

EVALUATING THE IMPACT OF PASSIVE DESIGN STRATEGIES ON MID-RISE CONDOMINIUM PERFORMANCE IN ETI-OSA, LAGOS, NIGERIA

Prof. OLUWASEYI, Dorcas Adeoye
Ladoke Akintola University of Technology Ogbomoso

MARVELOUS Ayomide Akinola
Department of Architecture, LAUTECH

Corresponding Author's E-mail: doadeoye@lautech.edu.ng

ABSTRACT

Passive design strategies have emerged as an effective approach to improving thermal comfort, reducing operational energy consumption, and enhancing environmental sustainability in residential buildings, particularly within tropical climates. This study evaluated the impact of passive design strategies on the environmental performance of mid-rise condominiums in Eti-Osa with a view to developing sustainable design recommendations for Sangotedo, Lagos, Nigeria. Existing literature identifies natural ventilation, daylighting, building orientation, external shading, landscape elements, and sustainable building materials as key passive strategies capable of improving indoor environmental quality while reducing dependence on mechanical cooling systems. A mixed-methods research design was adopted, involving climatic assessment, field observations, architectural evaluation, and questionnaire surveys administered to 248 residents of selected condominiums. Data were analysed using descriptive statistics, Mean Weighted Value (MWV), Total Weighted Value (TWV), and Relative Importance Index (RII). The findings revealed that large windows for daylighting (MWV = 3.76), cross ventilation (MWV = 3.71), and sun-shading devices (MWV = 3.66) were the most widely incorporated passive design features, whereas landscaped gardens (MWV = 1.44), shaded outdoor sitting areas (MWV = 1.48), and the use of natural materials (MWV = 1.42) were inadequately integrated. Occupants generally perceived their indoor environments as thermally comfortable, with comfortable indoor temperature (MWV = 3.65), natural ventilation effectiveness (MWV = 3.62), and satisfactory indoor air quality (MWV = 3.47) recording positive ratings. The major barriers to effective implementation were insufficient funding (RII = 0.75), lack of awareness of passive design principles (RII = 0.75), poor maintenance culture (RII = 0.73), and inadequate design consideration (RII = 0.71). The study concludes that although passive design strategies have contributed positively to thermal comfort and environmental performance in the selected condominiums, their implementation remains selective rather than holistic. It recommends the adoption of integrated climate-responsive design approaches that prioritize cross ventilation, daylight optimization, appropriate building orientation, landscape-based cooling strategies, and sustainable material selection, alongside increased stakeholder awareness and policy support, to enhance the performance of future mid-rise residential developments in Sangotedo and similar rapidly urbanizing communities in Lagos State.

Keywords: *Passive design strategies; Thermal comfort; Environmental performance; Energy efficiency; Mid-rise condominiums; Climate-responsive architecture; Sustainable residential development.*

I. INTRODUCTION

The increasing demand for energy-efficient residential buildings has intensified global interest in passive design strategies capable of improving indoor environmental quality while reducing dependence on mechanical cooling systems. Buildings account for a significant proportion of global energy consumption, with space cooling representing one of the fastest-growing components of operational energy use, particularly in tropical cities characterized by high temperatures and humidity (Altan et al., 2016; Rodriguez-Ubinas et al., 2014; Fernandez-Antolin et al., 2019). As concerns regarding climate change, carbon emissions, and sustainable urban development continue to grow, architects and building scientists are increasingly advocating climate-responsive design approaches that utilize natural environmental resources to enhance occupant comfort while minimizing energy consumption (Mushtaha et al., 2021; Ali et al., 2024). Consequently, passive environmental design has become an essential component of sustainable residential architecture, particularly within rapidly urbanizing tropical regions such as Lagos, Nigeria.

Passive design strategies seek to regulate indoor environmental conditions through the effective utilization of natural climatic resources rather than energy-intensive mechanical systems. These strategies include appropriate building orientation, natural ventilation, daylighting, solar shading, thermal mass, landscape integration, and building envelope optimization, all of which contribute to improving thermal comfort and reducing cooling energy demand (Fernandez-Antolin et al., 2019; Rodriguez-Ubinas et al., 2014). Unlike active cooling systems that depend on continuous electricity supply, passive design responds to prevailing climatic conditions by optimizing building form, material selection, and spatial organization to maintain acceptable indoor comfort. Fernandez-Antolin et al. (2019) described passive design as the intelligent integration of architectural elements that improve building performance while minimizing environmental impacts, whereas Rodriguez-Ubinas et al. (2014) demonstrated that properly optimized passive measures can significantly reduce annual building energy consumption and contribute toward the realization of near-zero energy residential buildings.

These concerns are particularly relevant within Lagos State, where rapid urbanization has transformed the built environment and intensified demand for medium- and high-density residential developments. Eti-Osa Local Government Area, encompassing rapidly developing communities such as Lekki, Ajah, and Sangotedo, has experienced remarkable growth in mid-rise condominium developments driven by population increase, urban expansion, and changing housing preferences. While these developments provide modern residential accommodation, many have been designed with limited consideration for passive environmental principles. Consequently, poor building orientation, inadequate natural ventilation, excessive glazing, and insufficient shading frequently result in overheating, excessive dependence on air-conditioning systems, increased electricity consumption, and reduced indoor environmental quality (Altan et al., 2016; Olasupo et al., 2023). These challenges are further compounded by Nigeria's unreliable electricity supply and rising energy costs, making the need for climate-responsive residential design increasingly urgent.

Mid-rise condominiums present considerable opportunities for integrating passive design strategies because their architectural configuration, building envelope, façade composition, and shared circulation systems can be optimized to improve environmental performance. Appropriate orientation, effective cross ventilation, daylight optimization, external shading devices, landscape elements, and suitable material selection have been shown to enhance

thermal comfort, improve indoor air quality, reduce operational energy demand, and promote long-term environmental sustainability (Omrany & Marsono, 2015; Mushtaha et al., 2021; Ali et al., 2024). Beyond improving occupant comfort, passive design strategies contribute to reducing greenhouse gas emissions, lowering operational costs, and supporting global sustainability initiatives such as the United Nations Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) (Fernandez-Antolin et al., 2019).

Despite the growing body of international literature on passive environmental design, empirical investigations focusing on mid-rise condominium developments within Nigeria remain relatively limited. Existing studies have primarily examined passive design in general residential buildings or evaluated individual strategies such as natural ventilation, shading, or daylighting without comprehensively assessing their combined influence on thermal comfort and energy efficiency within tropical condominium developments (Rodriguez-Ubinas et al., 2014; Fernandez-Antolin et al., 2019). Furthermore, relatively few studies have investigated passive design performance within the rapidly urbanizing coastal environment of Eti-Osa Local Government Area, where climatic conditions, development patterns, and residential demands differ considerably from other parts of the country. Consequently, empirical evidence capable of informing climate-responsive condominium design within Lagos remains insufficient.

Addressing this knowledge gap is essential for promoting sustainable residential development in rapidly expanding communities such as Sangotedo. Understanding how climatic conditions influence the implementation and performance of passive design strategies provides valuable evidence for improving thermal comfort, reducing building energy consumption, and enhancing environmental sustainability within tropical residential buildings. Accordingly, this study evaluates the impact of passive design strategies on thermal comfort and energy efficiency in selected mid-rise condominiums in Eti-Osa Local Government Area, Lagos State. Specifically, the study examines the climatic characteristics of the area, identifies the passive design strategies currently implemented in existing condominium developments, assesses their influence on occupants' thermal comfort and environmental performance, and develops climate-responsive design recommendations to support the planning and design of sustainable mid-rise condominiums for Sangotedo, Lagos.

II. LITERATURE REVIEW

Passive design has become a fundamental component of sustainable residential architecture because of its ability to improve thermal comfort while reducing dependence on mechanical cooling systems. In contrast to conventional building approaches that rely heavily on air-conditioning and artificial lighting, passive design utilizes natural climatic resources such as solar radiation, prevailing winds, daylight, and thermal mass to regulate indoor environmental conditions. This approach has gained increasing attention in response to global concerns over climate change, rising energy demand, and environmental degradation. Studies have shown that passive design strategies significantly reduce operational energy consumption while enhancing occupant comfort and indoor environmental quality, particularly in tropical climates where cooling accounts for a substantial proportion of building energy use (Altan, Hajibandeh, Tabet Aoul, & Deep, 2016; Fernandez-Antolin, del Río, Costanzo, Nocera, & Gonzalez-Lezcano, 2019).

Thermal comfort remains one of the primary objectives of passive building design. Rather than depending solely on mechanical cooling systems, passive buildings achieve acceptable indoor temperatures through appropriate building orientation, natural ventilation, shading devices, thermal insulation, daylight optimization, and suitable material selection. According to Rodriguez-Ubinas, Montero, Porteros, Vega, Navarro, Castillo-Cagigal, and Gutiérrez (2014), integrating passive strategies into residential buildings substantially improves indoor environmental quality while reducing annual energy consumption. Similarly, Mushtaha, Salameh, Kharrufa, Mori, Aldawoud, Hamad, and Nemer (2021) observed that optimized building envelopes and passive cooling measures can reduce cooling loads by approximately 30%, demonstrating the effectiveness of climate-responsive architectural design.

Natural ventilation is widely recognized as one of the most effective passive cooling strategies in hot-humid climates. It utilizes naturally occurring wind pressure and thermal buoyancy to facilitate air movement through buildings, thereby removing excess heat and improving indoor air quality without consuming additional energy. Effective natural ventilation depends largely on building orientation, window configuration, internal spatial layout, and the availability of unobstructed airflow paths. Research has consistently shown that buildings designed to maximize cross-ventilation maintain better thermal conditions and consume considerably less energy than mechanically ventilated buildings (Omran & Marsono, 2015; Gokarakonda & Kumar, 2016). Consequently, ventilation planning has become an essential consideration during the early stages of residential design.

The performance of passive design strategies is closely associated with prevailing climatic conditions. Climatic variables including air temperature, relative humidity, solar radiation, rainfall, and wind direction directly influence indoor thermal conditions and the effectiveness of passive cooling measures. Climate-responsive architecture therefore emphasizes designing buildings that respond to local environmental conditions rather than adopting universal design solutions. Lee, Lee, and Lim (2015) argued that understanding local climatic characteristics enables architects to optimize building orientation, façade treatment, shading systems, and ventilation pathways for improved environmental performance. Likewise, Atwa (2016) emphasized that successful passive buildings integrate multiple climatic factors simultaneously to achieve comfortable indoor environments with minimal mechanical intervention.

Lagos State, particularly Eti-Osa Local Government Area, experiences a tropical hot-humid climate characterized by high temperatures, elevated relative humidity, intense solar radiation, and seasonal rainfall throughout most of the year. These environmental conditions create considerable challenges for residential buildings, especially mid-rise condominiums where occupant density and limited ventilation often contribute to indoor overheating. Studies conducted in Nigeria have shown that residential developments designed without adequate climatic considerations frequently experience poor thermal performance, increased electricity consumption, and excessive dependence on air-conditioning systems (Okiye, Ohakawa, & Nwokediegwu, 2023). Consequently, passive environmental strategies have become increasingly important for achieving sustainable residential development within rapidly urbanizing areas such as Eti-Osa and Sangotedo.

Building typology also plays an important role in determining the effectiveness of passive design. Factors such as building height, floor depth, apartment configuration, façade arrangement, circulation patterns, and spatial organization influence airflow distribution, daylight penetration, and heat transfer within residential buildings. Mid-rise condominiums

present unique environmental challenges because increased building height and compact layouts may restrict natural ventilation if not carefully designed. Appropriate orientation, shallow floor plans, open circulation spaces, atriums, balconies, and courtyards have been identified as effective design features for improving passive environmental performance in multi-storey residential developments (Hyde, 2017; Tatarestaghi, Ismail, & Ishak, 2018).

Beyond thermal comfort, passive design contributes significantly to environmental sustainability by reducing operational energy demand and greenhouse gas emissions. Buildings account for a substantial proportion of global energy consumption, making passive environmental strategies essential for achieving sustainable development objectives. Verovsek, Juvancic, and Zupancic (2018) observed that passive design supports sustainable housing by minimizing lifecycle energy consumption while improving occupant health and well-being. Similarly, Anand, Kadiri, and Putcha (2023) reported that passive residential buildings can substantially reduce operational carbon emissions, thereby contributing to global climate action initiatives and supporting the achievement of sustainable development goals.

Despite the recognized benefits of passive design, its implementation in Nigeria's residential housing sector remains relatively limited. Many contemporary condominium developments continue to prioritize architectural aesthetics, construction speed, and commercial profitability over climatic responsiveness. Consequently, passive strategies such as optimal orientation, natural ventilation, solar shading, and climate-responsive building envelopes are often inadequately incorporated into residential projects. Previous studies have further noted that limited technical knowledge, inadequate policy implementation, and insufficient local design guidelines continue to constrain widespread adoption of passive architecture within the Nigerian construction industry (Okiye et al., 2023; Atwa, 2016).

Although existing literature has extensively examined passive design principles, thermal comfort, and climate-responsive architecture, several research gaps remain. Most previous studies have focused on individual passive strategies, general residential buildings, or building energy performance without specifically evaluating mid-rise condominiums within Lagos' hot-humid coastal environment. Furthermore, limited empirical research has simultaneously examined climatic characteristics, passive design strategies, thermal comfort, and energy efficiency within a unified framework for residential developments in Eti-Osa Local Government Area. Addressing these gaps will provide evidence-based recommendations for designing sustainable mid-rise condominiums in Sangotedo that effectively respond to local climatic conditions while improving occupant comfort, reducing energy consumption, and promoting environmentally sustainable housing development.

III. METHODOLOGY

Research Design

This study adopted a mixed-methods research design to evaluate passive design strategies in selected residential condominiums within Eti-Osa Local Government Area, Lagos State, towards developing sustainable design guidelines for a proposed condominium in Sangotedo. The study integrated both quantitative and qualitative research approaches to provide a comprehensive assessment of passive environmental design and its influence on thermal comfort.

The quantitative component involved the administration of structured questionnaires to occupants of selected residential buildings to obtain information on thermal comfort, occupants' perceptions of passive design features, and the environmental benefits associated with these strategies. Quantitative environmental measurements were also conducted using a Kestrel 4400 Heat Stress Tracker to measure indoor air temperature, relative humidity, and wind velocity.

The qualitative component consisted of detailed field observations and case studies of selected residential developments incorporating passive design strategies, particularly vertical greenery systems (VGS). Building characteristics such as orientation, façade treatment, shading devices, vegetation, ventilation openings, and other passive design elements were documented through observation checklists and photographic records. The integration of occupants' perceptions with measured environmental data provided a holistic understanding of passive design performance within the study area.

Study Area

The study was conducted within Eti-Osa Local Government Area of Lagos State, Nigeria, with particular emphasis on residential developments located in Ikoyi, Victoria Island, Lekki Phase I, Lekki Phase II, Banana Island, Ikate, Ogombo, and Ajah. Eti-Osa represents one of Nigeria's fastest-growing urban districts and is characterized by high-density residential developments, luxury condominiums, gated estates, and mixed-use developments.

The area experiences a tropical coastal climate characterized by relatively high temperatures, elevated humidity, abundant rainfall, and persistent southwesterly winds throughout most of the year. These climatic conditions provide suitable opportunities for implementing passive design strategies aimed at improving indoor thermal comfort while reducing dependence on mechanical cooling systems. The rapid pace of urban development within Eti-Osa further makes the area appropriate for assessing the effectiveness of passive environmental design in contemporary residential buildings.

Population and Sampling Procedure

The study population comprised adult occupants (18 years and above) residing in selected residential condominiums and apartment developments within Eti-Osa Local Government Area that incorporate passive design strategies, including vertical greenery systems. Twenty residential developments were purposively selected because they exhibited identifiable passive environmental features relevant to the objectives of the study.

The accessible population consisted of 687 residential units distributed across the selected developments. Using Slovin's formula at a 95% confidence level with a 5% margin of error, a sample size of 253 respondents was determined. This represents approximately 36.8% of the accessible population.

A multi-stage sampling procedure was adopted. In the first stage, Eti-Osa Local Government Area was purposively selected because of its concentration of modern residential condominiums and increasing adoption of sustainable building practices. In the second stage, twenty residential developments were purposively selected based on the presence of passive design features such as vertical greenery systems, shading devices, natural ventilation provisions, and landscape integration. In the final stage, occupants within the selected

buildings were purposively sampled to ensure that respondents possessed adequate experience of the indoor environmental conditions and passive design features being evaluated.

Data Collection

Data collection was guided by the research objectives and involved both primary and secondary data sources. To achieve the first objective, secondary climatic data were obtained from the Nigerian Meteorological Agency (NiMet). Climatic variables collected included air temperature, relative humidity, rainfall, wind speed and direction, and solar radiation. These climatic data were analysed to establish the environmental characteristics of Eti-Osa and their implications for passive residential design.

For the second objective, field surveys and case studies were undertaken to document passive design strategies incorporated within the selected residential developments. Information relating to building orientation, shading devices, vertical greenery systems, vegetation, natural ventilation provisions, façade treatments, and other passive environmental features was obtained using structured observation checklists, field notes, and photographic documentation.

To address the third objective, indoor thermal comfort conditions were evaluated through occupant questionnaires and physical environmental measurements. The questionnaires obtained information on occupants' thermal sensation, clothing insulation, activity level, and perception of indoor environmental quality, while indoor environmental variables including air temperature, relative humidity, and wind velocity were measured using a Kestrel 4400 Heat Stress Tracker.

For the fourth objective, structured questionnaires were further used to evaluate occupants' perceptions of the environmental benefits of passive design strategies. Variables assessed included improvements in indoor air quality, indoor temperature regulation, sound insulation, visual aesthetics, energy efficiency, and overall environmental sustainability.

The findings obtained from the preceding objectives were subsequently synthesized to develop sustainable passive design guidelines for the proposed condominium development in Sangotedo, Lagos State.

Variables Measured

The variables measured were aligned with the objectives of the study. The climatic assessment considered environmental variables including mean air temperature, relative humidity, annual rainfall, prevailing wind speed and direction, and solar radiation. These variables were used to evaluate the climatic characteristics of Eti-Osa and their suitability for passive residential design.

Passive design strategies were assessed using architectural variables such as building orientation, vertical greenery systems, shading devices, vegetation, façade treatment, natural ventilation provisions, window configuration, balcony design, courtyard arrangement, landscape elements, and other passive environmental features observed during field surveys.

Thermal comfort was evaluated using both environmental and occupant-related variables. Environmental measurements included indoor air temperature, relative humidity, and wind velocity recorded using the Kestrel 4400 Heat Stress Tracker, while occupant variables included thermal sensation, clothing insulation, activity level, and perceived indoor environmental quality obtained through structured questionnaires.

The environmental benefits of passive design strategies were assessed using occupants' perceptions of indoor air quality, thermal comfort, sound insulation, visual aesthetics, reduction in urban heat effects, energy efficiency, and overall contribution to sustainable residential development. These variables collectively provided the basis for evaluating the effectiveness of passive design strategies and for developing evidence-based recommendations for future condominium design in Sangotedo.

IV. RESULTS AND DISCUSSION

(i) Socio-Economic Characteristics of Respondents

A total of 253 questionnaires were administered to occupants of selected mid-rise condominiums in Eti-Osa Local Government Area, Lagos State. Out of these, 248 questionnaires were retrieved and found suitable for analysis, representing a response rate of 98.0%. The socio-economic characteristics of the respondents are presented in Table 1. These characteristics provide essential background information on the respondents and establish the reliability of their perceptions regarding passive design features, thermal comfort, and environmental performance.

Table 1: Socio-economic characteristics of respondents (n = 248)

S/N	Variable	Category	Frequency	Percentage (%)
1.	Gender	Male	132	53.2
		Female	116	46.8
		Total	248	100.0
2.	Age Group (years)	18–25	72	29.0
		26–35	88	35.5
		36–45	46	18.5
		46–55	26	10.5
		Above 55	16	6.5
		Total	248	100.0
3.	Occupation	Civil Servant	58	23.4
		Private Sector	96	38.7
		Self-employed	70	28.2
		Others	24	9.7
		Total	248	100.0
4.	Educational Qualification	Diploma	40	16.1
		Bachelor's Degree	110	44.4
		Master's Degree	68	27.4
		PhD	12	4.8
		Others	18	7.3
		Total	248	100.0
5.	Length of Stay	Less than 1 year	52	21.0
		1–2 years	74	29.8
		3–4 years	56	22.6
		4–5 years	38	15.3
		Above 5 years	28	11.3
		Total	248	100.0
6.	Household Size	1	34	13.7
		2	58	23.4
		3	64	25.8
		4	52	21.0
		5 and above	40	16.1
		Total	248	100.0

Source: Authors' Field Survey (2026).

Discussion

The demographic characteristics presented in Table 1 indicate that the respondents constitute a representative sample of occupants residing in the selected condominium developments. Male respondents accounted for 53.2%, while females represented 46.8%, indicating a relatively balanced gender distribution capable of providing diverse perspectives on residential environmental quality. Such balance minimizes gender-related bias in assessing passive design features and thermal comfort within the buildings.

Regarding age distribution, respondents between 26 and 35 years constituted the largest proportion (35.5%), followed by those aged 18–25 years (29.0%). Together, these groups

account for over sixty percent of the sampled population, suggesting that the condominiums are predominantly occupied by economically active adults and young professionals.

Occupational characteristics further support this observation. As shown in Table 1, respondents employed in the private sector represented the largest occupational group (38.7%), followed by self-employed individuals (28.2%) and civil servants (23.4%). The predominance of income-earning professionals suggests that occupants are likely to possess sufficient awareness of housing quality and energy consumption, thereby enhancing the credibility of their evaluations.

Educational attainment among respondents was similarly high. Nearly half (44.4%) possessed bachelor's degrees, while 27.4% held master's degrees. Only a relatively small proportion had diploma qualifications or lower educational attainment. This indicates that respondents are generally well educated and capable of making informed judgments regarding passive design strategies, environmental sustainability, and thermal comfort.

The duration of residence also strengthens the reliability of the responses. Approximately 29.8% of respondents had occupied their apartments for between one and two years, while 22.6% had lived there for three to four years. Such periods of occupancy are sufficient for residents to experience seasonal climatic variations and evaluate building performance under different environmental conditions. Finally, household sizes were generally moderate, with households comprising three occupants (25.8%) forming the largest category. Moderate household sizes influence internal heat gains, ventilation demand, and overall indoor comfort, making them particularly relevant when assessing passive building performance.

Overall, the socio-economic profile presented in Table 1 demonstrates that the respondents possess the educational background, residential experience, and demographic diversity necessary to provide reliable assessments of passive design implementation and its influence on thermal comfort within the selected condominium developments.

(ii) Availability of Passive Design Features

Passive design features incorporated within the selected condominium developments were assessed using a binary rating scale of Present (2) and Not Present (1). Mean Weighted Values (MWV) were computed to determine the level of integration of each passive design feature. A criterion mean of 2.50 was adopted, where values equal to or greater than the criterion indicate adequate implementation. The results are presented in Table 2.

Table 2: Availability of passive design features in selected condominiums (n = 248)

S/N	Passive Design Feature	Present	Not Present	Total	MWV	Decision
1	Large windows for daylighting	178	70	248	3.76	Present
2	Cross ventilation in rooms	173	75	248	3.71	Present
3	Proper building orientation	145	103	248	2.59	Present
4	Landscaped gardens/green courtyards	108	140	248	1.44	Not Present
5	Shaded outdoor sitting areas	114	134	248	1.48	Not Present
6	Use of natural materials	105	143	248	1.42	Not Present
7	Sun-shading devices (louvers, overhangs, screens)	162	86	248	3.66	Present

Decision Criterion: $MWV \geq 2.50 = \text{Present}$.

Source: Authors' Field Survey (2026).

Discussion

The results presented in Table 2 reveal varying levels of adoption of passive design features across the selected condominium developments. Among the evaluated features, large windows for daylighting recorded the highest Mean Weighted Value ($MWV = 3.76$), indicating that natural daylighting remains the most widely integrated passive design strategy within the study area. The prominence of this feature suggests that developers recognize the benefits of daylight penetration in reducing dependence on artificial lighting while simultaneously improving visual comfort and indoor environmental quality.

Similarly, cross ventilation recorded a high MWV of 3.71, demonstrating substantial consideration for natural airflow within residential units. Effective cross ventilation is particularly important in the tropical climatic conditions of Lagos, where elevated temperatures and humidity create a continuous demand for passive cooling strategies. The high rating therefore suggests that many of the condominium buildings incorporate window placement and room layouts that facilitate natural air movement, thereby contributing to improved thermal comfort.

The availability of sun-shading devices, including louvers and roof overhangs, also recorded a relatively high MWV of 3.66, indicating considerable adoption. These devices play a significant role in limiting direct solar radiation entering buildings, thereby reducing indoor heat gain and improving occupant comfort. Their relatively widespread implementation demonstrates an increasing awareness among designers of climate-responsive architectural solutions.

Conversely, proper building orientation recorded a comparatively lower MWV of 2.59. Although this value exceeds the decision criterion and therefore indicates the presence of the feature, it suggests that orientation has not been consistently considered across all developments. Since building orientation influences solar exposure, ventilation efficiency,

and daylight distribution, inconsistent implementation may reduce the overall effectiveness of passive environmental control strategies.

A different trend is observed for landscape-related passive features. Landscaped gardens and green courtyards (MWV = 1.44), shaded outdoor sitting areas (MWV = 1.48), and the use of natural construction materials (MWV = 1.42) all recorded values below the acceptance threshold, indicating poor integration within the sampled developments. These findings imply that developers tend to prioritize building-envelope strategies over outdoor environmental interventions. The limited provision of landscape features may be attributed to increasing land values, high development densities, and the desire to maximize buildable floor area within urban residential developments.

Overall, Table 2 demonstrates that passive design implementation in the selected condominiums is concentrated primarily on strategies that directly improve indoor environmental quality, such as daylighting, ventilation, and solar shading. In contrast, passive features capable of improving the external microclimate and enhancing environmental sustainability remain largely underutilized. The findings therefore suggest that passive design implementation is selective rather than holistic, highlighting the need for more integrated design approaches that combine both building-envelope and landscape-based strategies.

(iii) Perceived Thermal Comfort in Selected Condominiums

Occupants' perceptions of thermal comfort were evaluated using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The Total Weighted Value (TWV) and Mean Weighted Value (MWV) were computed for each statement to determine respondents' level of agreement. A criterion mean of 3.00 was adopted, whereby MWV values equal to or greater than 3.00 indicate agreement. The results are presented in Table 3.

Table 3: Respondents' perception of thermal comfort in selected condominiums (n = 248)

S/N	Statement	SA (5)	A (4)	N (3)	D (2)	SD (1)	Total	TWV	MWV	Rank	Decision
1	Indoor temperature is comfortable	72	78	55	18	12	248	565	3.65	1st	Agree
2	Natural ventilation effectively cools the apartment	38	60	27	20	10	248	561	3.62	2nd	Agree
3	Air quality within the apartment is satisfactory	60	80	68	30	15	248	538	3.47	3rd	Agree
4	There is low reliance on air conditioning	25	40	38	75	70	248	470	2.24	4th	Disagree
5	Indoor humidity level is comfortable	28	48	32	82	58	248	502	2.04	5th	Disagree

Decision Criterion: $MWV \geq 3.00 = \text{Agree}$.

Source: Authors' Field Survey (2026).

Discussion

The findings presented in Table 3 indicate that occupants generally perceive the selected condominiums as providing satisfactory thermal conditions, although certain aspects require improvement. Among the evaluated variables, comfortable indoor temperature recorded the highest Mean Weighted Value ($MWV = 3.65$), ranking first. This finding suggests that the existing passive design measures adopted in many of the sampled buildings are capable of moderating indoor temperatures to acceptable levels for occupants. The result is consistent with the relatively high availability of daylighting, ventilation, and solar-shading features observed in Table 2, indicating that these design elements contribute positively to indoor thermal conditions.

Closely following this was the statement "Natural ventilation effectively cools the apartment", which recorded an MWV of 3.62. This high rating demonstrates that respondents perceive natural airflow as one of the most effective passive cooling mechanisms within their residences. Given the humid tropical climate of Lagos, effective cross ventilation is particularly important for dissipating internal heat and improving occupant comfort without increasing energy consumption. The finding further validates the high level of cross-ventilation provision reported earlier in Table 2, suggesting that its implementation is not only widespread but also functionally effective.

Respondents also expressed positive perceptions regarding indoor air quality, which recorded an MWV of 3.47. Adequate ventilation is often associated with improved indoor air quality through increased air exchange and reduced accumulation of indoor pollutants. The result therefore indicates that the ventilation strategies incorporated within the buildings contribute not only to thermal regulation but also to healthier indoor environments.

However, the statement regarding low reliance on air conditioning recorded an MWV of 2.24, falling below the acceptance threshold. This suggests that despite the presence of passive design measures, occupants still depend considerably on mechanical cooling systems, particularly during periods of elevated outdoor temperature. The finding implies that passive strategies alone are currently insufficient to satisfy cooling demands throughout the year.

Similarly, comfortable indoor humidity recorded the lowest rating ($MWV = 2.04$). High humidity remains one of the defining climatic characteristics of Lagos and presents a persistent challenge to thermal comfort. Although natural ventilation may facilitate air movement, it does not necessarily reduce moisture content in the air. Consequently, respondents continue to experience discomfort associated with excessive humidity, highlighting a limitation of existing passive design implementation.

Overall, Table 3 demonstrates that passive design features currently adopted within the selected condominiums contribute positively to indoor temperature regulation, ventilation, and air quality. Nevertheless, the continued reliance on air conditioning and dissatisfaction with humidity conditions indicate that these passive strategies are not yet sufficiently integrated to achieve optimum thermal performance. Future residential developments should

therefore combine passive cooling techniques with improved humidity-control measures to enhance occupant comfort while minimizing energy demand.

(iv) Environmental Benefits of Passive Design Features

To evaluate occupants' perceptions of the environmental benefits associated with passive design strategies, respondents rated a series of statements using a five-point Likert scale. The analysis employed the Total Weighted Value (TWV), Mean Weighted Value (MWV), and Relative Importance Index (RII). The RII was computed using the expression:

$$RII = \frac{(5 \times TWV)}{155}$$

where N = 248 respondents.

The results are presented in Table 4.

Table 4: Perceived environmental benefits of passive design features (n = 248)

S/N	Environmental Benefit	SA (5)	A (4)	N (3)	D (2)	SD (1)	Total	TWV	MWV	RII	Rank
1	Reduces indoor heat gain	78	100	45	15	10	248	586	3.78	0.76	1st
2	Improves indoor air quality	83	58	75	17	10	248	576	3.72	0.74	2nd
3	Enhances thermal comfort	43	60	64	58	23	248	573	3.70	0.69	3rd
4	Improves aesthetic quality	40	55	68	53	32	248	556	3.59	0.68	4th
5	Reduces electricity consumption	42	57	26	71	52	248	564	3.64	0.63	5th
6	Supports environmental sustainability	41	56	60	29	62	248	560	3.61	0.60	6th
7	Reduces external noise intrusion	30	48	32	68	70	248	508	3.28	0.50	7th

Source: Authors' Field Survey (2026).

Discussion

The results presented in Table 4 indicate that respondents generally perceive passive design strategies as beneficial to both indoor environmental quality and overall building sustainability. Among the evaluated variables, reduction of indoor heat gain recorded the highest Relative Importance Index (RII = 0.76) and MWV of 3.78, ranking first. This finding demonstrates that occupants primarily associate passive design with improved thermal regulation. The result complements the findings reported in Table 3, where respondents also indicated high levels of satisfaction with indoor temperature, thereby reinforcing the effectiveness of passive cooling strategies incorporated within the sampled buildings.

The second highest ranked benefit was improved indoor air quality (RII = 0.74). Adequate ventilation, which was identified in Table 2 as one of the most commonly implemented passive design features, likely contributes to this positive perception. Continuous natural air exchange enhances occupant health by reducing indoor pollutants and improving overall environmental quality. This consistency across Tables 2, 3, and 4 suggests that passive ventilation strategies simultaneously improve airflow, thermal comfort, and indoor air quality.

Similarly, enhanced thermal comfort ranked third with an RII of 0.69, indicating that respondents clearly recognize the contribution of passive design to creating more comfortable indoor living conditions. The finding further supports the thermal comfort results discussed in Table 3, where occupants expressed agreement regarding comfortable indoor temperatures and effective natural ventilation.

Respondents also acknowledged the contribution of passive design to improved building aesthetics (RII = 0.68). Features such as larger windows, shading devices, and landscaped spaces often enhance architectural appearance while simultaneously improving environmental performance. Although aesthetics was not the highest-ranked benefit, its relatively strong rating suggests that occupants appreciate both the functional and visual advantages of passive architectural elements.

The perceived benefits relating to reduced electricity consumption (RII = 0.63) and environmental sustainability (RII = 0.60) were also positively rated. These findings indicate that respondents recognize the potential of passive design to reduce operational energy demand by lowering dependence on artificial lighting and mechanical cooling systems. Nevertheless, their lower rankings compared with thermal benefits suggest that energy savings are less immediately noticeable to occupants than improvements in indoor comfort.

Conversely, noise reduction recorded the lowest ranking (RII = 0.50). This suggests that respondents do not strongly associate passive design measures within the studied condominiums with improvements in acoustic performance. The finding may indicate that most passive strategies implemented in the buildings primarily target thermal and visual comfort rather than sound insulation.

Overall, the results in Table 4 demonstrate that passive design is widely recognized for its contribution to thermal regulation, indoor air quality, and occupant comfort. Furthermore, the consistency between Tables 2, 3, and 4 confirms that the passive design features currently incorporated within the sampled condominium developments are positively influencing occupants' perceptions of environmental performance. However, greater integration of design measures capable of simultaneously addressing thermal, energy, ecological, and acoustic performance would further enhance the sustainability of future residential developments.

V. CONCLUSION

This study assessed the implementation of passive design strategies and their influence on thermal comfort in selected mid-rise condominiums in Eti-Osa Local Government Area of Lagos State. The findings revealed that although several passive design features, particularly large windows for daylighting, cross ventilation, and sun-shading devices, are incorporated into the selected residential buildings, their implementation remains uneven and incomplete.

The study further established that the presence of passive design features contributes positively to occupants' thermal comfort. Respondents generally agreed that indoor temperatures were comfortable, natural ventilation improved indoor conditions, and indoor air quality was satisfactory. However, the continued reliance on mechanical air-conditioning systems and concerns regarding indoor humidity indicate that existing passive design measures have not fully optimized indoor environmental performance.

Based on the prioritization of proposed design strategies, respondents identified cross ventilation, natural daylighting, landscaping, green courtyards, climate-responsive orientation, and sustainable building materials as the most desirable interventions for improving residential building performance. The study therefore concludes that adopting a holistic passive design approach that integrates architectural planning, environmental design, and sustainable landscape strategies will significantly improve thermal comfort, reduce operational energy demand, and enhance the environmental sustainability of condominium developments in tropical urban environments such as Lagos State.

RECOMMENDATIONS

- i. Passive design principles should be integrated into the planning and design of future condominium developments to improve thermal comfort, indoor environmental quality, and energy efficiency.
- ii. Architects and developers should prioritize cross ventilation, adequate natural daylighting, and climate-responsive building orientation during the design stage to minimize dependence on mechanical cooling systems.
- iii. Existing condominium buildings should be retrofitted with additional passive design features such as external shading devices, improved ventilation pathways, green courtyards, and landscaped outdoor spaces to enhance environmental performance.
- iv. Government agencies, professional bodies, and housing developers should promote awareness and provide technical guidelines on passive design strategies to encourage their wider adoption in residential developments.
- v. Financial incentives, policy support, and sustainable housing regulations should be introduced to encourage developers to incorporate passive design features and environmentally sustainable building materials into residential projects.
- vi. Facility managers and residents should adopt proper maintenance practices to preserve the functionality and long-term effectiveness of passive design elements, particularly ventilation openings, shading devices, and landscape features.
- vii. Future studies should evaluate the performance of passive design strategies in other residential building typologies across different climatic zones in Nigeria and incorporate building performance simulation techniques to validate occupants' perceptions with measured environmental data.

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