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Integrating Sustainable Design in Southwest Nigerian University Buildings to Mitigate Climate Change Impacts on Staff and Students

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ABSTRACT

Climate change poses a great danger to the existence of life on Earth. As the effects of climate change intensify, the university community faces increasing pressure to create resilient and sustainable environments for learning and work. However, universities worldwide are actively addressing issues of climate change through environmentally friendly design. Thus, there is a need for Nigerian universities to incorporate sustainable design principles into their buildings. This study aimed to investigate the integration of sustainable design principles in university buildings within Southwest Nigeria, focusing on the level of integration, awareness, barriers, and mitigation strategies. A mixed-method approach, combining physical building inspections, questionnaires, and interviews with architects, facility managers, and university administrators, was employed. The findings show that Nigerian universities have initiated the practice of sustainable design, but at a very slow pace, which is mostly attributed to implementation and funding problems. Passive ventilation, solar energy systems, insulation, and green landscaping are sustainable design features identified by the study as having the potential to make a building climate-responsive. The study concluded that implementing sustainable design principles in Southwest Nigerian universities' buildings will help achieve their broader climate adaptation objectives by reducing the negative impact of buildings on the environment and creating resilient, healthier learning environments.

Keywords: Sustainable Buildings, Climate change, Staff and students, Sustainable design, University.

Introduction

The impact of climate change on the environment has raised serious concerns in many sectors, particularly in the university-built environment. Climate change is an alteration in the environment mostly due to human activities such as fossil fuel combustion, deforestation, and industrial emissions, among others (Agboola *et al.* 2023). World Bank (2010) defined climate change as long-term changes in the Earth's climatic system, such as temperature patterns, precipitation levels, wind patterns, and other aspects of Earth's climate system. Tropical regions such as Nigeria, characterized by rising temperatures, erratic rainfall patterns, worsening humidity, and high energy demands, are the worst hit by climate change as it not only affects infrastructure but also the health,

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productivity, and comfort of building occupants (Efeizomor, 2023).

Recently, the global trend for sustainable solutions across all sectors intensified to mitigate the impact of climate change. Universities are vulnerable because of their diverse functional spaces and dense populations, which have an impact on the environment. Both staff and students are expected to be in a safe, supportive, and resilient environment at these establishments. According to Anber and Esmall (2018), students tend to focus in a comforTable environment but easily get distracted in an uncomforTable environment, which may be due to inadequate lighting, heating, cooling, and ventilation.

However, with the emergence of sustainable building design, which has received considerable attention in the construction sector lately, it offers a more resilient response to climate change by lessening its impact on the environment, saving energy, improving indoor environmental performance, and increasing the overall resilience of buildings (Darko *et al.* 2017; Li, 2021).. Sustainable building is defined as one designed to enhance occupant comfort and health while being economical, ecologically friendly, and energy efficient (Tomasowa, 2018). Universities are expected to lead in fostering sustainability through research, inclusion of SD practice in their curriculum development, formulating policies geared towards sustainable development, encouraging sustainable lifestyle in addition to sustainable building construction and retrofitting (Aishuwaikhat and Abubukar, 2008). For example, institutions in Europe and North America have embraced green building standards such as LEED, BREEAM, and Passive House standards to reduce operational costs, decrease environmental impact, and increase occupant satisfaction (Fong *et al.* 2014).

A sustainable campus is recognized as the place where innovative design and energy-efficient solutions are implemented and studied in real-life environments, and which is an inspiration for wider societal change (Leo Filho *et al*. 2018). McCowan (2020) study presented a framework for understanding the roles universities play in combating climate change, which includes capacity programs and public engagement.

Studies show that buildings are the most substantial man-made structures responsible for significant carbon emissions and the highest energy-consuming assets in an institution. Unfortunately, Nigerian universities paid little attention to the global call to reduce these impacts through SD practices. The evidence can be seen in public universities in Nigeria, as their buildings are often confronted with ageing infrastructure, poor thermal performance, inefficient energy systems, and limited access to up-to-date environmental control systems (Ayoko *et al*. 2023). This inefficiency not only increases operational costs but also exacerbates carbon emissions and undermines national and global sustainability objectives. Many studies have investigated a wide range of sustainable building practices within the building industry. However, there is a research gap regarding the development of practical strategies geared towards SD integration in Nigerian university buildings. It is therefore imperative to understand sustainable design approach and the roles it plays in combating the effects of climate change in the university community. The study assesses thermal comfort and discomfort experienced by staff and students in university buildings and the current state of SD in Nigerian universities.

Methodology

The study adopted a mixed-method research design, combining both quantitative and qualitative approaches. This design was selected to provide a comprehensive understanding of the state of sustainable design in public universities in the Southwest, of Nigeria by integrating numerical data with in-depth qualitative insights. The purposive sampling method was employed in the selection of universities, buildings, and interviewers. Three (3) universities, which include; Olabisi Onabanjo University, Ago-Iwoye, Federal University of Agriculture, Abeokuta, and Osun State University, Osogbo, were selected based on geographic spread

across Southwest Nigeria and the willingness of university management to grant access for data collection. Within the selected university, six (6) buildings each were inspected to assess the sustainable design features incorporated in them; these include site zoning, energy efficiency systems, natural lighting, ventilation, material use, and waste management systems. 125 questionnaires were administered to staff (academic and non–academic), and students of the selected universities to capture occupants' satisfaction, comfort levels, and thermal discomfort experienced in university buildings, out of which 105 questionnaires distributed were returned. The questionnaire comprised both closed-ended and Likert scale questions. Additionally, Semi-structured interviews were also conducted for twelve (12) interviewees (four from each university) to include architects, facility managers, and university administrators to explore their knowledge of sustainable design and barriers to its implementation. Data collected were analyzed using Statistical Package for the Social Sciences (SPSS) version 22. Descriptive statistics, including frequency counts and percentages, were used to present demographic data, satisfaction levels, and thermal comfort responses before being presented in a simple pie chart. Interview transcripts and inspection notes were analyzed thematically. Emerging themes were grouped under key categories.

Results and Discussion

The results integrate findings from physical building assessments, questionnaire surveys, and interviews to provide a comprehensive understanding of sustainable design practices in the public universities within the Southwest of Nigeria.. Results show that about 56% of respondents are students and 28% are staff, which represents the distribution of the 84% questionnaires retrieved. While 61.40% of staff and students, as shown in Figure 1, reported an uncomforTable state of the buildings, especially during the dry season, most of the respondents justified that by reporting feelings of excessive sweating during lectures or office hours, fatigue, leading to reduced concentration and productivity, as represented in Figure 2. This means that the principles of sustainable design were not fully integrated into the buildings, thereby affecting the indoor environmental quality. This trend is also attributed to the fact that most classrooms and offices do not utilize ceiling fans or air conditioning, largely due to intermittent power supply and inadequate funding for energy-intensive systems.

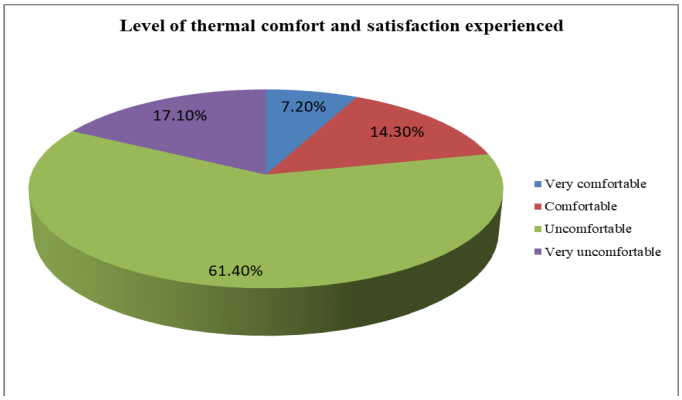

Figure 1: Level of Thermal Comfort and Satisfaction Experienced

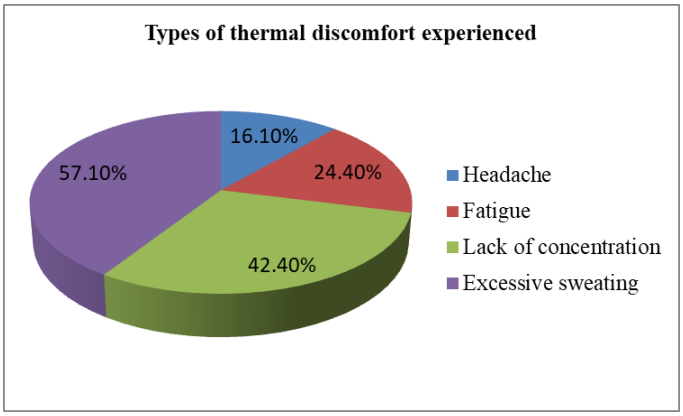

Figure 2: Types of Thermal Discomfort Experienced

Physical Assessment of Selected Buildings

A total of six (6) buildings, including lecture halls, administrative offices, a studio, and a hostel, were assessed in the selected universities. The result shows that the buildings adhered to site zoning but lacked shading devices and also had poor thermal comfort, with indoor temperatures exceeding 39°C at the time of visit. In the buildings assessed, passive design

strategies achieved were minimal; thus, to ensure students are moderately comforTable, the university relies on mechanical cooling, which is inefficient due to intermittent power supply. The buildings lack innovative water conservation methods, as there was an absence of low-flow fixtures, such as dual-flush toilets and faucet aerators, which would have significantly reduced water consumption in these buildings. Hemantha *et al*. (2024) findings show that water-efficient fixtures can reduce water consumption in a building by 55%. Rainwater harvesting system, which is another sustainable way of conserving water, were not practiced in the university buildings assessed. This practice would have reduced water conservation in the buildings by providing non-poTable water for toilet flushing and cooling systems. Solar photovoltaic cells, a sustainable way to achieve energy and reduce greenhouse gas emissions, were rare, with only one building among the selected being equipped with small-capacity panels. This places the institution's dependence on conventional energy, which is rarely available. The building materials used in the construction of these buildings were mainly conventional materials and are not all of low-carbon materials, with only 29% locally sourced, contributing to a higher carbon footprint and limited recyclability. According to Myint and Shafique (2024), using local materials that have low carbon emissions can reduce 40% of the materials' embodied carbon. In the selected universities trucks were seen evacuating waste from different locations were there are waste bins, although it was not adequate as waste are littered on the ground. There is no recycling plant in these institutions resulting to waste been dumped in three or more places for burning. Overall, the buildings demonstrated minimal sustainable design integration, highlighting the need for enhanced passive features, renewable energy, local materials, and waste recycling.

Analysis of Interviews

An interview was conducted with twelve (12) key stakeholders who are involved in the management of the university infrastructure of the selected universities, which includes architects, facility managers, and university administrators. An expert and purposive sampling method was employed in the selection of the interviewees. The interview questions focus on the level of awareness of sustainable design principles, how the various universities are implementing SD, and barriers that affect the pace at which SD is incorporated in university buildings. The interview responses are presented as follows:

i. Sustainable Design Awareness and Implementation: Nine (9) of the interviewees (about 75%) clearly stated that they are aware of SD and its benefits. Unfortunately, over 60% of the interviewees do not understand the techniques for implementing SD principles into university buildings. This shows there is a significant gap between awareness and implementation of SD principles among stakeholders in the universities. Barnett *et al*. (2011) emphasized that a lack of understanding of an innovative concept can significantly hinder its effective implementation. In some cases, institutional fragmentation, where there are three or more off-campus locations of the same university, affects the pace at which SD is implemented, as each campus has to receive attention in different areas, this is exactly what Olabisi Olabanjo University is experiencing. Others include limited technical know-how, and inadequate funding. However, to overcome these barriers, requires organizational change, institutional policy reform, training of expertise, and capacity-building programs.

ii. SD Integration Level: All the interviewees reported that their university has started integrating SD principles into their buildings which was seen during the physical observation, but at a slow pace, reflecting a cautious and incremental approach rather than a comprehensive transformation. The interviewees decry the huge amount needed to install solar Photovoltaic (PV) cells that will service the university, which the university may not afford due to inadequate funds. Most of the PV installed was donations from individuals. While this demonstrates a positive shift towards environmental consciousness in university development, the gradual progress may

limit the immediate benefits of sustainable design in addressing pressing environmental challenges. The implication is that there exists institutional inertia and poor coordination between social and technical subsystems of universities, affecting the efficient implementation of the innovation and mainstreaming of sustainability principles in these universities.

iii. SD Integration Barriers in Universities: The interviewees identified several barriers that significantly affect effective SD integration in university buildings. All the interviewees lamented the lack of clear institutional policy and guidelines as a major barrier affecting SD incorporation in universities. They opined that universities should adopt a sustainable building practice guideline that will influence the execution of SD buildings in their institutions. Other barriers identified include: limited budg*et al*locations and inadequate training in climate-responsive architecture. An architect in the physical planning unit of one of the selected universities emphasized that " budgetary allocation for electricity in the university is not adequate, and there is no provision for solar installations in the university, as few departments managed to install solar in their building". Collectively, these barriers indicate that achieving sustainable design integration in Nigerian universities will require a multi-pronged approach to overcome systemic obstacles and accelerate the transition towards climate-resilient university infrastructure.

Climate–Responsive Sustainable Design Strategies

Sustainable design (SD) is an approach that integrates ecological principles into the design process of buildings to minimize environmental impact, optimize the use of resources, and reduce the impact and long-term effects of climate change (Fuller, 1957; Liu, 2022). From the study's findings, supported by the literature reviewed, there is a need to hasten the integration of SD in Nigerian universities in order to mitigate the effects of climate change on staff and students. This can be achieved through retrofitting of existing buildings, designing the buildings to maximize natural ventilation through proper orientation, and incorporating suiTable shading devices. This approach can greatly improve the building's energy consumption, interior temperature, and airflow. Rajkovich and Kwok (2010) found that optimizing a building's orientation, utilizing trees, shading devices, and natural ventilation, can reduce carbon emissions of buildings and lower indoor temperature by 5^{o}C.

Universities should use decentralized renewable energy solutions, particularly in high-demand areas like lecture halls, labs, and administrative buildings to improve thermal and visual comfort, given Southwest Nigeria's abundant solar resources. To provide dependable off-grid energy and lessen reliance on petroleum and natural gas, photovoltaic (PV) systems can be installed on rooftops and building walkways. Oladokun and Odesola (2020) demonstrated that up to 40% of university grid electricity consumption can be offset by small- to medium-sized PV installations in university buildings, thereby increasing energy security and lowering operating expenses. Additionally, it is highly recommended that university buildings install green roofs to improve thermal comfort and reduce interior temperatures. This aligns with the findings of Souza *et al*. (2018), who found that green roofs can reduce indoor room temperature by about 4.96 °C. Similarly, cool roofs made of reflective materials can reduce the heat absorption by up to 30 percent (Akbari *et al.* 2009). University planning should prioritize green landscaping, as open areas without vegetation offer the opportunity to incorporate vegetation and create green corridors, which will enhance microclimates and lessen the effects of heat islands. Mpundu and Shem (2024) study revealed that institutions with more vegetation reported lower heat-related problems during the dry season. Rainwater harvesting systems (RWH) should be encouraged in Nigerian universities to reduce reliance on municipal supplies and promote sustainable water management, even though rainfall in Nigeria is seasonal. Studies have shown that RWH can improve the sanitary conditions of

hostels, toilets, and canteens. Rahman *et al*. (2014) have demonstrated that well-designed RWH systems can supply 60% -70% of the annual poTable water demand of a building, thereby reducing the energy consumed by pumping water from boreholes.

For institutions with extensive roof areas, this approach encourages stormwater management and reduces the risk of flooding in the event of heavy rainfall. To optimize energy use, smart controls such as programmable thermostats, automated shading, and occupancy sensors should be promoted. Masekameni *et al*. (2021) reported that in South African universities, HVAC smart lighting and controls reduce annual electricity consumption of lecture halls by up to 22%. These strategies can be adopted to improve operational efficiency in Nigerian universities. Furthermore, stakeholders should focus on training programmes and demonstration buildings that could showcase the advantages of sustainable design and serve as catalysts for institutional change and policy reform.

Conclusion and Recommendations

The concept of sustainable design is to execute construction projects in a way that balances economic, social, and environmental performance. To address climate change-induced conditions that may have a negative impact on staff and students, this study assessed the incorporation of sustainable design principles in Southwest Nigerian university buildings. The found out that the temperature of the buildings is usually above 37^{o}C during dry season due to poor orientation of the buildings. Also inadequate natural ventilation in the buildings results in high levels of thermal discomfort, increased energy consumption, and a decrease in staff productivity and students' learning outcomes.

Major challenges, such as institutional policy, inadequate funding, lack of SD guidelines, and regulatory obstacles, were identified as hindering the actual implementation of SD in Nigerian universities. Buildings that are ill-suited to a warm environment have been constructed in part in the universities due to the lack of sustainable design guidelines that take local climate conditions into account. However, the study identifies methods for low-cost, high-impact interventions in Nigerian universities, including rainwater harvesting, installation of photovoltaic cells, passive ventilation, and green landscaping. Strategic implementation of these interventions can improve the university community's environment, staff and students' well-being, reduces operating costs, and improve environmental performance. Incorporating SD into the universities physical development not only helps Nigeria adapt to climate change, but it also shows leadership in environmental preservation and resilient education. This study is also not without limitations, as the research focused only on three public universities in Southwest Nigeria. Findings may not be fully representative of universities in other geopolitical zones. Therefore, further research involving larger sample sizes and broader geographical coverage would strengthen the generalizability of the findings and inform more context-specific sustainable design strategies.

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