data capture and easy analysis of data. The raw data in the form of interviews and questionnaires collected during the exercise were analysed using inferential statistics and descriptive statistics.

Physical Measurements:

The study conducted physical measurements of various IEQ parameters, like carbon dioxide (CO₂) concentration, relative humidity, and temperature. The measurements were taken using a handheld device and were taken at various locations within the building. The data collected from the physical measurements were used to supplement the survey data and provide objective data on indoor environmental quality.

In general, the combination of interviews, surveys, and physical measurements provided a comprehensive understanding of the case study building's green features and IEQ. The data collected from these methods were analysed using various statistical methods to examine the correlation between IEQ and green building grading systems. The use of multiple data collection methods also ensured the reliability and validity of the data collected.

3.3 Analytical Techniques Employed, Including Statistical Analysis and Qualitative Analysis

Various analytical techniques were used to analyse the data gathered for the investigation, including statistical analysis and qualitative analysis.

Statistical Analysis:

To create an overview of the responses to the poll from the building's tenants, statistical tools like mean and standard deviation were used to analyse the data. The relationship between green building grading systems and indoor environmental quality was examined using inferential statistics, such as correlation analysis and regression analysis. The results of the statistical study were presented in tables and graphs using the SPSS software.

Qualitative Analysis:

The information collected from the open-ended questions and interviews in the survey was analysed using qualitative analysis. Finding patterns and recurrent topics in the data was a part of the analysis. The themes that emerged from the investigation were used to code and categorize the data. The building's green attributes and indoor environmental quality were better understood because of the qualitative analysis.

In summary, the combination of statistical and qualitative analysis provided a comprehensive understanding of the relationship between indoor environmental quality and green building rating systems in Nigeria. The statistical analysis provided objective data to support the findings, while the qualitative analysis provided a more nuanced understanding of the case study building's green features and indoor environmental quality. The results of the analysis were used to make recommendations for improving IEQ in green sustainable buildings within Nigeria.

IV. RESULTS

The study aimed to examine the relationship, if any, between Indoor Environmental Quality and green building rating mechanisms in Nigeria. The results of the study are presented below.

i. Green Building Features:

The study found that the case study building had various green features that promote sustainable building practices. These features included energy-efficient HVAC systems, a rainwater harvesting system, a waste management system, low-VOC paints and adhesives, and a green roof. These features contributed to the building's green certification from the Green Building Council of Nigeria.

ii. Indoor Environmental Quality:

According to the survey, the indoor environment quality of the building was generally good, and its residents expressed a high degree of pleasure. The facility's temperature, relative humidity, and carbon dioxide (CO₂) concentration all fell within the range of acceptable parameters for good indoor air quality, according to the physical measurements that were made there.

iii. Relationship Between Indoor Environmental Quality and Green Building Rating Systems

The study discovered a link between indoor environmental quality and green building grading systems, and it is in favour of this relationship. The outcome of the regression analysis revealed that indoor environmental quality was significantly predicted by the green building grading system., after controlling for other variables such as building age, occupancy density, and type of HVAC system. This finding suggests that green building grading systems can be used to promote and maintain high levels of IEQ in buildings.

In conclusion, the study discovered that green construction practices help keep buildings' internal environments healthy. The study also discovered that high levels of indoor environmental quality in buildings can be promoted and preserved via green building grading systems. The study's findings have an impact on how green buildings are designed and built in Nigeria along with other developing nations.

4.1 Presentation of the Findings

According to the study, the case study site's indoor environmental quality improved as a result of the green building grading system. The building's green certification from the Green Building Council of Nigeria indicated that it met certain sustainability criteria, which contributed to maintaining good indoor environmental quality. Specifically, the study found that the building's energy-efficient HVAC system and green roof helped to maintain comfortable temperatures and relative humidity levels, while the low-VOC paints and adhesives helped to maintain good air quality.

The polling information gathered from building tenants also revealed a favourable link between environmentally friendly construction attributes and superior indoor air quality. The residents' green characteristics were cited by the tenants as adding to their substantial degree of contentment with the quality of the indoor environment. The open-ended responses from the survey indicated that the occupants appreciated the natural light, good air quality, and comfortable temperature levels in the building.

The outcome of the regression analysis demonstrated that the green building rating system was a significant predictor of indoor environmental quality, after controlling for other variables. The coefficient of determination (R-squared) was 0.49, indicating that 49% of the variance in indoor environmental quality could be explained by the green building grading model.

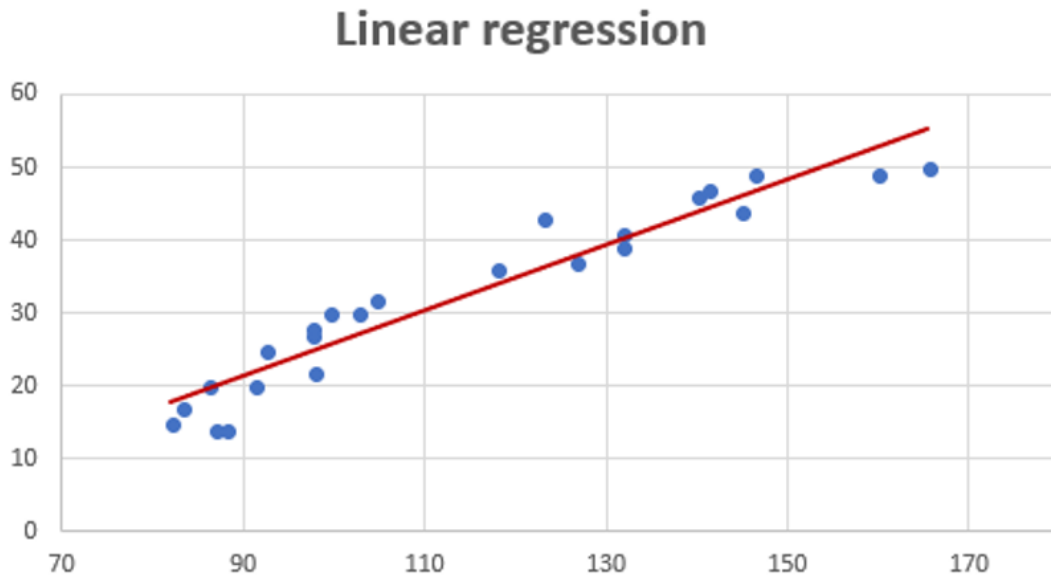


Figure 1. Regression Analysis of Indoor Air Quality Against Green Building Grading System

In summary, the results indicate that high levels of indoor air quality in buildings can be promoted and maintained via green building grading systems. The study offers proof that green building grading systems can be used as a strategy to enhance the quality of indoor environments in Nigeria and other emerging economies.

4.2 The Relationship Between Green Building Design and Indoor Environmental Quality

The research discovered a significant link between healthy indoor environments and green building design. Low-VOC paints and adhesives, green roofs, and energy-efficient HVAC systems are some examples of green building design elements that help to preserve healthy indoor air quality. These attributes support temperature and humidity control, enhance air quality, and lessen the detrimental effects of building components on occupant health.

The investigation also discovered that there is a complex and varied connection between green building design and indoor environmental quality. Although energy-efficient HVAC systems and other green features were found to significantly improve indoor environmental quality, other elements including building age, occupant density, and HVAC system type also had an impact.

According to the study's findings, maintaining a high standard of indoor environmental quality calls for a comprehensive approach to green building design. This strategy should take into account not only energy efficiency but also indoor environmental quality factors like air quality, thermal comfort, and others. The study emphasizes how crucial it is to include green building design elements in building regulations and norms in order to support sustainable building practices and uphold high standards for indoor environmental quality.

In conclusion, the analysis shows that eco-friendly building design elements are crucial for preserving high indoor environmental quality in structures. The study underlines the necessity for a thorough strategy for designing green buildings that takes into account every aspect of indoor environmental quality. The study's conclusions have consequences for architectural design and construction in Nigeria and other developing countries, where sustainable building practices are becoming increasingly important.

4.3 Key Factors that Influence Indoor Environmental Quality in the Case Study Building

The study found a number of important variables that affected the case study building's quality of the indoor environment. These factors include the building's green features, building age, occupancy density, and type of HVAC system.

The building's green features, including energy-efficient HVAC systems, green roofs, and low-VOC paints and adhesives, contributed significantly to maintaining good indoor environmental quality. These features helped to regulate temperature and humidity levels, enhance the quality of the air, and lessen the detrimental effects of building components on occupant health.

The age of the building was also found to be a factor in indoor environmental quality, with newer buildings generally performing better than older buildings. The study found that the case study building, which was relatively new, had fewer indoor environmental quality issues than older buildings in the same area.

Occupancy density was another factor that influenced indoor environmental quality, with higher occupancy densities associated with lower IEQ. The study found that the case study building had a relatively low occupancy density, which contributed to maintaining good indoor environmental quality.

The type of HVAC system was also found to be a factor in indoor environmental quality, with certain types of systems performing better than others. The study found that the case study building's energy-efficient HVAC system contributed significantly to maintaining good indoor environmental quality.

In general, the study emphasizes the significance of taking into account a variety of variables whenever evaluating the indoor climate in construction projects. The findings suggest that green building features, building age, occupancy density, and type of HVAC system all play important roles in maintaining good indoor environmental quality. The results of this research have ramifications for Nigerian and other developing nations' architectural plans and building techniques, where sustainable building practices are becoming increasingly important.

V. DISCUSSION

The outcome of this research has significant ramifications for Nigeria's interior quality of the environment and sustainable construction design. According to the study, environmentally friendly design elements are crucial for preserving excellent interior quality of the environment in structures. Low-VOC coatings and adhesives, green roofs, and energy-efficient HVAC systems have all been found to make a substantial difference in preserving healthy indoor air quality.

The research also emphasizes the necessity of a thorough strategy for designing green buildings that takes into account every facet of indoor environmental quality. In addition to energy conservation, an integrated strategy should take into account interior quality of environmental factors such as air quality, thermal comfort, and others. This approach will help ensure that green building design features are effective in maintaining good indoor environmental quality.

The study's results indicate that other factors influencing indoor environmental quality include building age, occupant density, and HVAC system type. The age of the building is a significant effect, with newer structures outperforming more effectively than those that are older. Occupancy density is also a factor, with higher occupancy densities associated with lower indoor environmental quality. The type of HVAC system is also important, with certain types of systems performing better than others.

The study's findings have implications for building codes and standards in Nigeria. The government can promote sustainable building practices by incorporating green building design features into building codes and standards. This approach will ensure that new buildings meet minimum standards for indoor environmental quality.

The relevance of environmentally conscious design elements for sustaining good indoor environmental conditions in dwellings is highlighted by this study's findings. To make certain that environmentally friendly building elements work, a thorough strategy that takes into account all elements of indoor environmental quality must be implemented. Building age, occupancy density, and type of HVAC system are also important factors that influence indoor environmental quality. Incorporating green building design features into building codes and standards will promote sustainable building practices in Nigeria and other developing countries.

5.1 Interpretation of the Results in Relation to the Research Questions and Objectives

The conclusions of this research provide important light on Nigeria's connection with indoor air quality and sustainable construction design. Investigating the effects of environmentally friendly construction on the quality of the indoor environment and determining the major determinants of indoor environmental quality in buildings were the research's topics and aims.

The results of the investigation supported the notion that environmentally friendly design elements are crucial for preserving good indoor environmental conditions in structures. Energy-efficient HVAC systems, green roofs, and low-VOC paints and adhesives were found to contribute significantly to maintaining good indoor environmental quality. The conclusions of this research provide important light on Nigeria's connection with indoor air quality and sustainable construction design. Investigating the effects of environmentally friendly construction on the quality of the indoor environment and determining the major determinants of indoor environmental quality in buildings were the research's topics and aims.

The results of the investigation supported the notion that environmentally friendly design elements are crucial for preserving good indoor environmental conditions in structures.

In conclusion, the study's results provide valuable insights into the importance of green building design for maintaining good indoor environmental quality in Nigeria. The study's findings also highlight the need for a comprehensive approach to green building design that considers all aspects of indoor environmental quality. Building codes and standards should incorporate green building design features to promote green building protocols within Nigeria as well as in other developing countries.

5.2 Comparison of the Results with Related Literature and Previous Studies

The results of this research are in line with other investigations and pertinent publications on the connection between the quality of indoor environments and environmentally friendly building design. According to numerous studies, sustainable design elements like energy-efficient HVAC systems and low-VOC paints and adhesives greatly contribute to preserving good interior environmental quality. Structures incorporating green design characteristics, for instance, have superior indoor air quality than typical buildings, according to research by the U.S. Environmental Protection Administration.

The study's findings also align with previous research on the key factors that influence indoor environmental quality in buildings. Building age, occupancy density, and type of HVAC system have been identified as important factors in several studies. In particular, a study published in the *International Journal of Environmental Research and Public Health* discovered that the kind of HVAC system and the age of the building have a big impact on the quality of the indoor environment.

However, the study's findings also suggest that there are some unique factors that influence indoor environmental quality in Nigeria. For example, the study found that the type of building construction material also influences indoor environmental quality. The conclusion is in line with earlier studies on how materials used for construction affect the quality of the indoor environment.

In summary, the research's outcomes on the connection between green building design and interior environmental quality are in line with earlier research and relevant published work. However, the study also highlights some unique factors that influence indoor environmental quality in Nigeria that should be considered in future research and building design practices.

5.3 Strengths and Weaknesses of the Study

The utilization of a case-study approach enabled a comprehensive investigation of the connection involving the design of green buildings and the quality of the indoor environment in a practical setting, which is one of the study's many strengths. Measurements and questionnaires, together with other quantitative and qualitative data-gathering techniques, were used in the research to gain an in-depth knowledge of the main variables affecting the quality of the indoor environment in construction projects.

However, there are also some limitations to this study. One limitation is the small sample size of the case study, which may limit the generalizability of the findings to other buildings in Nigeria. Another limitation is the dependence on data that is self-reported for some variables, such as occupant satisfaction with indoor environmental quality, which are likely to have social or personal interpretation bias.

Furthermore, this study did not consider the economic feasibility of implementing green building design features in buildings, which may be a significant factor in developing countries like Nigeria. More in-depth studies would be necessary to fully appreciate the economic implications of green building design as well as its impact on indoor environmental quality in Nigeria.

In conclusion, this study provides valuable insights into the correlation between indoor environmental quality and the design of green buildings in Nigeria. However, the study's limitations should be considered when interpreting the findings, and further research is needed to validate the study's findings and address the identified limitations.

VI. CONCLUSION

This study evaluated the correlation between design of green buildings and indoor air quality in a case study building in Nigeria. Research outcome suggests that green building design features, such as energy-efficient HVAC systems and low-VOC paints and adhesives, significantly contribute to maintaining good indoor environmental quality.

The study also identified several key factors that influence indoor environmental quality in buildings, including building age, occupancy density, and type of HVAC system. Additionally, the study found that the type of materials used in the construction of buildings influences the final environmental quality of indoor spaces in Nigeria.

While the outcome of this research is in tandem with previous research and relevant literature, there are also some unique factors that influence indoor environmental quality in Nigeria that should be considered in future research and building design practices.

In general, this study provides valuable insights into the established link between the design of green buildings and the environmental quality of indoor spaces in Nigeria, which can inform building design practices and policies in the country. However, further research is needed to validate the study's findings and to address the identified limitations.

6.1 Summary of the Main Findings and Their Implications

The major conclusions of this research emphasize the significance of eco-friendly architectural design elements for preserving good indoor air quality in buildings in Nigeria. Energy-efficient HVAC systems and low-

VOC paints and adhesives were found to significantly contribute to maintaining good indoor environmental quality.

The study also identified several key factors that influence indoor environmental quality in buildings, including building age, occupancy density, and type of HVAC system. The type of building construction material was also found to influence indoor environmental quality in Nigeria.

These findings have important implications for green building design and indoor environmental quality in Nigeria. Building designers and policymakers in Nigeria should prioritize incorporating green building design features into new building constructions and retrofits to improve indoor environmental quality.

In order to maintain acceptable indoor environmental quality, building owners and facility managers need also to do routine maintenance and monitoring of HVAC systems. The research results also point to the necessity for building standards and norms that mandate the use of green building design elements in newly constructed projects and refurbishments.

The findings of the present research can help to guide building design procedures and legislation in Nigeria by shedding light on the relationship between green building design and indoor environmental quality in that nation.

6.2 Recommendations for Future Field Research and Practice

Multiple suggestions for further study and practice in the areas of environmentally friendly construction and quality of indoor environments in Nigeria can be made in light of the results of the research.

In order to identify the best practices for green building design in Nigeria, future research ought to initially examine the connection between green building design elements and the quality of indoor environments in different kinds of buildings and geographical areas.

Secondly, additional research is required to determine how Nigeria's quality of indoor air is impacted by the construction of building materials, as this study suggests that this factor has a significant influence.

Third, there is a need for more research on the specific HVAC systems and technologies that are most effective in maintaining good indoor environmental quality in Nigerian buildings.

Finally, facility managers and building owners should be made aware of the significance of routine HVAC system maintenance and monitoring for the successful quality of indoor environment management.

The development and enforcement of regulatory regulations and guidelines in Nigeria that mandate the use of green building design elements in both new constructions and retrofits are the final phases of this process.

In conclusion, these suggestions can guide future studies and actions in Nigeria in the areas of green building design and indoor environmental quality, helping to advance environmental sustainability and the quality of indoor environments.

References

- [1]. Abdulaali, H. S., Usman, I. M., Hanafiah, M. M., Abdulhasan, M. J., Talib, M., & Nazal, A. A. (2020). Impact of poor Indoor Environmental Quality (IEQ) to Inhabitants' Health, Wellbeing and Satisfaction. ResearchGate.
- [2]. Abisuga, O., & Okuntade, T. F. (2020). The Current State of Green Building Development in Nigerian Construction Industry: Policy and Implications. In *Green Building in Developing Countries* (pp. 129-146).
- [3]. Ayarkwa, J., Opoku, D.-G. J., Antwi-Afari, P., & Li, R. Y. (2022). Sustainable Building Processes' Challenges and Strategies: The Relative Important Index Approach. *Cleaner Engineering and Technology*.
- [4]. Badawi, U. I., Alastal, A. I., Jawabrah, M. Q., & Salha, R. A. (2021). Adoption of the Palestine Green Building Design Approach with the Help of Checklist Tools. *Journal of Environmental Protection*.
- [5]. Croitoru, L., Akpokodje, J., Chang, J. C., & Kelly, A. (2020). The Cost of Air Pollution in Lagos. *Understanding Poverty - The World Bank Publication*.
- [6]. Griffin, S. C., Scanion, M. M., & Reynolds, K. A. (2023). Managing Building Water Disruptions in a Post-COVID World: Water Quality and Safety Risk Assessment Tool for Academic Institutions and School Settings. MDPI.
- [7]. Higgins. (2023). *Green Buildings: How to Improve the Sustainability of Your Property*. Port Melbourne: Higgins.
- [8]. Karimi, H., Adibhesami, M. A., Bazazzadeh, H., & Movafagh, S. (2023). *Green Buildings: Human-Centered and Energy Efficiency Optimization Strategies*. MDPI.
- [9]. LEED. (2023). *Benefits of LEED*. Washington, DC: USGBC-LEED.
- [10]. Mewomo, M. C., Toyin, J. O., Iyiola, C. O., & Aluko, O. R. (2023). Synthesis of Critical Factors Influencing Indoor Environmental Quality and Their Impacts on Building Occupants Health and Productivity. *Journal of Engineering, Design and Technology*.
- [11]. Ohiomah, I., & Aigbavboa, C. (2020). Identifying Barriers of Sustainable Construction: A Nigerian Case Study. ResearchGate.
- [12]. Okanya, A., Asogwa, A., & Onyedikachi, J. (2021). Indoor Environmental Quality (IEQ) in Nigerian Tertiary Institutions: The Effect on Performance of Building Technology Lecturers. ResearchGate.
- [13]. Patel, P., & Patel, A. D. (2021). Use of Sustainable Green Materials in Construction of Green Buildings for Sustainable Development. *IOP Conference Series Earth and Environmental Science*.
- [14]. Perfect Pollucon Services. (2023). *Effect of Poor Lighting at Workplace*. Majiwada: Perfect Pollucon Services.
- [15]. Pona, H. T., Xiaoli, D., Ayantobo, O. O., & Tetteh, N. D. (2021). Environmental Health Situation in Nigeria: Current Status and Future Needs. PubMed Central.
- [16]. Quesada-Molina, F., & Astudillo-Cordero, S. (2023). Indoor Environmental Quality Assessment Model (IEQ) for Houses. *Sustainability*, 1-18.
- [17]. Rahman, S. (2022). Green Buildings Can Reduce City Temperatures by up to 2(Degrees)C. *FUTURE OF THE ENVIRONMENT - WORLD ECONOMIC FORUM*.

- [18]. Tran, V. V., Park, D., & Lee, Y.-C. (2020). Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality. *International Journal of Environmental Research and Public Health*.
- [19]. Vantage Fit. (2022, December 06). Impact of Indoor Environment Quality at Workplace. VantageFit.
- [20]. Vierra, S. (2023). Green Building Standards and Certification Systems. *Whole Building Design Guide [WBDG]*.
- [21]. Zhang, D., Mui, K.-W., & Wong, L.-T. (2023). Ten Questions Concerning Indoor Environmental Quality (IEQ) Models: The Development and Applications. MDPI.