International Journal of Spectrum Research in Science & Engineering (IJSRSE)
2(2), April-June, 2026, Pages 18-25
© Noble City Publishers ISSN: 3092-9512
https://www.ijsrjournal.com/ijsrse.v2i2.2026.ijsr-528936

The Role of Sustainable Building Design Strategies in Designing Secondary School in Tropical Climate: A Case of Ikorodu Lagos

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ABSTRACT

Secondary school buildings in tropical locations, such as Ikorodu, Lagos, present major issues in terms of thermal comfort, indoor environmental quality (IEQ), and energy efficiency. This study looks at sustainable building design solutions for improving comfort, daylighting, natural ventilation, and environmental performance in tropical educational environments. A qualitative approach was used, consisting of a comprehensive literature review and thematic analysis of research published between 2019 and 2025. The study focuses on measures such as building orientation, passive cooling, biophilic integration, material selection, shading devices, and renewable energy solutions. The results show that appropriately oriented buildings, cross-ventilation corridors, reflecting roofs, green areas, and optimal daylighting reduce heat gain and energy consumption while improving student well-being and cognitive performance. Financial restrictions, a lack of understanding, and shortages in technical capacity are all impediments to adoption. The study finds that combining passive, biophilic, and climate-responsive methods can result in more energy-efficient, comfortable, and health-promoting school environments. To address implementation issues, recommendations stress design prioritizing, material and landscape integration, renewable energy uptake, and governmental assistance.

Keywords: *biophilic integration, indoor environmental quality, passive design, sustainable building design, thermal comfort, tropical schools*

INTRODUCTION

Background of the Study

The global drive to cut carbon emissions, increase energy efficiency, and alleviate environmental deterioration has sparked renewed interest in sustainable building design (UN Habitat, 2020). High temperatures, severe humidity, and strong solar radiation in tropical settings necessitate climate-responsive methods that improve thermal comfort while lowering operating energy demand (Afolabi & Tunji-Olayeni, 2023). These difficulties are especially important in educational facilities, where large numbers of students require suitable indoor environments to support learning activities throughout the academic year (Chong et al., 2021). Rapid urbanization in Nigeria has increased pressure on energy consumption, indoor environmental quality (IEQ), and overall building performance, particularly in hot-humid zones such as Lagos State. Many secondary school buildings endure excessive heat gain, insufficient natural ventilation, and thermal discomfort, which harms students' health, concentration, and academic production (Kalu, Ogunnaike, & Eze, 2025). Passive design solutions, such as correct building orientation, cross-ventilation, shading, insulation, reflective roofing, and biophilic elements, have been proven to increase IEQ while saving up to 50% on energy (Kalu et al., 2025). Green spaces, natural lighting, and water elements are examples of biophilic characteristics that contribute to user happiness and well-being.

Despite its usefulness in other building types throughout Nigeria, passive and biophilic solutions are infrequently used in secondary school buildings, particularly in heavily populated tropical districts like Ikorodu (Kalu, Ogunnaike, & Eze, 2025; Egwabor et al., 2024). High occupancy, extended school hours, limited landscaping, and urban heat island effects worsen indoor thermal issues, while mechanical cooling is frequently hampered by an unstable electrical supply (Otuoze et al., 2022; Adeleye et al., 2022). Furthermore, there is a lack of clearly defined sustainable design guidelines for secondary schools, and

school administrators are often unaware of the long-term benefits of passive strategies, such as energy savings, reduced maintenance, and improved learning outcomes (Adegun et al., 2020; Afolabi & Tunji-Olayeni, 2023).

This study uses a literature-based method to evaluate how sustainable design principles might improve secondary school environments in Ikorodu, Lagos, by combining global and local data to advise architects, planners, and policymakers.

Scope of Study

The study focuses on secondary school buildings in Ikorodu, Lagos, a place known for tropical humid weather, high temperatures (27°C-34°C), and relative humidity levels of 70% (Nigerian Meteorological Agency, 2021). This study uses a conceptual review method to investigate literature on building orientation, passive and biophilic design strategies, daylighting, materials, envelope performance, landscape integration, and renewable energy integration in educational buildings. By relying on literary evidence, the study highlights design methods and best practices for tropical secondary schools, indicating gaps and potential for enhanced thermal comfort, energy efficiency, and environmental performance without the need for primary field measurements.

Problem of Study

Many secondary school buildings in tropical locations, like Ikorodu, are built without proper climate-responsive or sustainable design techniques, resulting in thermal discomfort, poor ventilation, and high energy consumption (Otuoze et al., 2022; Afolabi & Ojelabi, 2020). Mechanical cooling is frequently unsustainable due to intermittent electrical supply, and there is a scarcity of context-specific design guidelines for tropical educational buildings (Adeleye et al., 2022;Oluwunmietal.,2021). While the literature supports passive and biophilic solutions for enhancing indoor comfort and efficiency, there is a gap in integrating this knowledge for tropical secondary schools, which this study seeks to fill by conducting a conceptual synthesis of research findings.

Aim

The study aims to examine the role of sustainable building design strategies in improving the performance, comfort, and environmental efficiency of secondary school buildings in the tropical climate of Ikorodu, Lagos

Objectives

i. Identify sustainable design characteristics in secondary school buildings in Ikorodu.
ii. Evaluate thermal comfort, ventilation, daylight, and environmental performance in selected secondary school buildings.
iii. Assess the effectiveness of current architectural approaches in addressing tropical climate conditions in Ikorodu, Lagos.

Justification of Study

This conceptual study is justified by the critical need for climate-responsive and energy-efficient secondary school designs in tropical places such as Ikorodu, where high temperatures, humidity, and urbanization worsen heat stress (IPCC, 2021; Olanipekun & Aigbavboa, 2021). The literature suggests that enhancing indoor environmental quality has a direct impact on student cognitive ability, concentration, and academic achievement (Olatunji et al., 2022). The study makes a contribution by bringing together global and local evidence on sustainable design techniques for tropical secondary schools, as well as providing assistance to architects, legislators, and school administrators. Academically, it contributes to the understanding of climate-responsive school architecture in Sub-Saharan Africa and serves as a framework for future practical research (UN-Habitat, 2020; Egwabor et al., 2024).

LITERATURE REVIEW

Overview of Sustainable Building Design in Tropical Schools

Sustainable building design has emerged as a key emphasis in current architectural research due to its ability to reduce carbon emissions, improve energy efficiency, and improve indoor environmental quality (IEQ) (Lu et al., 2025; UN-Habitat, 2020). High temperatures, excessive humidity, intense sun radiation, and protracted rainy seasons in tropical places such as Ikorodu, Lagos, produce difficult inside conditions for educational facilities. Secondary schools are especially vulnerable since classrooms are often filled, often densely crowded, and typically built with low-cost materials that lack thermal insulation. These problems contribute to excessive interior heat, poor ventilation, glare, and high energy consumption, which have a negative impact on student focus, health, and learning outcomes (Adeleye, Olawale, & Iroham, 2022; Olatunji, Ogunjimi, & Fadamiro, 2022). Passive design strategies—such as proper building orientation, natural ventilation, shading, reflective roofing, optimized window-to-wall ratios, and biophilic integration—have emerged as critical tools for creating low-energy, comfortable educational environments (Kalu, Ogunnaike, & Eze, 2025). Such solutions are especially important in areas with unstable electricity, where mechanical cooling is unsustainable (Afolabi & Ojelabi, 2020). Beyond environmental benefits, sustainable design improves cognitive function, well-being, and learning productivity, proving that climate-responsive architecture is a technological and societal necessity (Olaoye et al., 2023).

Supportive Evidence for Sustainable Strategies

Research confirms the efficacy of sustainable design when properly implemented. Lu et al. (2025) reported considerable increase in sustainable building research, with a focus on energy efficiency, new materials, and smart technology. Gu, Guo, Peng, and Wang (2023) stated that contractor talents, skills, and processes are crucial to successful green building. Imafidon, Enwerem, and Boye (2024) proved that green building techniques, when paired with smart technologies, may be efficiently implemented even in resource-constrained environments, resulting in long-term gains in energy efficiency and comfort.

The incorporation of health-oriented building standards improves sustainability by promoting occupant wellness. Assoumou, Zhu, and Khayeka Wandabwa (2025) stressed the incorporation of human-centered criteria into green building frameworks, thereby broadening sustainability to cognitive and physical well-being. Emere, Aigbavboa, and Oguntona (2025) emphasize the need of effective project execution and stakeholder cooperation in obtaining long-term benefits. Collectively, these studies reveal that when correctly implemented, sustainable building techniques improve comfort, energy efficiency, and educational environments.

Barriers to Adoption

Despite its benefits, sustainable construction adoption poses hurdles, particularly in developing tropical regions. Financial restrictions, limited awareness, technical skill gaps, and inadequate regulatory frameworks impede widespread use (Komurlu et al., 2024; Mogaji, 2024; Agboola, Idowu, Yusuf, & Musa, 2023). Adeniyi, Ijiga, Lawal, and Ojo (2025) identified inconsistencies in energy supplies and inadequate resources as further hurdles. Mohamed et al. (2023) discovered comparable hurdles in Saudi Arabia, such as high costs, poor market demand, and insufficient technical capacity. Even techniques like sustainable building rating systems, which are theoretically advantageous, are frequently underutilized due to costs, complexity, and socioeconomic restraints (Akadiri, 2025). In Nigeria, secondary schools face additional challenges due to high occupancy, urban heat island effects, inadequate landscaping, and little stakeholder knowledge (Onipe, 2025). This combination of technical, economical, and institutional constraints emphasizes the importance of context-specific studies in tropical secondary school settings.

Design Strategies for Tropical Secondary Schools

Building Form and Orientation

Building orientation has a considerable impact on indoor comfort in tropical schools. East-west orientation minimizes solar heat input on classroom facades while improving daylight distribution and ventilation (Adegun et al., 2020; Adeleye et al., 2022). Optimized architectural shapes, such as extended classroom blocks, shaded hallways, and central courtyards, promote ventilation and reduce heat exposure.

Figure 2.2: Recommended East–West Orientation for Classroom Blocks in Tropical Climates (Source: Chong et al., 2021)

Passive and Biophilic Design

Passive techniques govern indoor conditions in the absence of mechanical devices. Indoor heat gains can be reduced by up to 50% using techniques such as cross ventilation, shading devices, reflecting roofs, and optimal window-to-wall ratios (Kalu, Ogunnaike, & Eze, 2025). Biophilic interventions, such as green courtyards, vegetated buffers, and shaded outdoor learning areas, improve student happiness, focus, and well-being while lowering façade heat gain (Oluwunmi, Iroham, & Akinjare, 2021; Mohamed et al., 2023).

Passive Cooling and Biophilic Integration in Educational Buildings (Source: Kalu et al., 2025)

Daylighting and Visual Comfort

Properly sized and positioned windows, deep overhangs, adjustable louvers, and light shelves improve daylight distribution and reduce glare (Ojo, Ogunleye, & Balogun, 2023). Improved daylighting minimizes the need for artificial lighting, which is crucial in areas with unpredictable electricity, such as Ikorodu.

Building Materials and Envelope

Material selection influences thermal performance. Lightweight, low-thermal-mass materials heat quickly, whereas larger thermal-mass materials keep indoor temperatures stable (Otuoze, Musa, & Bello, 2022). Roofing materials are crucial; reflective coatings and insulation limit heat gain from metal roofs, while new wall systems such insulated hollow blocks improve comfort (Adeleye et al., 2022; Gu et al., 2023).

Landscape and Environmental Integration

Vegetation and landscape aspects improve microclimate conditions by providing shade, lowering ambient temperatures, and promoting outdoor learning. Green courtyards, shaded walks, and permeable pavements improve both thermal comfort and stormwater management (Adegun et al., 2020; Oluwunmi et al., 2021; Mohamed et al., 2023).

Renewable Energy Integration

Solar photovoltaic systems and hybrid ventilation powered by renewable energy improve indoor comfort while lowering reliance on intermittent grid electricity (Afolabi & Ojelabi, 2020; Komurlu et al., 2024). Solar shading structures offer two benefits: shading and energy generation.

Research Gap

Existing research demonstrates that sustainable construction strategies improve thermal comfort, energy efficiency, and student well-being. However, there is a scarcity of literature that combines these tactics, particularly for tropical secondary schools in fast urbanizing locations such as Ikorodu, Lagos. This study brings together global and local facts to help architects, planners, and politicians with climate-responsive school design.

RESEARCH METHOD

Research Design

This study takes a qualitative research strategy, combining rigorous literature review and thematic analysis. This method is appropriate for investigating how sustainable building design strategies—such as building form, orientation, passive cooling, and biophilic integration—affect thermal comfort, daylighting, natural ventilation, and IEQ in tropical secondary schools, particularly in densely populated areas like Ikorodu, Lagos. By focusing on literature rather than real case studies, the study avoids the requirement for images or on-site measurements while still delivering useful insights.

Data Collection and Search Strategy

Relevant resources were obtained from peer-reviewed publications, conference proceedings, and institutional repositories via databases like ScienceDirect, Scopus, Google Scholar, and JSTOR. Targeted search terms included “sustainable school design tropical climate,” “climate-responsive architecture Africa,” “passive design strategies in tropical buildings,” “natural ventilation and daylighting in schools,” and “building orientation and indoor environmental quality.” Only English-language publications between 2019 and 2024 were evaluated. Inclusion criteria included studies conducted in tropical or high-density urban environments, empirical research, simulations, or design evaluations, as well as research on building form, orientation, or sustainable design methods that affect daylighting, ventilation, or IEQ. Publications unrelated to architecture or building performance were excluded, as were opinion pieces without empirical proof and research that lacked clear data or measurable results.

Analytical Framework

The literature was analyzed using a theme synthesis, which identified recurring sustainable design concepts, evaluated outcomes in terms of thermal comfort, energy efficiency, and IEQ, and assessed their application to tropical secondary schools in Ikorodu. This method is consistent with the objectives and viewpoints given in Chapters 1 and 2.

Limitations

While the report gives useful information, it does admit shortcomings. Focusing on Ikorodu may limit the applicability to other places. Restricted access to architectural blueprints or performance data, a lack of field-based measurements, and reliance on literature may all limit quantitative evaluation. Observations cover certain time periods and may not capture seasonal fluctuations. Despite these limitations, the study clearly identifies major sustainable techniques, their benefits, and challenges, and provides evidence-based suggestions for enhancing comfort, energy efficiency, and sustainability in tropical secondary school buildings.

RESULTS AND DISCUSSION

An assessment of sustainable building design solutions reveals that climate-responsive architecture is critical for improving indoor environmental quality (IEQ), energy efficiency, and student comfort in tropical secondary schools such as Ikorodu, Lagos. Passive design strategies, such as building orientation, cross-ventilation, shading, reflective roofing, and biophilic integration, consistently reduce heat gain and improve natural airflow, benefiting cognitive performance and overall well-being (Kalu, Ogunnaike, & Eze, 2025; Oluwunmi, Iroham, & Akinjare, 2021).

Building orientation and form emerged as significant variables in reducing solar heat intake. The east-west alignment of classrooms, elongated blocks, shaded corridors, and central courtyards improves daylight distribution, ventilation, and indoor comfort (Adegun et al., 2020; Danjuma, Ajayi, & Daramola, 2023). Urban heat island impacts from intensive development in Ikorodu highlight the importance of careful architectural planning and the use of landscape features such vegetated buffers and green courtyards (Olanipekun & Aigbavboa, 2021).

Daylighting tactics and material choices are equally significant. Proper window placement, overhangs, louvers, and reflective roof coatings reduce the need for artificial lighting and mechanical cooling, which is especially beneficial in places with unpredictable electricity (Ojo, Ogunleye, & Balogun, 2023; Gu et al., 2023). Material selections that balance thermal mass with lightweight construction help to maintain indoor temperatures and improve thermal comfort (Otuoze, Musa, & Bello, 2022).

Despite the benefits, the literature identifies various impediments to widespread implementation of sustainable solutions in secondary schools. Financial restrictions, low stakeholder knowledge, regulatory gaps, inadequate technical skills, and opposition to change all impede implementation (Komurlu et al., 2024; Mogaji, 2024; Agboola et al., 2023). This demonstrates that the potential of sustainable design is frequently untapped unless accompanied by legislation, capacity-building, and cost-effective solutions. By combining these data, it is clear that a mix of passive design, biophilic integration, daylighting optimization, and renewable energy technologies can effectively handle the issues of tropical school environments. The study emphasizes the significance of tailoring design tactics to local climate conditions, urban setting, and socioeconomic realities in order to achieve both environmental and educational benefits

CONCLUSION

This study demonstrates that sustainable building design solutions are critical for increasing thermal comfort, interior environmental quality, and energy efficiency in secondary schools in tropical climes like Ikorodu, Lagos. Passive design features such as building orientation, natural ventilation, shading, material selection, and biophilic integration provide practical, low-cost solutions for reducing heat stress and improving student well-being. The literature also shows that, while these tactics are well-established in principle, their practical application is limited due to financial, technical, and institutional limitations. Addressing these issues involves a combination of educated architectural design, stakeholder education, supportive policy frameworks, and capacity-building activities.

RECOMMENDATIONS

Architects and school planners should consider building orientation, passive cooling, and daylighting measures in all new school buildings to improve indoor comfort.

1. To improve environmental quality and prevent internal heat gain, schools should use high-performance materials, reflective roofing, insulated walls, and green planting.
2. Adopting Renewable Energy: Solar photovoltaic systems and hybrid ventilation solutions can supplement passive cooling and reduce dependency on intermittent grid electricity.

3. Policy and Stakeholder Engagement: Policymakers may encourage sustainable school design by providing guidelines, funding, and awareness initiatives to overcome financial and regulatory constraints.
4. Future research should include measuring indoor air quality, temperature, and daylighting in tropical schools to confirm proposed techniques and inform local design decisions.
5. Secondary schools in Ikorodu and other tropical regions that implement these guidelines can create climate-responsive, energy-efficient, and health-promoting educational spaces that improve learning outcomes and long-term sustainability

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