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# Evaluation of Natural Ventilation and Daylighting Strategies in Mixed-Use Buildings on Lagos Island: Implications for Climate-Responsive Design in Ibadan, Nigeria

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## ABSTRACT

*The rapid growth of mixed-use developments in Nigerian cities has increased the need for buildings that provide comfortable indoor environments while minimizing energy consumption. In tropical climates such as Lagos, high temperatures, elevated humidity, and intense solar radiation often result in increased dependence on mechanical cooling and artificial lighting, particularly where passive environmental design strategies are poorly integrated. Natural ventilation and daylighting are widely recognized as effective passive design approaches for improving indoor environmental quality, reducing energy demand, and enhancing occupant well-being. However, there is limited empirical evidence on how these strategies perform in mixed-use buildings within high-density urban environments in Nigeria.*

*This study evaluates the performance of natural ventilation and daylighting strategies in selected mixed-use buildings on Lagos Island, with the aim of developing climate-responsive design recommendations applicable to the rapidly growing city of Ibadan. A mixed-method research design was adopted, combining quantitative and qualitative approaches. Primary data were obtained through questionnaire surveys administered to building users, field observations, and physical assessments of selected buildings. Secondary data were collected from relevant literature and climatic records. Climatic conditions were analysed using the Mahoney Tables to establish appropriate passive design requirements, while descriptive statistical techniques were employed to analyse occupants' perceptions of ventilation, daylighting, and indoor environmental comfort.*

*The study investigates prevailing climatic conditions, evaluates existing ventilation and daylighting strategies, identifies architectural factors influencing their effectiveness, and examines the design challenges limiting passive environmental performance in mixed-use buildings. It also develops evidence-based recommendations for improving building orientation, natural ventilation pathways, daylight penetration, shading systems, façade design, and spatial planning in tropical urban environments.*

*The study contributes to sustainable architectural practice by providing practical guidance for architects in the design of mixed-use buildings. The findings are expected to support the development of energy-efficient, climate-responsive, and occupant-centred buildings that reduce dependence on mechanical environmental control systems while improving indoor environmental quality in rapidly urbanising Nigerian cities.*

**Keywords:** Natural ventilation; Daylighting; Mixed-use buildings; Passive design; Climate-responsive architecture; Sustainable buildings; Lagos Island; Ibadan; Tropical architecture.

## I. INTRODUCTION

The building sector is one of the largest consumers of energy worldwide and contributes significantly to greenhouse gas emissions. A substantial proportion of this energy is used for heating, cooling, ventilation, and lighting (International Energy Agency [IEA], 2021; United Nations Environment Programme [UNEP], 2020). As concerns about climate change and environmental sustainability continue to grow, architects and building professionals are increasingly adopting passive design strategies that improve building performance while reducing energy demand. Among these strategies, natural ventilation and daylighting are widely recognized as effective approaches for enhancing indoor environmental quality and reducing dependence on mechanical systems (Szokolay, 2014; Etheridge and Sandberg, 2020; Nguyen and Reiter, 2019).

In tropical regions such as Nigeria, where high temperatures, elevated humidity, and intense solar radiation are experienced throughout most of the year, passive environmental design is particularly important (Adebayo, P. O., 2020). Buildings that fail to respond to these climatic conditions often experience excessive indoor heat gain, inadequate air movement, and poor daylight distribution. These shortcomings increase reliance on air-conditioning systems and artificial lighting, resulting in higher operational costs and greater environmental impacts. Consequently, climate-responsive architectural design has become an essential requirement for improving occupant comfort and achieving sustainable development in tropical cities (Szokolay, 2014; Etheridge and Sandberg, 2020).

Natural ventilation improves indoor environmental quality by allowing fresh outdoor air to circulate through interior spaces. Effective ventilation removes excess heat, dilutes indoor pollutants, and supports thermal comfort without excessive energy consumption (Etheridge and Sandberg, 2020). Likewise, daylighting introduces natural light into buildings, reducing the need for artificial lighting while improving visual comfort, occupant well-being, and productivity (Li and Tsang, 2018). When these two passive strategies are integrated during the design process, they contribute significantly to energy-efficient, healthy, and environmentally responsive buildings.

Mixed-use buildings have become an important feature of contemporary urban development because they combine residential, commercial, office, and recreational functions within a single development. This form of development promotes efficient land use, reduces travel distances, and supports vibrant urban environments. In rapidly urbanizing cities such as Lagos, mixed-use developments have become increasingly common due to high land values and growing development pressures. However, the complexity of accommodating multiple building functions often creates environmental design challenges, particularly in achieving adequate natural ventilation and daylight penetration.

The physical characteristics of many mixed-use developments in Lagos Island including deep floor plans, reduced building setbacks, compact urban forms, and closely spaced buildings restrict airflow and limit access to natural daylight. As a result, many occupants depend heavily on mechanical cooling systems and artificial lighting to maintain acceptable indoor conditions. This dependence increases energy consumption, operating costs, and carbon emissions while reducing the environmental performance of buildings. These challenges highlight the need for architectural solutions that prioritize climate-responsive design over purely economic or aesthetic considerations.

Previous studies have shown that building orientation, window configuration, façade design, shading devices, and internal spatial planning strongly influence the effectiveness of natural

ventilation and daylighting (Aflaki et al., 2015; Olanipekun and Babatunde, 2019). Although these passive strategies have been widely investigated in residential and office buildings, relatively limited attention has been given to their combined performance in mixed-use developments within high-density tropical environments. Consequently, there remains insufficient evidence on how architectural design decisions influence indoor environmental quality in these increasingly common building types (Adunola, 2014; Ngowi, 2020).

Lagos Island provides an appropriate case study because it represents one of the most densely developed urban environments in Nigeria. The environmental challenges experienced within its mixed-use buildings offer valuable lessons for other rapidly growing cities such as Ibadan, where similar development patterns are emerging. Evaluating the effectiveness of existing ventilation and daylighting strategies in Lagos Island can therefore provide practical design knowledge that supports the development of more sustainable and climate-responsive mixed-use buildings in Ibadan.

This study therefore evaluates the performance of natural ventilation and daylighting strategies in selected mixed-use buildings on Lagos Island. It examines how architectural design characteristics influence indoor environmental performance and occupant comfort and proposes design strategies that can improve the environmental quality and energy efficiency of future mixed-use developments in Ibadan, Nigeria. The study contributes to sustainable architectural knowledge by providing evidence-based recommendations that can guide architects, planners, developers, and policymakers in designing climate-responsive mixed-use buildings for tropical urban environments.

## II. LITERATURE REVIEW

### 2.1 Natural Ventilation and Sustainable Building Performance

Natural ventilation is a fundamental passive design strategy that improves indoor environmental quality by allowing fresh outdoor air to circulate through buildings without relying on mechanical systems. Air movement is primarily driven by wind pressure and temperature differences, commonly referred to as the stack effect. When these natural forces are effectively incorporated into building design, they improve thermal comfort, remove indoor pollutants, and reduce the energy required for mechanical cooling. In tropical climates, where buildings are exposed to high temperatures and humidity throughout the year, natural ventilation plays an important role in maintaining acceptable indoor conditions while lowering operational energy consumption (Etheridge and Sandberg, 2020; Szokolay, 2014; Hassan and Ahmed, 2018).

The effectiveness of natural ventilation depends largely on architectural design decisions. Building orientation, spatial configuration, window size and location, façade design, and the surrounding urban environment all influence the amount and pattern of airflow within a building. Cross-ventilation is generally considered the most efficient passive ventilation strategy because it allows air to flow between openings located on opposite or adjacent façades. However, where building depth is excessive or openings are poorly positioned, airflow becomes restricted, leading to stagnant indoor conditions and reduced thermal comfort. Alternative strategies such as atria, ventilation shafts, courtyards, and hybrid ventilation systems have therefore become increasingly important in improving airflow within deep-plan and high-rise buildings (El Sayed et al., 2021; Fakhriah Muhsin et al., 2016; Su et al., 2022; Sakiyama et al., 2024).

Despite the well-established benefits of natural ventilation, its application in many rapidly developing cities remains inconsistent. Urban densification often results in closely spaced buildings, reduced setbacks, and deep floor plates that obstruct prevailing winds and limit

opportunities for effective cross-ventilation. Consequently, many contemporary buildings continue to depend heavily on mechanical cooling systems, increasing both energy consumption and operating costs. These challenges are particularly evident in mixed-use developments, where multiple occupancy types create varying ventilation requirements that must be addressed within a single building (Olanipekun and Babatunde, 2019; Opoko et al., 2025; Sholanke et al., 2022).

### 2.2 Daylighting and Indoor Environmental Quality

Daylighting refers to the planned use of natural light to illuminate interior spaces while minimizing dependence on artificial lighting. Effective daylighting enhances visual comfort, supports occupant health, and contributes to energy efficiency by reducing daytime electricity demand. Unlike artificial lighting, daylight provides a dynamic lighting environment that positively influences occupants' psychological well-being, productivity, and overall satisfaction with indoor spaces (Dubois and Blomsterberg, 2018; Frontczak and Wargocki, 2011).

The quality of daylight within buildings depends on several architectural factors, including building orientation, window placement, glazing characteristics, interior surface reflectance, and the integration of shading devices. Well-designed daylighting systems distribute light evenly throughout interior spaces while minimizing excessive solar heat gain and glare. Architectural features such as clerestory windows, skylights, light shelves, and reflective interior finishes can improve daylight penetration, particularly in buildings with deep floor plans. Conversely, excessive glazing without adequate shading may increase cooling loads and reduce occupant comfort, especially in tropical climates where solar radiation remains high throughout the year (Li and Tsang, 2018; Raji et al., 2021; Fadeyi et al., 2024).

Several performance indicators have been developed to evaluate daylight quality in buildings, including the Daylight Factor (DF), Useful Daylight Illuminance (UDI), Spatial Daylight Autonomy (sDA), and glare assessment metrics. These indicators assist architects in balancing daylight availability with thermal performance and visual comfort, enabling the development of buildings that respond effectively to local climatic conditions (Reinhart and Mardaljevic, 2020).

### 2.3 Integration of Natural Ventilation and Daylighting in Mixed-Use Buildings

Natural ventilation and daylighting are closely related passive design strategies because both depend on similar architectural variables, including building orientation, façade configuration, spatial planning, and opening design. Integrating these strategies during the early stages of design allows buildings to maximize natural resources while reducing dependence on mechanical ventilation and artificial lighting. Such integration improves thermal comfort, indoor air quality, visual comfort, and overall environmental performance (Szokolay, 2014; Ghaffarianhoseini et al., 2021).

Mixed-use buildings present unique design challenges because they accommodate multiple activities with different environmental requirements within a single structure. Residential units, offices, commercial spaces, and recreational facilities often require different levels of ventilation, lighting, privacy, and thermal control. Achieving satisfactory environmental performance therefore requires a balanced design approach that considers the interaction between building form, occupancy patterns, and climatic **conditions** (GhaffarianHoseini et al., 2018; Salami et al., 2021).

In dense urban environments such as Lagos Island, opportunities for effective passive design are frequently constrained by high development intensity, limited site dimensions, and

surrounding buildings that restrict airflow and daylight penetration. As urban land becomes increasingly scarce, developers often prioritize maximum floor area over environmental responsiveness. These conditions reduce the effectiveness of passive design strategies and increase reliance on mechanical systems, thereby undermining sustainability objectives (George et al., 2025; Opoko et al., 2025; Sholanke et al., 2022).

**Knowledge Gap**

Existing literature demonstrates that natural ventilation and daylighting significantly improve building performance, occupant comfort, and energy efficiency when appropriately integrated into architectural design. However, most previous studies have concentrated on residential, commercial, or office buildings independently, with relatively limited attention given to mixed-use developments that combine multiple functions within a single building. Furthermore, available studies have largely examined ventilation and daylighting as separate design variables rather than evaluating their combined influence on building performance in high-density tropical cities (Ghaffarian Hoseini et al., 2018; Salami et al., 2021).

Although Lagos Island represents one of Nigeria's most densely developed urban environments, there remains limited empirical evidence on how existing mixed-use buildings perform with respect to the integration of natural ventilation and daylighting. There is also insufficient guidance on how lessons from Lagos can inform the design of emerging mixed-use developments in cities such as Ibadan, where urban growth is accelerating (Opoko et al., 2025; George et al., 2025).

This study addresses these gaps by evaluating the performance of natural ventilation and daylighting strategies in selected mixed-use buildings on Lagos Island. The findings provide evidence-based recommendations that support the design of climate-responsive, energy-efficient, and environmentally sustainable mixed-use buildings suitable for rapidly urbanizing tropical cities.

## III. RESEARCH METHODOLOGY

This section presents the methodological approach adopted for investigating the relationship between natural ventilation and daylighting performance in mixed-use buildings. The study employs a systematic research framework combining environmental assessment, building performance evaluation, and analytical methods to examine how spatial configuration, building orientation, façade characteristics, and climatic conditions influence indoor environmental quality. The methodology was structured to generate empirical evidence on passive design strategies suitable for dense tropical urban environments.

### 3.1 Research Design

The study adopts a mixed-method research design, integrating quantitative and qualitative approaches to evaluate natural ventilation and daylighting performance in selected mixed-use buildings. The quantitative component focuses on measurable environmental parameters, including indoor air movement, temperature variation, daylight availability, and spatial characteristics, while the qualitative component examines users' perceptions of thermal and visual comfort within the selected buildings.

A case study approach is employed because it allows detailed investigation of real-life building conditions and provides insight into how architectural design decisions influence environmental performance. Selected mixed-use buildings are analysed based on their functional arrangement, orientation, openings, shading devices, façade treatment, and spatial organization.

The research framework follows three major stages: preliminary assessment of selected buildings, environmental performance evaluation, and interpretation of findings to identify effective passive design strategies for improving comfort and reducing dependence on mechanical systems.

### 3.2 Study Area

The study is conducted within Lagos Island, Lagos State, Nigeria, a highly urbanized commercial district characterized by intense land use, increasing building density, and a predominantly tropical climate. Lagos Island represents one of the oldest and most economically significant urban centres in Nigeria, containing a mixture of commercial, institutional, residential, and mixed-use developments. The rapid transformation of the area has resulted in the construction of multi-storey buildings with varying degrees of consideration for passive environmental design strategies.

The study area experiences a tropical wet and dry climatecharacterized by high temperatures, high relative humidity, and seasonal rainfall patterns. Average temperatures generally remain within the range of approximately 25°C to 32°C throughout the year, creating a significant need for effective passive cooling strategies to improve indoor thermal conditions. Due to the dense urban fabric, limited setbacks, and increasing reliance on mechanical ventilation systems, achieving adequate natural ventilation and daylight penetration presents a major challenge for contemporary buildings within the area.

The selection of Lagos Island as the study location is based on its high concentration of mixed-use developments where commercial, residential, and service functions are integrated within limited urban spaces. These characteristics provide an appropriate context for evaluating how architectural features such as building orientation, window-to-wall ratio, façade configuration, internal layouts, and shading devices influence daylight availability and ventilation effectiveness.

Furthermore, the area's urban density makes it representative of many rapidly developing tropical cities where environmental performance must be balanced with land-use efficiency and economic demands. Findings from this study are therefore expected to provide valuable insights into passive design approaches that can enhance occupant comfort, reduce dependence on artificial lighting and mechanical cooling systems, and support sustainable building practices within tropical urban environments.

### 3.3 Data Collection Methods

Data collection for the study involves both field observation and questionnaire survey methods to evaluate the physical characteristics of selected buildings and occupants' experiences of indoor environmental conditions.

Primary data were obtained through systematic observation of selected mixed-use buildings. The observation focused on key architectural and environmental variables influencing natural ventilation and daylighting performance. These variables include:

1. Building orientation and spatial arrangement
2. Window size, location, and opening characteristics
3. Building-to-building spacing
4. Presence of shading devices
5. Internal room configuration
6. Material characteristics of external surfaces
7. Availability of natural lighting and ventilation openings

A structured questionnaire was administered to building users to obtain information regarding occupants' perceptions of thermal comfort, air movement, daylight adequacy, glare occurrence, and overall satisfaction with indoor environmental conditions. The questionnaire employed a Likert scale measurement system to assess users' responses and identify relationships between perceived comfort and architectural characteristics.
In addition, photographic documentation and field measurements were used to support the assessment of building features and environmental conditions. These methods provided a comprehensive understanding of how passive design elements operate within actual building contexts.

### 3.4 Environmental Performance Assessment

The environmental performance assessment evaluates the effectiveness of natural ventilation and daylighting strategies within the selected buildings. The assessment framework considers both physical building characteristics and occupant responses.

Natural ventilation performance is examined through indicators including:

1. Availability and distribution of openings
2. Cross-ventilation potential
3. Airflow pathways
4. Building orientation relative to prevailing wind direction
5. Obstruction caused by surrounding structures
6. Daylighting performance is assessed based on:
7. Amount and distribution of natural light entering interior spaces
8. Window placement and size
9. Depth of daylight penetration
10. Use of shading elements
11. Potential occurrence of glare

The assessment is guided by established passive design principles, particularly those relating to tropical architecture, where effective building orientation, controlled solar exposure, and adequate ventilation openings are essential for achieving comfortable indoor environments.

The evaluation also considers the interaction between daylighting and ventilation strategies, recognizing that design decisions affecting one environmental factor may influence another. For example, larger openings may improve daylight penetration and ventilation but may also increase solar heat gain if not properly controlled.

### 3.5 Data Analysis Techniques

Collected data were analyzed using both descriptive and inferential statistical techniques. Questionnaire responses were coded and analyzed using statistical software to determine patterns in occupants' perceptions of environmental comfort.

Descriptive statistics such as frequency distribution, percentage, mean score, and standard deviation were used to summarize respondents' assessments of ventilation and daylighting conditions. Mean ranking analysis was employed to identify the most significant environmental factors affecting indoor comfort.

Where applicable, inferential analysis was conducted to examine relationships between building characteristics and occupant satisfaction. The results were presented using tables, charts, and graphical illustrations to facilitate interpretation and comparison.

The findings from the environmental assessment and questionnaire analysis were integrated to identify the effectiveness of existing passive strategies and determine recommendations for

improving natural ventilation and daylighting performance in mixed-use buildings within tropical urban settings.

## IV.RESULTS AND DISCUSSION

This section presents the findings from the assessment of natural ventilation and daylighting performance in selected mixed-use buildings. The results are organized around the major environmental variables examined in the study, including building characteristics, ventilation strategies, daylighting conditions, and occupants' perceptions of indoor environmental quality. The findings are subsequently discussed in relation to existing studies on passive design strategies within tropical climates.

### (i) Features within Selected Mixed-Use Buildings

The assessment of selected mixed-use buildings revealed variations in architectural configuration, spatial arrangement, and environmental design strategies. The buildings examined consist of different combinations of commercial, office, and residential functions, reflecting the dominant development pattern within Lagos Island where limited urban land has encouraged vertical and mixed-use development.

The analysis indicates that building orientation, façade design, window configuration, and surrounding urban density significantly influence the availability of natural ventilation and daylight within interior spaces. Buildings with greater exposure to external airflow pathways and strategically positioned openings demonstrated better potential for natural ventilation compared with buildings surrounded by closely positioned structures.

The findings further show that most buildings within the study area prioritize functional efficiency and maximum space utilization, often resulting in reduced building setbacks and limited consideration for passive environmental strategies. This condition affects the movement of air around buildings and reduces daylight penetration into deeper interior spaces.

**Table 1: Observation Checklist of Passive Design and Indoor Environmental Features**

| S/N | Variables | Victoria Tower | Greystone Tower | Great Nigeria House | Sapetro Towers | Rose of Sharon |
|---|---|---|---|---|---|---|
| 1 | Adequate building orientation for passive design | Available | Available | Available | Available | Not Available |
| 2 | Operable windows | Available | Available | Available | Available | Available |
| 3 | Adequate window provision | Available | Available | Available | Not Available | Not Available |
| 4 | Natural ventilation | Available | Available | Available | Available | Available |
| 5 | Cross ventilation | Available | Available | Available | Not Available | Not Available |
| 6 | Adequate daylighting | Available | Available | Available | Available | Available |
| 7 | External shading devices | Available | Available | Available | Not Available | Available |
| 8 | Solar shading/protection | Available | Not Available | Available | Not Available | Not Available |
| 9 | Low external obstruction | Available | Available | Available | Not Available | Not Available |
| 10 | Balcony/veranda | Available | Available | Not Available | Available | Available |
| 11 | Landscaped/open outdoor space | Available | Available | Not Available | Available | Available |
| 12 | Mechanical cooling provision | Available | Available | Available | Available | Available |
| 13 | Adequate room ventilation | Available | Available | Available | Not Available | Not Available |
| 14 | Acoustic separation | Available | Not Available | Not Available | Not Available | Available |
| 15 | Privacy provision | Available | Not Available | Not Available | Available | Not Available |
| 16 | Indoor environmental control features | Available | Available | Available | Not Available | Not Available |
| 17 | Passive design features generally | Available | Available | Available | Not Available | Not Available |

**Source: Author's Observation Checklist, 2026**

**(ii) Assessment of Natural Ventilation Strategies**

The second objective of this study was to evaluate the natural ventilation strategies incorporated within selected mixed-use buildings on Lagos Island. Natural ventilation represents one of the most effective passive environmental strategies for improving indoor thermal comfort, reducing dependence on mechanical cooling, and enhancing indoor air quality in tropical climates. In densely developed urban centres such as Lagos Island, where buildings compete for limited land space and are often constructed in close proximity to one another, the effectiveness of natural ventilation becomes increasingly dependent on building orientation, façade permeability, window configuration, spatial planning, and surrounding urban morphology.

The assessment was conducted through systematic field observation using an observation checklist developed from established passive design principles. Each building was examined with respect to key ventilation indicators including orientation relative to prevailing winds, availability of operable windows, adequacy of window sizes, cross-ventilation potential, airflow obstruction, internal ventilation effectiveness, building spacing, and dependence on mechanical cooling systems. Each indicator was recorded as either Available (✓) or Not Available (✗) for the five selected case study buildings. Since five buildings constituted the study sample, each occurrence of an observed feature represented twenty percent (20%) of the sample. The percentage availability for each variable was therefore calculated using:

$$\text{Percentage Availability} = \frac{Number\ \ of\ \ Buildings\ \ with\ Feature}{5} \times 100$$

The results of the frequency analysis and calculated percentages are presented in Table 2.

**Table 2: Frequency Distribution of Natural Ventilation Strategies within Selected Mixed-Use Buildings**

| S/N | Ventilation Variable | Available (F) | Not Available (F) | Availability (%) | Not Available (%) |
|---|---|---|---|---|---|
| 1 | Adequate building orientation | 4 | 1 | 80.0 | 20.0 |
| 2 | Operable windows | 5 | 0 | 100.0 | 0.0 |
| 3 | Adequate window provision | 3 | 2 | 60.0 | 40.0 |
| 4 | Natural ventilation | 5 | 0 | 100.0 | 0.0 |
| 5 | Cross ventilation | 3 | 2 | 60.0 | 40.0 |
| 6 | Low external obstruction | 3 | 2 | 60.0 | 40.0 |
| 7 | Adequate room ventilation | 3 | 2 | 60.0 | 40.0 |
| 8 | Indoor environmental control features | 3 | 2 | 60.0 | 40.0 |

**Source: Author's Field Survey 2026**

**(iii) Climatic Analysis of the Case Studies Using Mahoney Indicators**

The third objective of this study was to examine the climatic characteristics of Lagos Island and evaluate their implications for passive design strategies within mixed-use buildings. Climatic analysis forms an essential component of environmentally responsive architecture because the effectiveness of passive design measures is largely dependent on prevailing meteorological conditions. Unlike mechanical systems that consume energy to regulate indoor environments, passive design seeks to utilize natural climatic forces such as wind movement, solar radiation, rainfall patterns, humidity, and daylight availability to achieve indoor thermal comfort.

To establish the climatic characteristics of the study area, long-term monthly meteorological records for Lagos Island were analysed using the Mahoney Climatic Indicators. The Mahoney Tables remain one of the most widely accepted climatic design tools for tropical architecture because they transform climatic variables into practical architectural recommendations. Rather than merely describing climatic conditions, the Mahoney method provides direct guidance on building orientation, spacing, ventilation requirements, shading devices, and envelope design based on monthly climatic behaviour.

The climatic variables considered in this analysis include monthly maximum temperature (Tmax), minimum temperature (Tmin), relative humidity (RH), rainfall, sunshine duration, humidity classification, daytime and nighttime thermal stress conditions, together with the Mahoney design indicators (H1, H2, H3, A1 and A2). Integrating these variables into a single analytical framework enables the relationships between climatic conditions and passive design requirements to be clearly identified.

Temperature remains one of the principal determinants of thermal comfort within buildings. High daytime temperatures increase solar heat gain through roofs, walls, and glazed surfaces, while elevated nighttime temperatures reduce the opportunity for nocturnal cooling. Consequently, buildings located within regions experiencing persistently high temperatures require continuous passive cooling strategies rather than seasonal interventions. Relative humidity further influences occupants' perception of thermal comfort by limiting evaporative cooling from the human body. High humidity therefore increases thermal discomfort even when air temperatures remain moderate.

Rainfall and sunshine duration also play significant roles in determining passive design requirements. Heavy rainfall influences roof configuration, drainage systems, façade protection, and building durability, whereas sunshine duration determines the availability of natural daylight and the intensity of solar heat gain entering indoor spaces. These variables collectively influence window sizing, shading devices, glazing selection, roof overhangs, and external landscape design.

Following the Mahoney methodology, monthly relative humidity values were first classified into humidity groups before evaluating daytime and nighttime thermal stress conditions. These results were subsequently translated into climatic design indicators representing ventilation requirements (H1), solar protection (H2), outdoor sleeping suitability (H3), compact planning (A1), and open spacing (A2). The indicator frequencies were then examined to determine the dominant passive design requirements throughout the year.

Presenting all climatic variables within a unified analytical matrix provides a more comprehensive understanding of the climatic behaviour of Lagos Island than isolated tables. The integrated approach demonstrates how seasonal climatic variations directly influence passive design decisions and establishes a clear basis for evaluating the passive environmental performance of the selected mixed-use buildings presented in subsequent sections.

**Table 3: Integrated Mahoney Climatic Analysis Matrix for Lagos Island**

| Month | Tmax (°C) | Tmin (°C) | RH (%) | Humidity Group | Rainfall (mm) | Sunshine (hrs/day) | Day Condition | Night Condition | H1 | H2 | H3 | A1 | A2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 32 | 23 | 80 | 4 | 25 | 5.2 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Feb | 33 | 24 | 79 | 4 | 40 | 6.0 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Mar | 33 | 25 | 81 | 4 | 85 | 5.5 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Apr | 32 | 25 | 84 | 4 | 150 | 5.8 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| May | 31 | 24 | 86 | 4 | 210 | 5.0 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Jun | 29 | 23 | 88 | 4 | 310 | 4.0 | Warm | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Jul | 28 | 22 | 89 | 4 | 280 | 3.5 | Warm | Comfortable | ✓ | ✓ | – | ✗ | ✓ |
| Aug | 28 | 22 | 88 | 4 | 110 | 3.7 | Warm | Comfortable | ✓ | ✓ | – | ✗ | ✓ |
| Sep | 29 | 23 | 87 | 4 | 300 | 4.2 | Warm | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Oct | 30 | 23 | 86 | 4 | 190 | 5.1 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Nov | 31 | 23 | 83 | 4 | 60 | 6.1 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| Dec | 32 | 22 | 80 | 4 | 20 | 6.2 | Hot | Warm | ✓ | ✓ | – | ✓ | ✓ |
| **Frequency** | — | — | — | **12 Months** | — | — | **Hot = 8 Warm = 4** | **Warm = 10 Comfortable = 2** | **12** | **12** | **0** | **10** | **12** |

**Source:** Author's Climatic Analysis Based on Mahoney Indicators (2026)

**(iv) Occupants' Perception of Thermal and Visual Comfo**rt

The assessment of occupants' perceptions provides additional insight into the effectiveness of natural ventilation and daylighting strategies within the selected mixed-use buildings. While physical building characteristics determine the potential performance of passive design strategies, occupants' experiences reveal the actual level of comfort achieved during building use.

The questionnaire responses indicate that occupants' satisfaction with indoor environmental conditions is influenced by factors such as air movement, indoor temperature, daylight availability, glare control, and dependence on artificial systems. The findings demonstrate that buildings with improved access to natural airflow and daylight generally recorded higher levels of user satisfaction compared with buildings where environmental conditions were largely dependent on mechanical systems.

**Occupants' Perception of Natural Ventilation Adequacy**

Natural ventilation is one of the most effective passive cooling strategies for buildings located in warm-humid climates. It facilitates continuous air movement, promotes heat dissipation, improves indoor air quality, and reduces dependence on mechanical cooling systems. In mixed-use developments where commercial, office, and residential functions coexist, effective ventilation is particularly important because occupancy patterns, internal heat gains, and operational activities vary considerably throughout the day. Consequently, occupants' perception provides valuable insight into whether the available ventilation strategies adequately satisfy indoor comfort requirements.

The questionnaire assessed occupants' satisfaction with different aspects of natural ventilation, including airflow movement, fresh air availability, cross ventilation, indoor heat reduction, humidity control, dependence on air-conditioning, and overall thermal comfort. These variables were selected because they collectively represent the major indicators of natural ventilation performance within tropical buildings. Higher satisfaction scores imply that passive ventilation strategies are functioning effectively, whereas lower scores indicate the need for improved architectural design interventions.

The responses further reveal the practical influence of surrounding building density and urban morphology on indoor environmental quality. Buildings with adequate spacing, multiple operable windows, and better exposure to prevailing winds are expected to receive higher satisfaction ratings than buildings constrained by adjacent structures or limited external openings. Therefore, the analysis not only evaluates users' experiences but also validates the physical observations presented in the preceding section. The frequency distribution, Total Weighted Value (TWV), Mean Weighted Value (MWV), ranking, and decision for each variable are presented in Table 5.

**Table 5: Occupants' Perception of Natural Ventilation Adequacy (N = 293)**

| S/N | Natural Ventilation Variable | VD (1) | D (2) | U (3) | S (4) | VS (5) | TWV | MWV | Rank | Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Adequate air movement within occupied spaces | 10 | 23 | 42 | 126 | 92 | 1146 | 3.91 | 1st | High Satisfaction |
| 2 | Fresh outdoor air enters indoor spaces easily | 12 | 28 | 46 | 119 | 88 | 1122 | 3.83 | 2nd | High Satisfaction |
| 3 | Window arrangement promotes cross ventilation | 15 | 31 | 49 | 115 | 83 | 1099 | 3.75 | 3rd | High Satisfaction |
| 4 | Natural ventilation effectively reduces indoor heat | 20 | 40 | 61 | 102 | 70 | 1041 | 3.55 | 4th | High Satisfaction |
| 5 | Indoor humidity is adequately controlled naturally | 24 | 46 | 63 | 96 | 64 | 1009 | 3.44 | 5th | Moderate Satisfaction |
| 6 | Natural ventilation minimizes dependence on air-conditioning | 28 | 48 | 66 | 91 | 60 | 986 | 3.37 | 6th | Moderate Satisfaction |
| 7 | Indoor spaces remain comfortable throughout the day without mechanical cooling | 32 | 51 | 69 | 87 | 54 | 959 | 3.27 | 7th | Moderate Satisfaction |
| **Average** | | | | | | | | **1052** | **3.59** | |

**Source:Author's Field Survey (2026)**

The results in Table 3 indicate that occupants generally expressed a high level of satisfaction with the natural ventilation conditions within the selected mixed-use buildings, as reflected by the overall Mean Weighted Value of 3.59. The highest-rated variable was adequate air movement within occupied spaces (MWV = 3.91), suggesting that respondents considered the movement of air through indoor spaces to be generally satisfactory. This finding supports the observational survey, which revealed that most buildings provided operable windows and opportunities for natural ventilation.

Similarly, respondents expressed high satisfaction with the availability of fresh outdoor air (MWV = 3.83) and the effectiveness of window arrangement in promoting cross ventilation (MWV = 3.75). These findings suggest that the placement and operation of windows contributed positively to indoor airflow, particularly in buildings where openings were

provided on multiple façades. The results reinforce the importance of façade permeability and proper opening configuration in enhancing passive ventilation performance.

Although respondents acknowledged the contribution of natural ventilation to indoor comfort, lower satisfaction levels were recorded for humidity control (MWV = 3.44), reduced dependence on air-conditioning (MWV = 3.37), and overall thermal comfort without mechanical cooling (MWV = 3.27). These moderate ratings indicate that natural ventilation alone is insufficient to offset the combined effects of high temperature and persistent humidity characteristic of Lagos Island's tropical climate. Consequently, occupants still depend on mechanical cooling during periods of intense heat.

Overall, the findings demonstrate that while the passive ventilation features incorporated into the selected buildings contribute positively to indoor comfort, additional strategies such as improved solar shading, increased building setbacks, enhanced cross-ventilation pathways, and reduced urban heat accumulation are necessary to achieve optimal thermal performance throughout the year.

**Occupants' Perception of Daylighting Adequacy**

Natural daylight constitutes an essential passive environmental strategy because it improves indoor visual quality, reduces electricity consumption associated with artificial lighting, and enhances occupants' comfort and productivity. In tropical climates, however, maximizing daylight must be carefully balanced with the need to minimize excessive solar heat gain and visual discomfort caused by glare. Therefore, evaluating occupants' perception of daylight performance provides valuable insight into the effectiveness of daylight-responsive architectural design within the selected mixed-use buildings.

The assessment focused on respondents' satisfaction with several aspects of daylight performance, including daylight availability, reduction in artificial lighting, uniform distribution of natural light, adequacy of window design, glare control, visual comfort during indoor activities, and overall satisfaction with indoor lighting conditions. These variables collectively represent the principal indicators of effective daylighting in buildings.

The responses further indicate whether architectural elements such as window size, glazing configuration, façade orientation, and external shading devices provide sufficient daylight while maintaining acceptable indoor visual conditions. Higher satisfaction ratings imply that daylight is adequately harnessed to improve the indoor environment, whereas lower ratings reveal opportunities for improving façade design and daylight management. The frequency distribution, Total Weighted Value (TWV), Mean Weighted Value (MWV), ranking, and decision are presented in Table 6.

**Table 6: Occupants' Perception of Daylighting Adequacy (N = 293)**

| S/N | Daylighting Variable | VD (1) | D (2) | U (3) | S (4) | VS (5) | TWV | MWV | Rank | Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Adequate natural daylight within indoor spaces | 8 | 18 | 36 | 121 | 110 | 1186 | 4.05 | 1 | High Satisfaction |
| 2 | Natural daylight reduces dependence on artificial lighting | 10 | 22 | 40 | 118 | 103 | 1161 | 3.96 | 2 | High Satisfaction |
| 3 | Daylight is evenly distributed throughout indoor spaces | 16 | 29 | 52 | 112 | 84 | 1098 | 3.75 | 4 | High Satisfaction |
| 4 | Window design provides sufficient daylight penetration | 14 | 27 | 48 | 114 | 90 | 1118 | 3.82 | 3 | High Satisfaction |
| 5 | Glare from direct sunlight is effectively controlled | 24 | 45 | 63 | 96 | 65 | 1012 | 3.45 | 6 | Moderate Satisfaction |
| 6 | Natural daylight improves visual comfort during daily activities | 12 | 24 | 41 | 116 | 100 | 1147 | 3.91 | 5 | High Satisfaction |
| 7 | Overall satisfaction with indoor daylight conditions | 13 | 26 | 44 | 115 | 95 | 1132 | 3.86 | 5 | High Satisfaction |
| **Average** | | | | | | | | **1122** | **3.83** | |

**Source: Author's Field Survey (2026)**

The findings presented in Table 6 reveal an overall Mean Weighted Value of 3.83, indicating a high level of satisfaction with daylighting conditions within the selected mixed-use buildings. Respondents rated adequate natural daylight within indoor spaces highest (MWV = 4.05), demonstrating that most occupied spaces receive sufficient daylight during normal daytime activities. This finding reflects the widespread provision of windows observed during the physical survey.

Similarly, respondents agreed that daylight significantly reduces dependence on artificial lighting (MWV = 3.96) and improves visual comfort during daily activities (MWV = 3.91). These findings suggest that passive daylighting contributes positively to both occupant comfort and energy efficiency by minimizing electricity consumption during daylight hours. The satisfactory ratings also indicate that window dimensions and façade openings generally provide adequate illumination for routine indoor functions.

Despite these positive outcomes, glare control recorded the lowest satisfaction level (MWV = 3.45), indicating only moderate satisfaction. This suggests that although daylight penetration is generally adequate, direct solar radiation entering through unshaded or improperly oriented windows occasionally produces excessive brightness and visual discomfort. Such conditions are common in tropical environments where high solar intensity can lead to glare if effective external shading devices or glazing treatments are not incorporated into the building envelope.

Overall, the results demonstrate that the selected mixed-use buildings provide satisfactory daylight performance; however, improvements in glare mitigation, façade shading, and daylight distribution strategies would further enhance occupants' visual comfort while maintaining the energy-saving benefits of natural lighting. These findings corroborate the Mahoney climatic analysis, which identified solar protection and controlled daylight admission as critical design requirements for buildings located within the warm-humid climate of Lagos Island.

**(v) Daylighting Design Strategies and Challenges**

Daylighting is a fundamental component of passive building design because it improves indoor visual comfort while reducing dependence on artificial lighting during daytime occupancy. In mixed-use buildings, effective daylighting contributes to lower operational energy costs, enhanced occupant productivity, and improved indoor environmental quality. However, the success of daylighting depends not only on the provision of windows but also on the careful integration of glazing materials, shading devices, daylight distribution systems, and interior surface finishes. These architectural elements collectively determine the quantity, quality, and distribution of natural light entering occupied spaces.

Within Lagos Island, daylighting design is particularly important because of the region's tropical climatic conditions characterized by high solar radiation throughout the year. Although abundant sunlight provides significant opportunities for passive lighting, excessive solar exposure may also result in glare, overheating, and increased cooling demand if daylight is not properly controlled. Consequently, the selection of appropriate daylighting strategies becomes essential for balancing visual comfort with thermal performance.

**Existing Daylighting Design Strategies**

Effective daylighting requires the integration of several architectural components that collectively regulate the admission, distribution, and control of natural light within buildings. These include glazing materials that determine light transmission, shading devices that reduce glare and solar heat gain, daylight distribution strategies that improve illumination of deeper interior spaces, and interior surface finishes that enhance light reflection. The adoption of these features varies across the selected mixed-use buildings and provides an indication of the extent to which passive daylighting principles have been incorporated into contemporary building design within Lagos Island. The findings presented in Table 7 indicate that clear glass (37.2%) remains the most widely adopted glazing material among the selected buildings. Although clear glazing promotes high daylight transmission and visual connection with the external environment, its widespread use may also contribute to excessive solar heat gain and glare when not complemented with appropriate shading devices.

Tinted glass accounts for 29.4% of the buildings, indicating moderate adoption of glazing systems designed to reduce solar radiation entering interior spaces. Reflective glass (18.8%) and Low-E glass (14.7%) were comparatively less common, suggesting that high-performance glazing technologies capable of simultaneously improving daylight quality and thermal performance have not yet gained widespread acceptance within the study area, possibly because of higher installation costs.

Regarding shading systems, internal shading devices constitute the most frequently adopted strategy (32.1%). While curtains and blinds assist in reducing glare, they do little to prevent solar heat from entering the building envelope. External shading devices, which are generally more effective in intercepting solar radiation before it reaches glazing surfaces, account for only 26.6% of the surveyed buildings. Furthermore, only about one-fifth of the buildings combine both internal and external shading systems, indicating that integrated solar control remains relatively limited.

The dominance of side-lighting (42.7%) confirms that façade windows remain the principal source of daylight within the sampled buildings. Although this strategy effectively illuminates spaces adjacent to external walls, it provides limited daylight penetration into deeper interior areas. Consequently, many centrally located spaces continue to rely on artificial lighting during daytime occupancy.

Interior reflectance results further reinforce this observation. The predominance of medium reflectance finishes (45.4%) suggests that many buildings achieve reasonable daylight diffusion; however, the presence of low-reflectance finishes in approximately one-quarter of the buildings limits daylight penetration by absorbing rather than redistributing incoming natural light. This contributes to uneven illumination and increased dependence on electrical lighting systems.

Overall, the findings demonstrate that daylight-responsive design within the selected buildings remains largely conventional. While basic daylight admission strategies are common, the relatively low adoption of integrated shading systems, advanced glazing technologies, and optimized daylight distribution techniques suggests considerable opportunities for improving visual comfort, reducing cooling loads, and enhancing overall building energy performance. Table 7 presents the frequency distribution of the major daylighting design elements observed during the field survey.

**Table 7: Existing Daylighting Design Strategies in Selected Mixed-Use Buildings (n = 293)**

| S/N | Variable | Category | Frequency | Percentage (%) |
|---|---|---|---|---|
| **1.** | **Type of Glazing** | Clear Glass | 109 | 37.2 |
| | | Tinted Glass | 86 | 29.4 |
| | | Reflective Glass | 55 | 18.8 |
| | | Low-E Glass | 43 | 14.7 |
| **2.** | **Shading Devices** | Internal Shading Only | 94 | 32.1 |
| | | External Shading Only | 78 | 26.6 |
| | | Both External and Internal | 63 | 21.5 |
| | | None | 58 | 19.8 |
| **3.** | **Daylighting Strategy** | Side Lighting | 125 | 42.7 |
| | | Mixed System | 62 | 21.2 |
| | | Top Lighting | 54 | 18.4 |
| | | Atrium | 52 | 17.7 |
| **4.** | **Interior Reflectance** | Medium | 133 | 45.4 |
| | | High | 86 | 29.4 |
| | | Low | 74 | 25.3 |

**Source:** Author's Field Survey (2026)

**(vii) Challenges Affecting Daylighting**

The respondents were asked to indicate the extent to which various factors affect daylight performance within the selected mixed-use buildings using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The analysis evaluates the severity of common daylighting challenges experienced by occupants and ranks them according to their Average Mean Value (AMV). A benchmark mean of 3.50 was adopted for decision-making, where values above 3.50 indicate agreement that the identified issue constitutes a significant challenge.

The results presented in Table 8 show that "Adjacent buildings block daylight" ranked first with a Mean Weighted Value (MWV) of 4.06. This outcome is supported by 132 respondents (45.1%) who strongly agreed and 95 respondents (32.4%) who agreed, representing a combined 77.5% of the respondents. The finding indicates that the dense urban fabric of Lagos Island significantly limits daylight penetration into buildings, particularly those surrounded by high-rise developments and narrow street corridors.

The statement "Excess sunlight causes overheating" ranked second with an MWV of 4.00. A total of 124 respondents (42.3%) strongly agreed, while 94 respondents (32.1%) agreed,

meaning that approximately 74.4% acknowledged overheating as a major daylight-related challenge. This suggests that although daylight is abundant, inadequate solar control exposes indoor spaces to excessive heat gain, reducing thermal comfort.

Similarly, "Lack of shading worsens indoor comfort" recorded an MWV of 3.99, ranking third. The results indicate that 121 respondents (41.3%) strongly agreed and 96 respondents (32.8%) agreed, giving a combined agreement level of 74.1%. This finding reinforces the importance of integrating external shading devices such as overhangs, louvers, fins, and vegetation into building design to reduce direct solar radiation while preserving useful daylight.

The challenge "Glare reduces screen visibility and visual comfort" ranked fourth with an MWV of 3.95. The frequency distribution shows that 116 respondents (39.6%) strongly agreed and 97 respondents (33.1%) agreed, representing 72.7% of the respondents. This indicates that uncontrolled daylight creates visual discomfort and interferes with office and commercial activities that require prolonged use of computers and digital display screens.

Finally, "Retail frontage blocks daylight penetration" ranked fifth with an MWV of 3.84. Although it recorded the lowest mean score among the identified challenges, 104 respondents (35.5%) strongly agreed and 96 respondents (32.8%) agreed, indicating that 68.3% of the respondents still considered it a significant issue. This suggests that architectural projections, commercial signage, and shop canopies reduce daylight availability at the lower floors of many mixed-use buildings.

Overall, the findings demonstrate that daylighting challenges within the selected mixed-use buildings are influenced primarily by urban density, inadequate solar shading, glare, and excessive solar heat gain rather than insufficient daylight availability. These results imply that improving daylight performance in Lagos Island requires integrated passive design strategies that combine appropriate building spacing, optimized glazing, effective external shading devices, and daylight-responsive façade design to enhance both visual and thermal comfort while reducing dependence on artificial lighting and cooling systems.

**Table 8: Daylighting Problems (N = 293)**

| S/N | Statement | SA (5) | A (4) | N (3) | D (2) | SD (1) | TWV | MWV | Decision | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Adjacent buildings block daylight | 132 (45.1%) | 95 (32.4%) | 31 (10.6%) | 21 (7.2%) | 14 (4.8%) | 1189 | 4.06 | Agree | 1st |
| 2 | Excess sunlight causes overheating | 124 (42.3%) | 94 (32.1%) | 39 (13.3%) | 23 (7.8%) | 13 (4.4%) | 1172 | 4.00 | Agree | 2nd |
| 3 | Lack of shading worsens indoor comfort | 121 (41.3%) | 96 (32.8%) | 41 (14.0%) | 22 (7.5%) | 13 (4.4%) | 1169 | 3.99 | Agree | 3rd |
| 4 | Glare reduces screen visibility and visual comfort | 116 (39.6%) | 97 (33.1%) | 42 (14.3%) | 24 (8.2%) | 14 (4.8%) | 1156 | 3.95 | Agree | 4th |
| 5 | Retail frontage blocks daylight penetration | 104 (35.5%) | 96 (32.8%) | 51 (17.4%) | 27 (9.2%) | 15 (5.1%) | 1126 | 3.84 | Agree | 5th |

**Decision Rule:** Mean ≥ 3.50 = Agree; Mean < 3.50 = Disagree.

**Source:** A**uthor's Field Survey (2026)**

## V. CONCLUSION

This study examined the influence of natural ventilation and daylighting strategies on the environmental performance of mixed-use buildings within a tropical urban context. The research established that passive design strategies remain critical in achieving improved indoor environmental quality, reducing dependence on mechanical systems, and promoting sustainable building practices.

The findings revealed that natural ventilation performance within the selected mixed-use buildings is significantly influenced by building orientation, opening configuration, spatial arrangement, and surrounding urban density. Buildings with strategically positioned openings and better airflow pathways demonstrated improved ventilation potential, while compact urban configurations and restricted façades limited air movement and reduced indoor comfort.

The study further demonstrated that daylighting availability is generally satisfactory in areas located close to external openings but decreases significantly in deeper interior spaces. Although larger openings improve access to natural light, inadequate solar control measures contribute to glare and increased heat gain, affecting occupants' visual and thermal comfort.

The integration of questionnaire responses and building assessment findings indicates that passive design elements work most effectively when considered collectively. Natural ventilation, daylighting, shading devices, building orientation, and spatial organization must function as interconnected components rather than isolated strategies.

The research highlights that many contemporary mixed-use buildings within dense tropical cities prioritize space efficiency and commercial functionality over environmental performance. This approach often results in increased dependence on artificial lighting and mechanical cooling systems, leading to higher operational energy consumption.

Therefore, improving environmental performance in tropical mixed-use buildings requires a shift towards climate-responsive architectural approaches that incorporate passive strategies from the earliest stages of design development.

### 5.2 Recommendations

Based on the findings of the study, the following recommendations are proposed:

#### 5.2.1 Improved Building Orientation and Site Planning

Architects and developers should prioritize building orientation as a fundamental environmental design consideration. Buildings should be positioned to maximize exposure to prevailing winds while minimizing excessive solar heat gain. Adequate spacing between buildings should also be encouraged to improve airflow movement and reduce wind obstruction caused by dense urban arrangements.

#### 5.2.2 Optimization of Natural Ventilation Strategies

Mixed-use buildings should incorporate effective cross-ventilation strategies through the careful placement of openings on opposing or adjacent façades. Window location, size, and operability should be determined based on climatic conditions rather than solely aesthetic or functional considerations.

Where possible, designs should incorporate:

1. Larger operable windows for improved airflow control
2. Ventilation openings at different heights to encourage air movement
3. Atriums, courtyards, or ventilation shafts in deeper building layouts
4. Flexible openings that allow occupants to regulate airflow according to comfort needs

#### 5.2.3 Integration of Effective Daylighting Design

Daylighting strategies should focus on achieving balanced natural illumination while reducing glare and excessive heat gain. Building designs should consider:

1. Appropriate window-to-wall ratios
2. External shading devices such as overhangs and louvers
3. Light shelves and reflective interior surfaces
4. Proper orientation of glazed openings

These strategies will improve visual comfort while reducing dependence on artificial lighting during daytime hours.

### 5.2.4 Adoption of Climate-Responsive Façade Design

Building façades should be designed to respond to tropical climatic conditions. Instead of relying heavily on fully glazed façades, designers should incorporate shading elements, appropriate glazing materials, and façade articulation to regulate solar exposure.

1. Climate-responsive façades can contribute to:
2. Reduced indoor temperatures
3. Improved daylight distribution
4. Lower cooling energy requirements
5. Enhanced occupant comfort

### 5.2.5 Consideration of Passive Design in Building Regulations

Urban planning authorities and building regulatory agencies should strengthen requirements for passive environmental design in mixed-use developments. Building approval processes should encourage evaluation of ventilation potential, daylight access, solar orientation, and energy efficiency before construction approval.

## 5.3 Contribution of the Study

This research contributes to the understanding of passive environmental strategies within tropical mixed-use buildings by demonstrating the relationship between architectural design decisions and indoor environmental performance.

The study provides practical insights for architects, developers, and policymakers seeking to improve building sustainability within rapidly urbanizing cities. Specifically, it emphasizes that environmental comfort can be achieved through thoughtful design interventions without excessive dependence on mechanical systems.

The findings also contribute to the growing body of knowledge on sustainable tropical architecture by highlighting the importance of integrating natural ventilation and daylighting strategies within dense urban environments where site limitations often constrain conventional passive approaches.

## 5.4 Limitations and Suggestions for Future Research

Although this study provides valuable insights into ventilation and daylighting performance, certain limitations should be acknowledged. The research focused on selected mixed-use buildings within a specific urban context, meaning that findings may not represent all building types or climatic regions.

Future studies may expand this research by incorporating:

1. Long-term environmental monitoring using digital sensors
2. Computational Fluid Dynamics (CFD) simulations for airflow analysis
3. Daylight simulation tools for quantitative assessment
4. Comparative studies across different tropical cities
5. Evaluation of energy savings resulting from passive design interventions

Further research combining technological simulation with occupant-based evaluation would provide deeper understanding of how passive strategies can be optimized for future sustainable urban development.

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