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Utilization of Natural Ventilation Strategies for Improving Thermal Comfort and Energy Efficiency in Low-Cost Housing in Lagos State, Nigeria

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Abstract

Natural ventilation plays a crucial role in enhancing thermal comfort and reducing energy consumption in low-cost housing. This study investigates the effectiveness of natural ventilation strategies in Ajegunle, Lagos State, focusing on building orientation, window configuration, and structural permeability. A quantitative research approach was adopted, utilizing a structured questionnaire administered to 150 randomly selected respondents. Data analysis, conducted using descriptive statistics and regression analysis, revealed a negative correlation ($r = -0.62$) between natural ventilation efficiency and reliance on mechanical cooling systems. The study found that 73% of respondents in well-ventilated homes used fans and air conditioners less frequently, whereas 81% in poorly ventilated homes depended on these appliances daily. Additionally, factors such as financial constraints (64%), landlord unwillingness (58%), and security concerns (46%) were identified as barriers to implementing effective passive cooling solutions. Despite these challenges, the study underscores the potential of natural ventilation in improving living conditions in low-cost housing. The findings offer valuable insights for architects, urban planners, and policymakers, emphasizing the need for design innovations and policy support to enhance passive cooling strategies in affordable housing developments. Future research should explore advanced passive cooling techniques and their long-term impacts on energy efficiency and occupant well-being.

Keywords: Natural Ventilation, Thermal Comfort, Energy Efficiency, Low-Cost Housing, Passive Cooling.

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Introduction

The rapidly increasing urban population in Lagos State, Nigeria, has placed immense pressure on housing infrastructure, particularly in low-income communities. The demand for affordable housing has led to the proliferation of densely populated low-cost housing estates, where many dwellings are constructed with minimal consideration for thermal comfort and ventilation efficiency. Poor ventilation, suboptimal building orientation, and inefficient window configurations have contributed to excessive indoor heat retention, making living conditions uncomfortable, particularly during the hot and humid seasons (Babalola et al, 2019). As a result, a significant portion of residents rely heavily on mechanical cooling systems, such as electric fans and air conditioners, to mitigate indoor heat. This dependency has led to increased household energy consumption, exacerbating financial strain on low-income families who already struggle with high living costs (Ayoariyo, 2020).

Given the persistent energy crisis in Nigeria, where electricity supply remains inconsistent and expensive, this growing dependence on mechanical cooling solutions presents a critical challenge for sustainable urban living. Natural ventilation has been widely recognised as a sustainable, cost-effective solution for improving indoor thermal comfort while simultaneously reducing reliance on electricity. By harnessing passive cooling techniques, such as optimizing window placement, enhancing structural permeability, and improving air circulation, substantial improvements in indoor air movement and occupant comfort can be achieved (Nguyen & Reiter, 2014). However, despite the evident benefits, the integration of natural ventilation strategies remains largely underutilized in low-cost housing estates in Lagos State. Various socio-economic and infrastructural challenges hinder the widespread adoption of passive cooling solutions, ranging from poor building designs that do not prioritise airflow to residents' limited awareness of effective natural ventilation practices (Khajavi et al, 2021).

Lagos State, particularly Ajegunle, presents an interesting case study for exploring natural ventilation strategies due to its dense urban fabric and the socio-economic constraints that shape housing developments in the area (Onyenokporo & Ochedi, 2019). The neighbourhood's compact residential layout often limits airflow between buildings, exacerbating indoor heat buildup and leading to further dependence on artificial cooling. Existing research has highlighted the importance of ventilation mechanisms in enhancing residential thermal comfort. However, studies analysing the empirical effectiveness of these strategies, particularly in the context of low-cost housing in Nigeria, remain scarce (Ayoariyo & Atolagbe, 2021). This gap in research underscores the need for a systematic evaluation of how various natural ventilation strategies impact indoor climate regulation, particularly in resource-constrained urban environments.

Therefore, this study seeks to bridge this gap by evaluating the effectiveness of different natural ventilation strategies in low-cost housing estates in Lagos State, Nigeria. Specifically, it examines the influence of key design factors, such as building orientation, window configuration, and structural permeability, on indoor air movement and overall thermal comfort. Additionally, the study analyses the correlation between natural ventilation and energy consumption patterns to determine the extent to which passive cooling techniques can reduce household reliance on mechanical ventilation. Furthermore, the research assesses the practical feasibility of implementing natural ventilation strategies in existing low-cost housing developments, taking into account infrastructural limitations, economic constraints, and residents' adaptive behaviours. By addressing these critical aspects, this research aims to provide valuable insights for architects, urban planners, and policymakers striving to enhance passive cooling strategies in low-income residential developments. The findings will contribute to the formulation of evidence-based housing policies and the design of future housing models that prioritize energy efficiency and indoor thermal comfort, ultimately improving the quality of life for low-income residents in Lagos State.

Literature Review

The growing urban population in Lagos State, Nigeria, has intensified the demand for affordable housing, leading to the development of densely populated low-cost housing estates. However, many of these dwellings lack adequate thermal comfort due to poor ventilation, suboptimal building orientation, and inefficient window configurations (Babalola et al, 2019). The reliance on mechanical cooling systems, such as fans and air conditioners, has subsequently increased, leading to high energy consumption and financial burdens on low-income households (Ayoariyo, 2020). Natural ventilation presents a viable, energy-efficient alternative that can enhance indoor thermal comfort while reducing dependence on electricity (Nguyen & Reiter, 2014). By strategically implementing passive cooling techniques, such as optimizing window placement and enhancing structural permeability, significant improvements in indoor air movement and occupant comfort can be achieved (Khajavi et al, 2021).

Lagos State, particularly Ajegunle, presents a unique case study for exploring natural ventilation strategies due to its dense urban fabric and socio-economic constraints (Onyenokporo & Ochedi, 2019). Existing research highlights the role of ventilation mechanisms in improving residential thermal comfort, yet limited studies have empirically analysed their effectiveness within the context of low-cost housing in Nigeria (Ayoariyo & Atolagbe, 2021). Therefore, this study aims to bridge this gap by evaluating the effectiveness of different natural ventilation strategies in low-cost housing estates in Lagos State, Nigeria, focusing on their impact on thermal comfort and energy efficiency.

Natural ventilation strategies have been extensively studied in different climatic regions, with a focus on their effectiveness in enhancing indoor air movement, thermal comfort, and energy efficiency. According to Akinshilo et al. (2020), the utilization of personalized conditioned spaces can optimize thermal comfort while reducing energy consumption. Their study emphasises the need for improved ventilation designs to mitigate excessive reliance on artificial cooling methods. Similarly, Ayoariyo (2020) investigated ventilation mechanisms in Nigerian government housing estates, highlighting how inadequate airflow contributes to indoor heat accumulation and discomfort among residents. The findings suggest that strategic placement of windows and doors, as well as the incorporation of cross-ventilation techniques, can significantly improve the thermal environment in low-cost housing.

Ayoariyo and Atolagbe (2021) further expanded on the subject by examining how variations in building design influence ventilation efficiency. Their research indicated that homes with larger window-to-wall ratios and optimized orientation experienced better airflow and reduced indoor temperatures. This aligns with the conclusions of Khajavi et al. (2021), who examined the role of air infiltration in humid climates and found that enhancing natural ventilation could lead to substantial energy savings. Their findings emphasize the importance of structural permeability in facilitating airflow and maintaining comfortable indoor temperatures. In contrast, studies by Liu et al (2021) focused on ventilation efficiency in urban areas with high outdoor pollution, cautioning that while natural ventilation is effective in cooling, it requires careful implementation to avoid the infiltration of pollutants.

The effectiveness of passive cooling techniques has been demonstrated in various case studies. Nguyen and Reiter (2014) explored simulation-based optimization of passive ventilation designs in low-cost housing and found that certain configurations, such as high ceiling heights and louvered windows, significantly enhanced natural airflow. Their research provides a strong foundation for evaluating ventilation strategies in densely populated areas like Ajegunle. Similarly, Sarkar and Bardhan (2020) assessed the impact of interior design on cooling energy savings, revealing that the strategic use of shading devices and internal partitions can further enhance ventilation efficiency. These insights highlight the interconnectedness of architectural design and ventilation effectiveness, suggesting that a holistic approach is necessary for optimizing passive cooling techniques.

The study by Babalola et al (2019) expands on this by examining the predictors of housing quality in Lagos State. Their research indicates that ventilation is a key determinant of residential satisfaction, with inadequate airflow leading to increased reliance on artificial cooling, higher energy costs, and diminished indoor air quality. Similarly, G et al. (2023) identify critical factors contributing to poor natural ventilation, including high urban density, suboptimal building orientation, and limited access to cross-ventilation pathways. These findings emphasize the importance of urban planning and policy interventions in mitigating ventilation challenges.

In assessing cooling strategies for energy-efficient housing in Nigeria, Ibrahim, El-Nafaty, & Udale (2024) propose a framework for evaluating passive ventilation techniques in different climatic conditions. Their research suggests that optimized window placement, incorporation of ventilation stacks, and strategic shading significantly reduce indoor temperatures, thereby alleviating dependence on mechanical cooling. This aligns with findings from Khajavi, Farrokhzad, and Hosseini (2021), who discuss the role of air infiltration in controlling energy consumption in humid climates. Their study demonstrates that natural ventilation, when properly managed, can maintain thermal comfort without excessive reliance on external cooling systems.

The impact of hybrid ventilation strategies on energy savings is explored by Park et al (2022), who argue that integrating passive ventilation with occasional mechanical support yields the best results in mixed-humid climates. Their findings suggest that such an approach could be particularly beneficial in Lagos State, where fluctuating climatic conditions necessitate adaptable ventilation strategies. Likewise, Sarkar and Bardhan (2020) advocate for an optimal interior design framework that maximizes natural airflow while minimizing heat gain, a concept that has been successfully applied in other hot-humid environments. Expanding on these discussions, Spentzou, Cook, & Emmitt (2018, 2019) model natural ventilation strategies for Mediterranean dwellings, offering insights into how these principles can be adapted to Nigerian contexts. Their research underscores the necessity of computational simulations in optimizing building performance before construction, a technique that could significantly enhance ventilation efficiency in low-cost housing projects.

Taleb (2015) provides a compelling case study on the viability of natural ventilation as an energy-efficient solution in Dubai, a region with similar climatic challenges to Lagos. His findings indicate that passive cooling techniques, when properly implemented, can achieve significant energy savings while enhancing indoor comfort. Additionally, Zoure and Genovese (2022) emphasize the role of bioclimatic passive designs in sustainable building practices, arguing that integrating such strategies into low-cost housing can promote long-term environmental and economic benefits.

In the Nigerian context, studies by Onyenokporo and Ochedi (2019) have explored low-cost retrofit packages aimed at improving natural ventilation in residential buildings. Their findings indicate that simple modifications, such as enlarging windows and incorporating ventilation blocks, can significantly enhance indoor air movement. This supports earlier research by Spentzou et al (2018), who examined natural ventilation strategies in Mediterranean apartments and found that integrating courtyards and open-air corridors greatly improved airflow. Their subsequent study (Spentzou et al, 2019) reinforced these findings, demonstrating the long-term benefits of passive cooling in reducing energy costs and improving thermal comfort.

Supporting the role of natural ventilation, Taleb (2015) investigated low-energy housing solutions in Dubai, emphasizing the potential for passive cooling in hot climates. The study found that well-ventilated homes exhibited lower indoor temperatures compared to their mechanically cooled counterparts. This aligns with the conclusions of Park et al (2022), who analysed hybrid ventilation strategies and highlighted their potential for energy savings in mixed-humid climates. Their findings underscore the need for integrated approaches that combine natural and mechanical ventilation to optimize indoor comfort. Zoure and Genovese (2022) extended this discussion by focusing on bioclimatic passive designs for office buildings, demonstrating how principles of natural ventilation can be applied beyond residential settings. Their research underscores the broader implications of passive cooling techniques in sustainable building design.

Ibrahim et al (2024) specifically examined cooling strategies in Nigerian low-cost housing estates, revealing that passive ventilation can be a cost-effective solution for improving indoor conditions. Their study highlights infrastructural limitations as a key barrier to widespread adoption, suggesting that policy interventions are necessary to promote the integration of natural ventilation in housing projects. Collectively, these studies provide a comprehensive understanding of the potential and challenges associated with natural ventilation strategies. The existing body of research suggests that optimizing building orientation, window placement, and structural permeability can significantly enhance indoor air movement and reduce reliance on mechanical cooling systems. However, socio-economic constraints and infrastructural limitations remain significant barriers to implementation in low-cost housing estates. This study builds upon previous findings by examining these factors within the specific context of Ajegunle, Lagos State, providing empirical evidence to inform future housing policies and design strategies aimed at improving thermal comfort and energy efficiency.

Research Design

This study employed a quantitative research design utilising a structured questionnaire to systematically assess the impact of natural ventilation strategies on thermal comfort and energy efficiency within a designated low-cost housing estate in Lagos State, Nigeria. The research focused on Ajegunle, a highly urbanized and densely populated neighbourhood that exhibits a significant concentration of low-income housing. Ajegunle was selected due to its characteristic residential layouts, which often feature inadequate ventilation, high occupant density, and limited access to energy-efficient cooling alternatives, making it an ideal case study for evaluating the effectiveness of passive ventilation strategies. Data collection was conducted through the administration of a structured questionnaire, which was distributed to a randomly selected sample of residents living in various housing units across Ajegunle. The sampling approach ensured inclusivity across different demographic groups, including variations in age, household size, and education levels, to achieve a comprehensive understanding of ventilation-related challenges faced by residents.

The questionnaire was meticulously designed to capture essential variables related to thermal comfort and energy use, including subjective perceptions of indoor temperature, frequency of natural ventilation usage, satisfaction with thermal comfort, reliance on mechanical cooling devices, and household energy consumption patterns. The collected data underwent rigorous statistical analysis to identify correlations between natural ventilation practices and indoor thermal conditions. Descriptive statistics were used to summarize demographic and ventilation-related variables, while regression analysis was employed to determine the strength of relationships between ventilation strategies and energy consumption. The findings provided empirical insights into how variations in building orientation, window configuration, and structural permeability influenced air circulation, indoor temperature regulation, and the overall thermal experience of residents. By employing a structured and data-driven approach, this study offers a detailed evaluation of natural ventilation effectiveness in a challenging urban environment, with implications for sustainable housing policy and energy-efficient residential design in Nigeria.

Data Collection Methods

The study employed a structured questionnaire as the primary data collection instrument to obtain precise and measurable data on the impact of natural ventilation strategies on thermal comfort and energy efficiency in Ajegunle, Lagos State. Given the densely populated nature of the study area and its diverse socio-economic characteristics, the questionnaire was carefully designed to ensure clarity, relevance, and comprehensiveness in capturing key aspects of indoor environmental conditions and ventilation practices among residents. The structured format facilitated the collection of uniform responses, allowing for a robust quantitative analysis of ventilation-related factors affecting thermal comfort and energy usage in low-cost housing.

The questionnaire was administered to a randomly selected sample of residents to enhance the representativeness of the study and minimize selection bias. The selection process accounted for variations in household size, education levels, housing types, and access to ventilation mechanisms, ensuring a well-distributed sample across different socio-economic backgrounds. The questionnaire was designed to capture multiple dimensions of indoor thermal comfort, including subjective perceptions of indoor temperature fluctuations, frequency and duration of natural ventilation use, effectiveness of ventilation strategies in reducing indoor heat buildup, satisfaction levels with current ventilation conditions, and reliance on mechanical cooling systems such as fans and air conditioners. Data collection was conducted through face-to-face interactions with respondents to maximize the response rate and ensure the accuracy of the information provided. Trained field researchers facilitated the survey administration, clarifying questions where necessary to avoid misinterpretation and ensuring that responses were reflective of actual living conditions. This method also helped to overcome potential challenges such as literacy barriers and misunderstandings related to technical aspects of ventilation. Once the responses were collected, the data underwent thorough statistical analysis using appropriate tools to identify significant trends, patterns, and correlations between ventilation practices and thermal comfort indicators.

Descriptive statistics were utilised to summarise demographic characteristics and ventilation-related variables, while inferential statistical methods, including correlation and regression analysis, were employed to determine the strength and significance of relationships between natural ventilation usage and energy consumption levels. The analytical process enabled the study to generate empirical evidence on the effectiveness of passive cooling strategies in low-cost housing, providing valuable insights for urban planners, policymakers, and architects focused on improving sustainable residential environments in Lagos State.

Study Population and Sample Size

The study focused on residents of Ajegunle, a densely populated urban settlement in Lagos State, Nigeria, characterized by a high concentration of low-income housing and significant infrastructural challenges. Given the rapid urbanisation and continuous population growth in Ajegunle, obtaining an exact count of the total number of residents posed a challenge, thereby necessitating the assumption of an infinite population for sampling purposes. The study sought to gather representative data from individuals residing in various housing units within the area, ensuring a diverse sample that reflected different household compositions, socio-economic conditions, and exposure to natural ventilation strategies.

To determine an appropriate sample size, the Cochran's infinite population formula was applied, a widely recognised statistical method for calculating sample size in large or unknown populations. This formula is particularly useful when dealing with a vast population where the total number of residents cannot be precisely determined, ensuring that the selected sample remains statistically valid and representative. The Cochran's formula takes into account the desired confidence level, the estimated proportion of the population exhibiting a particular characteristic, and the acceptable margin of error. In this study, a margin of error of 0.08 (8%) was chosen to balance statistical precision with practical feasibility, ensuring that the sample size was large enough to provide reliable results while remaining manageable within the constraints of time and resources. By using this formula, the study was able to determine a sample size that was both scientifically robust and logistically feasible.

The randomly selected sample of respondents included individuals from various household sizes, age groups, and educational backgrounds to ensure inclusivity in the findings. This approach enabled the study to generate meaningful insights into the impact of natural ventilation strategies on thermal comfort and energy consumption patterns among residents of Ajegunle, ultimately contributing to a deeper understanding of sustainable housing solutions for low-income urban communities in Lagos State.

The sample size is as follows:

$n = Z^2 \times p \times (1 - p) / E^2$

where:

$Z = 1.96$ (z-score for a 95% confidence level)

$p = 0.5$ (assumed proportion)

$E = 0.08$ (margin of error)

Substituting these values:

$n = (1.96^2 \times 0.5 \times 0.5) / 0.08^2$

$n = (3.8416 \times 0.25) / 0.0064$

$n \approx 150$

Thus, a sample size of approximately 150 respondents was determined to ensure statistical significance and reliability of the results.

Data Analysis Procedures

The collected data was analysed using a combination of descriptive and inferential statistical methods to ensure a comprehensive understanding of the impact of natural ventilation strategies on thermal comfort and energy efficiency in low-cost housing. Descriptive statistics, including measures such as mean, frequency distributions, and percentage calculations, were utilized to summarize the responses from the structured questionnaire. These descriptive analyses provided valuable insights into prevailing trends, such as the common ventilation practices among residents, their perceived level of indoor comfort, and the extent of reliance on mechanical cooling systems. By breaking down responses into easily interpretable numerical summaries, the study was able to highlight key patterns and variations across different demographic and household groups. In addition to descriptive statistics, inferential statistical techniques were employed to further explore the relationships between various factors.

Correlation analysis was conducted to determine the strength and direction of the association between natural ventilation strategies and indoor temperature variations. This helped to establish whether increased reliance on passive ventilation techniques corresponded with improvements in thermal comfort. Regression analysis was also utilized to assess the predictive influence of different variables, such as building orientation, window configuration, and structural permeability, on indoor temperature regulation and energy consumption. By applying these inferential methods, the study was able to move beyond simple observations and draw meaningful conclusions regarding the statistical significance and potential causality of the identified trends.

To ensure accuracy and reliability, all data analysis was conducted using statistical software, which provided robust computational capabilities for handling large datasets and minimizing errors in calculations. The use of software tools enabled the identification of precise numerical relationships and trends that might have been difficult to detect through manual analysis. This methodological rigor ensured that the findings were not only data-driven but also statistically sound, providing a strong basis for informed conclusions and actionable recommendations. Ultimately, the analytical approach adopted in this study allowed for a nuanced evaluation of the effectiveness of natural ventilation strategies, contributing to a deeper understanding of their role in enhancing residential thermal comfort and reducing energy dependence in low-cost housing estates.

Findings & Discussion

Demographics of Respondents

Gender Distribution: The demographic profile of the 150 respondents showed that 57% were male, while 43% were female.

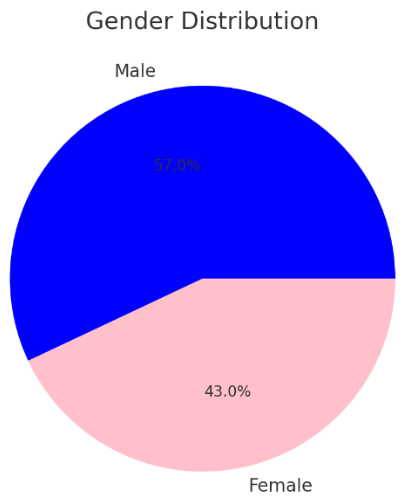

Figure 1: *Pie Chart Showing Gender Distribution*
Source: *Authors' Fieldwork (2024)*

The age distribution: indicated that 28% were between 18-30 years, 42% were between 31-45 years, and 30% were above 45 years.

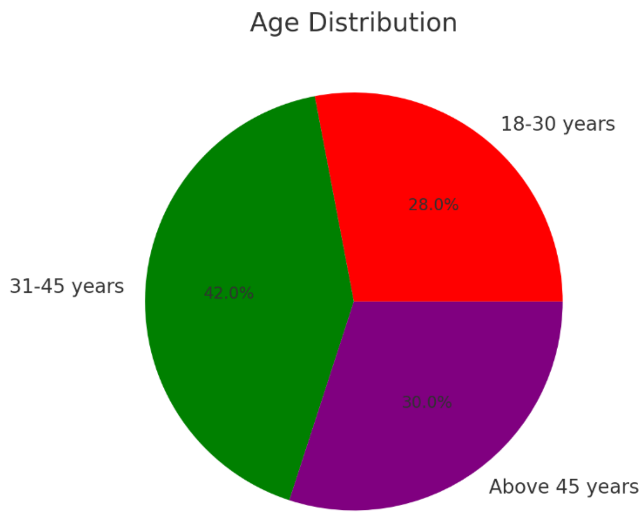

Figure 2: *Pie Chart Showing Age Distribution*
Source: *Authors' Fieldwork (2024)*

Education levels varied, with 35% having only primary education, 40% possessing secondary education, and 25% having tertiary education.

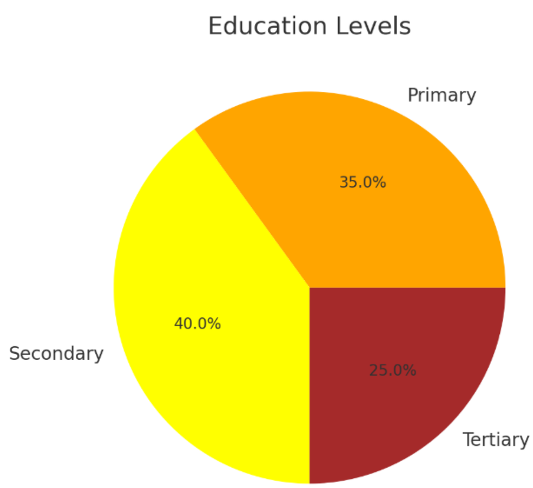

Figure 3: *Pie Chart Showing Education Level Distribution*
Source: *Authors' Fieldwork (2024)*

Household sizes: ranged from 3-5 members (50%), 6-8 members (35%), and over 8 members (15%).

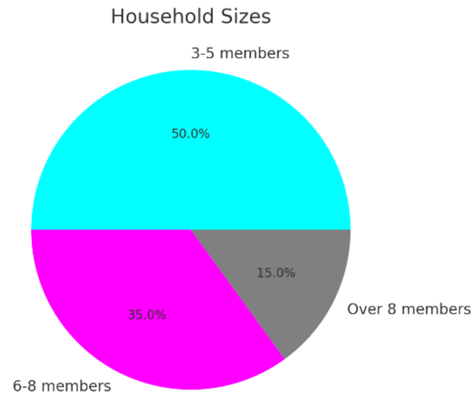

Figure 4: *Pie Chart Showing Household Sizes Distribution*
Source: *Authors' Fieldwork (2024)*

Effectiveness of Natural Ventilation Strategies

Building orientation was found to significantly influence airflow, with 68% of respondents in north-south-oriented buildings reporting better ventilation compared to 42% in east-west-oriented buildings. Regarding window configuration, 75% of respondents with cross-ventilation (windows on opposite walls) reported enhanced airflow, while only 39% of those with single-sided ventilation experienced adequate air movement. Structural permeability, such as the presence of vents and open courtyards, was also impactful, with 62% of respondents in houses with these features reporting improved comfort compared to 31% in enclosed structures.

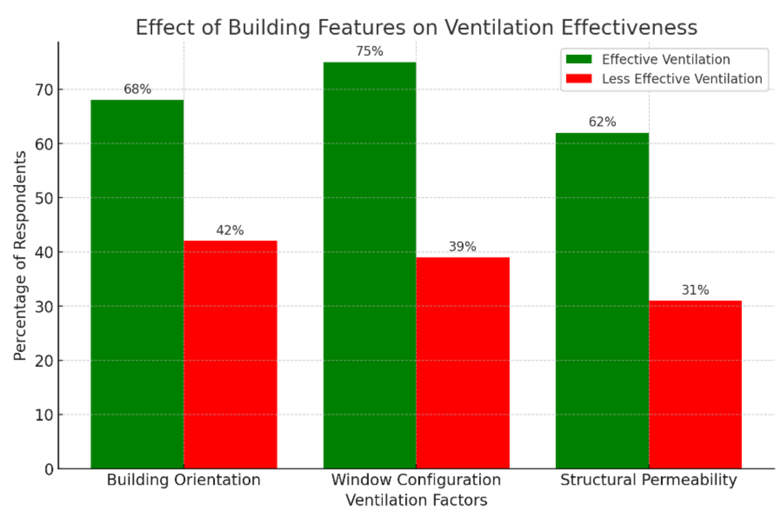

Figure 5: *Stacked Bar Chart Showing Effect of Building Features*
Source: *Authors' Fieldwork (2024)*

Correlation Between Natural Ventilation and Energy Consumption

Regression analysis indicated a negative correlation (r = -0.62) between effective natural ventilation and reliance on mechanical cooling systems, supporting the idea that enhanced passive ventilation reduces energy consumption.

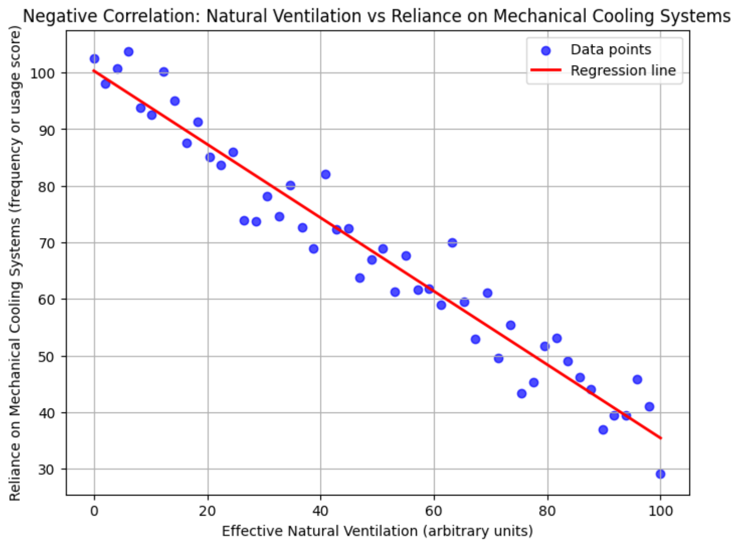

Figure 6: *Scatter Plot Showing Negative Correlation of Analysis*
Source: *Authors' Fieldwork (2024)*

Notably, 73% of respondents in well-ventilated homes reported using fans and air conditioners less frequently, while 81% in poorly ventilated homes depended on these appliances daily.

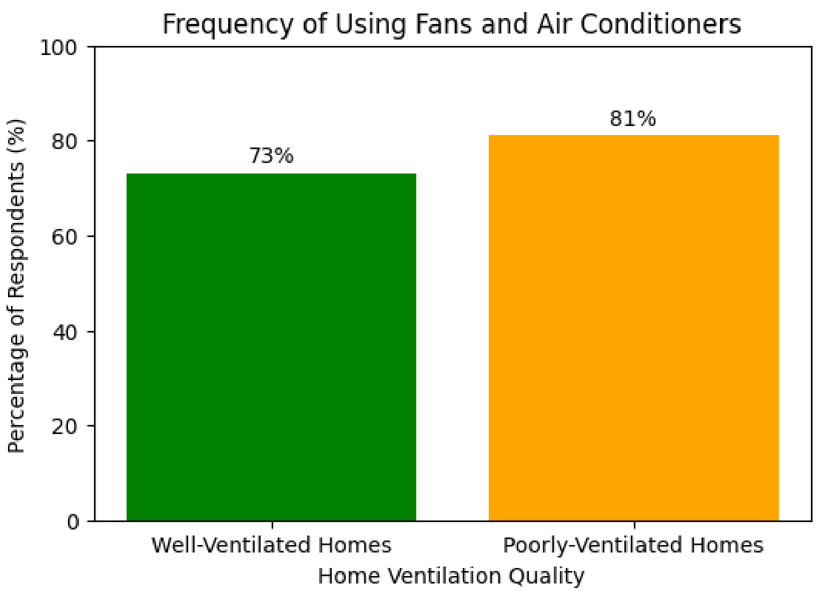

Figure 7: *Bar Chart Showing Frequency of Using Fans and Air Conditioners*
Source: *Authors' Fieldwork (2024)*

Practical Feasibility of Implementation

Despite the benefits, infrastructural and socio-economic constraints hindered widespread adoption. About 64% of respondents cited financial limitations in modifying existing structures, while 58% noted that landlords were unwilling to implement changes. 46% of respondents expressed concerns about security when leaving windows and vents open overnight, highlighting the need for strategic interventions in passive ventilation design.

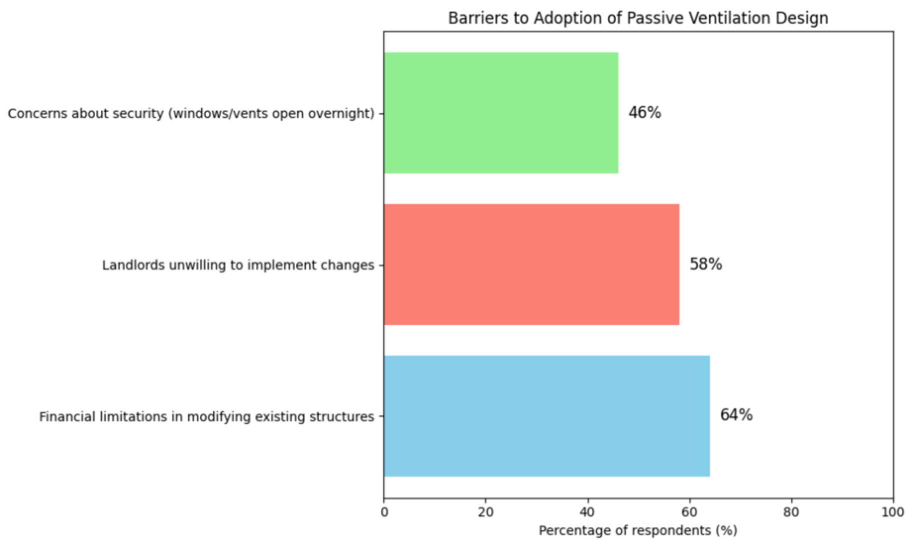

Figure 8: *Horizontal Bar Chart of Barriers to Adoption of Passive Ventilation Design*
Source: *Authors' Fieldwork (2024)*

Conclusion

This study has provided substantial evidence on the importance of natural ventilation in enhancing thermal comfort and reducing energy consumption in low-cost housing estates in Lagos State. The findings indicate that several key factors, including building orientation, window configuration, and structural permeability, significantly influence airflow and cooling efficiency in residential buildings. Homes that incorporated well-designed ventilation strategies exhibited improved indoor air quality and lower temperatures, reducing the need for mechanical cooling systems such as fans and air conditioners. The negative correlation identified between effective natural ventilation and reliance on mechanical cooling further underscores the potential of passive design approaches to minimize electricity consumption, ultimately leading to cost savings for low-income households.

Despite the evident benefits of natural ventilation, the study also highlighted several challenges that hinder its widespread adoption and effectiveness. Financial constraints emerged as a major barrier, with many residents unable to afford renovations or modifications that would enhance ventilation efficiency. Additionally, infrastructural limitations, such as poor building materials and compact urban layouts, restricted airflow in many dwellings. Security concerns also played a significant role in limiting the use of open windows and ventilation-enhancing features, particularly in high-density areas where crime rates are a concern. These challenges indicate that while natural ventilation offers a promising solution for improving residential thermal comfort, its implementation requires a multifaceted approach that addresses economic, structural, and social constraints.

To overcome these barriers, strategic policy interventions and targeted design innovations must be introduced. Government agencies and housing authorities should integrate passive ventilation strategies into building codes and urban planning policies, ensuring that new low-cost housing developments prioritise natural airflow. Additionally, financial incentives and subsidy programmes could support residents in retrofitting their homes with improved ventilation features. Community awareness campaigns are also essential to educate residents on the benefits of natural ventilation and encourage behavioural adaptations that enhance indoor air movement without compromising security.

Overall, this study contributes valuable insights for urban planners, architects, and policymakers striving to develop sustainable and energy-efficient housing solutions for low-income communities. By addressing the limitations identified and leveraging the potential of passive cooling strategies, stakeholders can create more liveable and environmentally friendly residential environments. Future research could further explore advanced passive cooling techniques, such as green roofs and adaptive shading systems, and assess their long-term impact on indoor climate regulation, energy efficiency, and occupant well-being. Moreover, longitudinal studies examining seasonal variations in natural ventilation effectiveness would provide deeper insights into optimizing passive cooling strategies across different climatic conditions. Through continued research and policy advancements, natural ventilation can play a transformative role in fostering sustainable, comfortable, and energy-efficient housing solutions in Lagos State and beyond.

Recommendations

To enhance the effectiveness of natural ventilation strategies in low-cost housing in Lagos State, several recommendations should be considered. First, building designs should prioritise proper orientation to maximise cross-ventilation. Houses should be aligned in a way that facilitates the natural flow of air, reducing reliance on mechanical cooling systems. Incorporating wider windows and adjustable louvers will enable residents to regulate airflow according to varying climatic conditions. Structural permeability should be improved by integrating materials that enhance air exchange without compromising indoor comfort. The use of perforated walls, shaded courtyards, and high ceilings can significantly improve passive cooling. In addition, adopting low-cost retrofit strategies, such as installing ventilation stacks and roof vents, will help in expelling hot air and drawing in cooler air, thereby improving indoor comfort levels.

Residents' awareness and education on the benefits of natural ventilation should also be promoted. Many households may not fully utilize existing passive cooling features due to a lack of knowledge. Government agencies and urban planners should implement educational programs to encourage best practices in ventilation management. Additionally, policies should mandate the inclusion of passive ventilation strategies in the construction of new low-cost housing estates, ensuring that future developments align with sustainable energy efficiency goals. Financial incentives should be provided to homeowners and developers to encourage the adoption of sustainable building techniques. This could include subsidies for using energy-efficient materials or grants for retrofitting older buildings with improved ventilation features. By implementing these recommendations, the thermal comfort of low-income households in Lagos State can be significantly improved while reducing energy consumption and promoting sustainable living practices.

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