Climate-Responsive Design Strategies for Affordable Urban Housing in Ibadan

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Article

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Abstract

Urban housing in Nigerian cities has become a major concern due to rapid urbanization, population growth, and the increasing demand for affordable accommodation. In cities such as Ibadan, housing development often prioritizes cost and speed over environmental performance, resulting in buildings that do not adequately respond to local climatic conditions and consequently provide poor indoor thermal comfort. This study examines climate-responsive design strategies for affordable urban housing in Ibadan, Nigeria, with a focus on improving comfort while maintaining affordability. A qualitative, design-based approach was adopted, drawing on climatic analysis, relevant literature, and field observations in rapidly developing areas such as Moniya. The study evaluated key passive design strategies, including building orientation, natural ventilation, solar shading, material selection, and spatial planning. Findings reveal that many existing housing developments neglect these principles, leading to excessive heat gain and poor airflow. However, the study demonstrates that the integration of simple, cost-effective climate-responsive strategies can significantly enhance indoor comfort and reduce reliance on mechanical cooling systems. It concludes that incorporating climate-responsive design is essential for improving housing performance and addressing energy challenges within the Nigerian context.

Keywords: urban housing; climate-responsive design; passive cooling; affordable housing; Ibadan

1. Introduction

Housing is one of the most fundamental human needs and remains core to individual well-being, societal stability, and national development. Beyond its primary function as shelter, it encompasses socioeconomic, psychological, and environmental dimensions that impact human existence and quality of life. Adequate housing provides not only privacy, security, and comfort, but also shapes access to education, health, employment, and community life [1].

Housing remains one of the most critical challenges facing developing countries, particularly in rapidly urbanizing cities. In Nigeria, cities such as Ibadan continue to experience steady population growth due to rural–urban migration and economic opportunities. This has resulted in an increased demand for affordable housing, especially among low- and middle-income groups. Recent studies have shown that environmental and spatial factors significantly influence housing development patterns [2]. For instance, research has examined the influence of natural and cultural landscapes on settlements [2], while others have highlighted the role of sustainable landscape planning in improving environmental quality and user well-being [3].

1.2. Statement of the Problem

In many parts of Ibadan, particularly in developing areas such as Moniya and its surrounding environments, residential buildings are often constructed without proper consideration for climatic conditions. Buildings are frequently closely spaced, poorly oriented, and inadequately ventilated.

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These conditions restrict airflow and increase heat buildup within indoor spaces, resulting in persistent occupant discomfort.

The climatic conditions of Ibadan further intensify these challenges; the city experiences a tropical climate characterized by high temperatures, high humidity, and significant solar radiation throughout the year. Consequently, there is a fundamental need for buildings to be designed specifically for thermal comfort. However, many modern housing developments do not reflect this necessity, leading to an increased dependence on mechanical fans and air-conditioning systems.

This not only raises energy consumption but also creates additional financial pressure for residents, especially within low-income households. This dependence is particularly problematic in the Nigerian context, where the power supply is often inconsistent and the cost of running cooling systems is prohibitive. Historically, traditional architectural practices in Nigeria responded effectively to the climate through features such as courtyards, shading devices, and high-thermal-mass walls.

However, contemporary housing developments have largely moved away from these principles, adopting standardized designs that ignore local environmental conditions. Climate-responsive design offers a sustainable solution by integrating environmental considerations into the design process. Passive strategies—including natural ventilation, solar shading, building orientation, and appropriate material selection—can significantly improve indoor comfort while maintaining affordability. Emerging research has also pointed to the role of policy and technological advancement in shaping housing delivery. For instance, land-use regulations significantly influence housing development patterns [4], while technological innovations, such as artificial intelligence, show potential for improving construction efficiency [5].

1.3. Aim and Objectives

This study therefore examines climate-responsive design strategies for affordable urban housing in Ibadan, Nigeria. The objectives are to identify climatic challenges affecting housing in Ibadan, examine relevant passive design strategies suitable for tropical environments, evaluate the effectiveness of these strategies in improving thermal comfort and propose practical design approaches for affordable housing.

1.4. Significance of the Study

This study is significant given the increasing urban housing demand and the urgent need for sustainable design solutions. It highlights the importance of integrating climatic considerations into residential design, particularly in tropical regions. The findings of this study will be useful to architects, planners, and policymakers by providing practical strategies that can improve housing performance without significantly increasing construction costs. Furthermore, it contributes to ongoing discussions regarding sustainable and affordable housing in Nigeria. Previous research [6] has demonstrated that integrating environmental and biophilic design principles can significantly enhance user comfort and well-being in residential environments.

1.5. Scope and Limitations

The study focuses on climate-responsive design strategies for affordable urban housing in Ibadan. It specifically examines passive design approaches such as natural ventilation, building orientation, solar shading, and material selection. The research is limited to a qualitative analysis based on climatic data, a comprehensive literature review, and targeted field observations. Furthermore, previous research [7] provided a conceptual framework linking built environments with user interaction, which supports the analytical focus of this study.

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2. Literature Review

2.1. Urban Housing in Nigeria

Urban housing in Nigeria has been widely studied in relation to rapid population growth, urbanization, and socioeconomic pressures. Major cities such as Ibadan, Lagos, and Abuja continue to experience increasing housing demand, which has led to the expansion of high-density residential developments. However, this expansion is often characterized by inadequate planning, poor infrastructure, and limited environmental consideration [8].

According to the United Nations Human Settlements Programme (UN-Habitat), the shortage of adequate housing in developing countries has resulted in informal settlements and overcrowded urban environments. In Nigeria, the situation is further compounded by limited access to affordable building materials. Research has shown that many affordable housing schemes focus primarily on cost reduction, often resulting in standardized building designs that do not respond to local climatic conditions [9].

This approach leads to buildings that perform poorly in terms of thermal comfort, thereby increasing dependence on artificial cooling systems. Previous research [10] emphasized the relationship between architectural design and community well-being, reinforcing the importance of user-centered housing development.

2.2. Climate-Responsive Architecture

Climate-responsive architecture refers to the design of buildings that are adapted to their local environmental conditions. This approach aims to improve thermal comfort while minimizing energy consumption through passive means. According to previous research, building design should be directly influenced by climatic factors such as temperature, solar radiation, humidity, and wind patterns [11]. Similarly, studies emphasize that effective climate-responsive design reduces reliance on mechanical systems by optimizing natural environmental conditions [12].

In tropical regions, climate-responsive architecture focuses primarily on reducing heat gain and enhancing heat dissipation. This involves strategies such as shading, ventilation, and material selection. These principles are particularly relevant in Nigeria, where climatic conditions demand careful environmental design. Furthermore, technological advancements have been highlighted as influential in shaping modern construction practices, offering opportunities for improving overall building performance [5].

2.3. Passive Cooling Strategies in Tropical Climates

Passive cooling strategies are essential for improving indoor comfort without relying on mechanical systems. These strategies are widely recognized in architectural research as cost-effective and sustainable solutions for buildings in tropical climates.

Natural ventilation is among the most critical passive cooling methods. Research indicates that proper building orientation and window placement can significantly enhance airflow within structures [13]. Cross-ventilation, in particular, facilitates continuous air movement, which effectively removes heat from indoor spaces. Shading is another key strategy; devices such as overhangs, louvers, and strategic vegetation reduce the solar radiation entering a building, thereby lowering indoor temperatures. Studies have shown that effective shading can reduce heat gain by a significant margin, especially in tropical climates [14].

Thermal mass also plays a vital role in regulating indoor temperatures. Materials such as concrete and stabilized earth absorb heat during the day and release it at night, helping to maintain stable indoor conditions [15]. Furthermore, established urban design frameworks emphasize the importance of enhancing environmental interaction and airflow within built environments to support these passive strategies [7].

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2.4. Traditional Architecture and Climate Adaptation

Traditional architecture in Nigeria demonstrates a robust understanding of climate-responsive design. Features such as interior courtyards, high-thermal-mass walls, and shaded openings were traditionally employed to enhance indoor thermal comfort. Courtyard housing, for instance, creates a distinct microclimate that promotes natural ventilation and effectively reduces heat buildup. Research indicates that these traditional buildings were designed to respond directly to environmental conditions, ensuring comfort despite the total absence of mechanical cooling systems [16].

However, many modern housing developments have diverged from these vernacular principles, often adopting generic designs that are ill-suited to the local climate. This shift has contributed to a notable decline in building performance and occupant comfort. Consequently, re-integrating vernacular strategies—such as natural ventilation, courtyards, and advanced shading devices—offers a sustainable and cost-effective solution for contemporary affordable housing [17].

2.5. Sustainable Materials and Construction

Sustainable materials are increasingly being explored as viable solutions for improving housing affordability. Previous research [18] identified bamboo and unfired clay bricks as cost-effective and environmentally friendly alternatives for construction. Similarly, studies have emphasized the structural and sustainability benefits of bamboo in various building applications [19].

Furthermore, the performance of stabilized earth blocks has been extensively evaluated. Research has examined their strength performance [20], while subsequent studies investigated the specific factors affecting their material properties [21]. In addition, the use of palm kernel shell ash has been explored as a means of enhancing the durability of these earth-based materials [22].

Beyond earth and bamboo, other composite materials show promise. Eco-friendly cement composites incorporating sawdust and steel fiber have been evaluated for their performance [23] and workability characteristics [24]. Furthermore, the use of bamboo leaf ash has been investigated as a viable method for improving soil stability for construction purposes [25].

2.6. Research Gap

While previous studies have extensively explored climate-responsive design and passive cooling strategies, there remains a critical need to apply these principles specifically to affordable urban housing in rapidly developing cities like Ibadan. Much of the existing research focuses either on theoretical concepts or large-scale, high-cost developments, with limited emphasis on practical, low-cost housing solutions for low-income populations. This study addresses this gap by focusing on context-specific strategies that can be implemented within the strict constraints of affordability and local construction practices.

3. Methodology

This study adopts a qualitative, design-based research approach aimed at evaluating climate-responsive strategies for affordable housing. Ibadan was selected as the study area due to its rapid urban expansion and characteristic tropical climate conditions. The research considers critical climatic factors—including temperature, solar radiation, humidity, and prevailing wind patterns—which directly influence building performance and occupant thermal comfort.

Data collection involved a comprehensive review of relevant literature, including academic books, peer-reviewed journal articles, and policy reports on climate-responsive architecture and urban housing. In addition, field observations were conducted in selected areas of Ibadan, specifically focusing on rapidly developing zones such as Moniya. These observations revealed recurring design deficiencies, such as poor building orientation, inadequate ventilation, and minimal spacing between residential structures. The analysis focused on evaluating passive design strategies based on their

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effectiveness in improving thermal comfort, reducing energy consumption, and maintaining affordability within the local socioeconomic context.

4. Discussion

4.1. Building Orientation

Building orientation significantly affects solar heat gain and overall thermal performance. Proper orientation reduces exposure to direct sunlight, particularly on the longer facades of a structure. Aligning buildings along the east–west axis—with the long axes facing north and south—minimizes direct solar heat gain and improves indoor comfort [11]. However, field observations in Ibadan indicate that building orientation is frequently neglected in favor of maximizing plot usage. This oversight results in increased indoor temperatures and a greater reliance on mechanical cooling

4.2. Natural Ventilation

Natural ventilation remains one of the most effective passive cooling strategies for residential buildings in tropical climates. By facilitating continuous air exchange, it improves indoor airflow and significantly reduces heat accumulation [5]. However, field observations in many residential areas of Ibadan reveal that buildings are often closely spaced, a layout that restricts external wind movement and creates stagnant air zones. Furthermore, poor window placement and inadequate opening sizes further limit the potential for effective cross-ventilation. In instances where ventilation is strategically integrated into the design—through aligned openings and optimized building separation—indoor conditions are noticeably more comfortable and thermally stable.

4.3. Solar Shading

Solar shading is a critical passive strategy that significantly reduces the cooling load by limiting the amount of direct short-wave solar radiation entering a building. Architectural elements—such as deep roof overhangs, recessed balconies, and horizontal or vertical louvers—are highly effective in blocking direct sunlight while maintaining natural daylighting [13].

Furthermore, the strategic use of vegetation contributes to effective shading and improves the surrounding microclimate. By providing natural canopy cover and facilitating evapotranspiration, green spaces around residential units help lower ambient temperatures, making the immediate environment more thermally comfortable for occupants.

4.4. Material Selection

The selection of building materials significantly influences the overall thermal performance of a structure. Materials characterized by high thermal mass, such as stabilized earth and concrete, help regulate indoor temperatures by effectively absorbing solar heat during peak daylight hours and releasing it gradually during the cooler night hours [15]. This thermal lag is essential for maintaining a stable and comfortable indoor environment in tropical climates like Ibadan.

Furthermore, the integration of locally sourced materials—including unfired clay bricks and bamboo—not only reduces construction costs but also supports sustainable architectural practices. Utilizing these materials minimizes the embodied energy associated with transportation and manufacturing, offering a viable path toward achieving both environmental responsibility and housing affordability.

4.5. Spatial Planning

Spatial planning is a fundamental determinant of both airflow patterns and heat distribution within a residential unit. Open-plan layouts and the integration of internal courtyards significantly improve cross-ventilation and create more thermally comfortable living spaces. By minimizing

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internal partitions that obstruct wind movement, architects can facilitate a more efficient cooling effect across the entire building footprint.

Furthermore, traditional courtyard housing—a historical architectural model in Nigeria—provides a highly effective template for climate-responsive design, particularly in tropical regions. These central voids serve as thermal regulators by promoting the "stack effect," where warm air rises and is replaced by cooler air drawn from the surrounding shaded spaces. Re-integrating these spatial planning principles into modern housing offers a practical way to achieve thermal comfort without increasing mechanical dependency.

5. Conclusions

This study demonstrates that climate-responsive design strategies are essential for improving the performance and livability of affordable urban housing in Ibadan. The evaluation of passive design techniques—specifically optimized building orientation, natural ventilation, strategic solar shading, and appropriate material selection—indicates that these methods can significantly enhance indoor thermal comfort without necessitating high capital investment.

These strategies are particularly critical in the Nigerian context, where an unreliable national power supply and the high cost of alternative energy sources limit the effectiveness and sustainability of mechanical cooling systems. By reducing the thermal load of a building through architectural means, dependency on the struggling power grid is minimized. Furthermore, integrating these climate-responsive principles into mass housing design provides a sustainable and practical solution to the persistent urban housing challenges in sub-Saharan Africa. The transition from purely cost-driven construction to climate-aware architecture is essential for ensuring that affordable housing remains both thermally comfortable and economically viable for low-income populations.

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