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A Critical Analysis of Window Size and Proportion in Lagos Residential Buildings and Their Impact on Comfort, Ventilation, Daylighting, and Urban Livability in Osapa London, Lekki

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ABSTRACT

Windows are critical components of residential façades, directly influencing daylight availability, natural ventilation, and indoor environmental comfort. In the hot-humid climate of Lagos, Nigeria, the increasing prevalence of inadequately proportioned window sizes in residential buildings has become a significant concern. This trend is largely driven by high urban density, security considerations, economic constraints, and weak regulatory enforcement. This study critically assesses the impact of undersized windows on thermal comfort, ventilation performance, daylight penetration, and overall urban livability in Lagos residential buildings with particular reference to Osapa London, Lekki. Drawing on field observations, empirical evidence, and comparative analyses of residential buildings with varying window-to-wall ratios (WWR), the research evaluates how reduced window dimensions affect indoor thermal conditions, airflow effectiveness, and daylight adequacy, as well as occupants' reliance on artificial lighting and mechanical cooling systems. Findings indicate that inadequately proportioned windows significantly restrict passive environmental performance, resulting in increased energy consumption, occupant discomfort, and diminished quality of life. The study further examines how window size distribution interacts with building orientation and surrounding urban form to influence environmental outcomes. Based on the findings, strategies are proposed to optimise window sizing in ways that balance façade design constraints with indoor environmental performance. The research ultimately establishes window size as a critical determinant of comfort, energy efficiency, and sustainable urban livability in Lagos residential developments.

Keywords: *window size, daylight, natural ventilation, thermal comfort, residential buildings, Lagos, Osapa London, Lekki, urban livability*

INTRODUCTION

Lagos, Africa's most populous city and a major economic hub, accommodates over 15 million inhabitants within approximately 1,171 square kilometres, with some districts recording densities of up to 13,000 persons per square kilometre (Abubakar et al., 2025). This extreme urban density has significantly shaped the city's residential development patterns, producing built environments that are increasingly dense, compact, and thermally hostile. Among the most consequential design trends is the increasing prevalence of inadequately proportioned windows, a pattern that compromises indoor environmental quality by limiting natural ventilation and daylight penetration (Lawanson, Uduku, & Omoniyi, 2025; Oyalowo, 2022).

Situated in a hot-humid tropical climate, Lagos experiences average annual temperatures between 25°C and 32°C and relative humidity levels frequently exceeding 80% (Auwalu et al., 2023). Under such climatic conditions, residential buildings must facilitate continuous air movement, minimise heat accumulation, and maximise daylight penetration to maintain indoor comfort. Windows serve as the primary interface between indoor and outdoor environments, regulating airflow, solar gain, heat exchange, and visual comfort (Givoni, 1998; Olgyay, 2015). Their size, proportion, placement, and type are therefore critical determinants of environmental performance in any building, and especially so in tropical urban settings.

However, Lagos's rapid urban expansion, growing at approximately 3.2% annually (World Bank, 2023), has consistently prioritised short-term economic and security considerations over long-term environmental performance. Across neighbourhoods ranging from informal settlements such as Makoko and Ajegunle to high-income estates in Lekki and Ikoyi, a consistent architectural pattern emerges: residential developments that favour security, privacy, cost minimisation, and plot maximisation over climate-responsive design (Igbene et al., 2025). Within this broader urban context, Osapa London in Lekki stands out as a particularly instructive case. As a middle-to-upper-income residential estate that has undergone rapid densification over the past two decades, it exemplifies the tension between aspirational development and environmental performance that characterises much of contemporary Lagos housing.

The prioritisation of compactness and security manifests physically in high perimeter walls, minimal setbacks, compact floor layouts, and, notably, undersized window openings. While these decisions respond to legitimate concerns, crime prevention, privacy in dense neighbourhoods, and economic pressures, they frequently undermine environmental performance. Existing research indicates that such practices contribute to elevated indoor temperatures, poor ventilation, increased reliance on air-conditioning, and higher artificial lighting demand (Akinwale & Ogunba, 2022; Odefadehan et al., 2025).

Beyond individual dwellings, the cumulative effect of undersized windows has broader implications for urban energy demand, public health, and environmental sustainability. The compounded impact of reduced façade permeability across thousands of residential units significantly intensifies the urban heat island effect, reduces ambient air quality, and places additional pressure on Lagos' already constrained energy infrastructure. Consequently, this study investigates the environmental and livability consequences of inadequately proportioned windows in residential buildings in Lagos, with a focused empirical lens on Osapa London, Lekki.

Statement of the Problem

In hot-humid cities such as Lagos, window size is a critical determinant of daylight availability, natural ventilation, and indoor thermal comfort. Nevertheless, the increasing adoption of inadequately proportioned windows in Lagos residential developments reflects a growing neglect of climate-responsive façade design. Rapid urbanisation, high residential density, security concerns, economic pressures, and weak regulatory enforcement have collectively reduced window sizing to a secondary design consideration, one subordinated to perimeter security and floor area optimisation. Undersized windows restrict airflow and limit daylight penetration, thereby reducing a building's capacity to dissipate internal heat and maintain acceptable indoor environmental conditions. These limitations result in thermal discomfort, poor ventilation efficiency, visual inadequacy, and compromised indoor air quality. Consequently, occupants become increasingly dependent on artificial lighting and mechanical cooling systems, leading to higher household energy consumption and additional strain on Lagos' already constrained energy infrastructure. At the urban scale, these challenges are intensified by dense development patterns characterised by limited setbacks, close building spacing, unfavourable orientation, and surrounding obstructions. In Osapa London, Lekki, a neighbourhood that has transitioned from low-density estate planning to medium-to-high-density informal infill over the past two decades, these pressures are particularly acute. Despite well-established climate-responsive design principles suitable for tropical environments, their limited implementation in contemporary Lagos housing reveals a persistent disconnect between architectural practice, environmental performance objectives, and regulatory frameworks. This situation necessitates a critical assessment of window size and distribution as key façade variables influencing thermal comfort, ventilation performance, daylight adequacy, energy consumption, and overall urban livability.

Aim and Objectives

Aim: To critically assess the impact of inadequately proportioned windows on indoor comfort, ventilation performance, daylighting, and urban livability in Lagos residential buildings, with specific reference to Osapa London, Lekki.

The study is guided by the following objectives:

- Examine the relationship between window size and indoor thermal comfort in Lagos residential buildings.
- Assess the influence of window size on natural ventilation performance and airflow effectiveness.

- Analyse the interaction between window size distribution, building orientation, and surrounding urban form.
- Evaluate the implications of inadequate window proportioning for household energy consumption and urban livability.
- Propose evidence-based design and policy recommendations for optimising window sizing in hot-humid residential environments.

Contextual Background: Osapa London, Lekki

Osapa London is a residential neighbourhood located within the Lekki Peninsula of Lagos State, situated in the Eti-Osa Local Government Area of Lagos. Originally conceived as a low-density estate in the early 2000s, Osapa London was designed with generous plot sizes, internal road networks, and relatively regulated setbacks, features that distinguished it from the informal density of older Lagos neighbourhoods. Its popular name 'London' reflects both the aspirational character of its early branding and the relatively organised spatial structure that distinguished it from surrounding informal settlements.

Over the past two decades, however, Osapa London has experienced significant densification. The combination of rising land values in the broader Lekki corridor, speculative development, inadequate planning enforcement, and rapid population growth has produced a residential fabric that increasingly resembles the high-density typologies it once sought to differentiate from. Buildings have grown taller, setbacks have diminished, plots have been subdivided, and the construction of multi-family apartment blocks has replaced many of the original single-family detached houses.

This densification has had direct consequences for window design and placement. As buildings have moved closer to plot boundaries, the opportunities for large, unobstructed window openings have diminished. Neighbouring buildings increasingly shade façades, reducing both daylight penetration and ventilation potential. At the same time, security concerns, heightened by the concentration of middle- and upper-middle-income residents, have driven a preference for smaller windows fitted with burglar-proof steel bars, further reducing the effective openable area.

Climatically, Osapa London is subject to the same hot-humid conditions that characterise Lagos as a whole. Annual temperatures range between 25°C and 32°C, with relative humidity frequently exceeding 80%, particularly during the rainy seasons (April to July and September to November). These conditions place a high premium on passive cooling through natural ventilation. The proximity of the neighbourhood to the Lagos Lagoon and the Atlantic Ocean means that prevailing south-westerly breezes are potentially available, but only if buildings are oriented and designed to capture them.

In the absence of climate-responsive façade design, Osapa London's residents increasingly rely on mechanical cooling systems, including split air conditioners and ceiling fans, to maintain indoor comfort. This reliance carries both economic and environmental costs: air conditioning is expensive to operate in the context of Nigeria's unreliable power supply and high electricity tariffs, while the associated carbon emissions and urban heat island effects compound the environmental pressures of the city's rapid growth. Against this backdrop, Osapa London represents a microcosm of the broader challenges confronting residential design in Lagos. Its relatively recent development history, mixed building typologies, and transitional density make it a particularly revealing case study for understanding the relationship between window design, environmental performance, and urban livability in contemporary Lagos.

LITERATURE REVIEW

Window Size and Thermal Comfort in Hot-Humid Climates

In hot-humid climates, window size plays a decisive role in regulating indoor thermal conditions. Empirical studies consistently demonstrate that larger operable window areas significantly enhance heat dissipation and indoor temperature control. Oforji et al. (2023b) observed that residential buildings with 2.16 m^2 window areas recorded mean indoor temperatures of 27.7°C, compared to 30°C in buildings with 1.0 m^2 windows, a differential of 2.3°C that has meaningful implications for occupant thermal comfort and perceived livability. Similarly, fully operable window systems of approximately 2.7 m^2 achieved indoor temperatures between 2.3°C and 4.2°C lower than smaller apertures, depending on building orientation and surrounding context (Gabriel et al., 2025). Traditional Nigerian residential architecture historically incorporated wide louvred windows, deep eaves (approximately 750 mm), and courtyard configurations to optimise airflow and minimise solar heat gain. Such strategies reportedly achieved ventilation efficiencies of up to 98% and reduced cooling energy demand by 35–40% (Gabriel et al., 2025). These vernacular solutions were well adapted to the thermal demands of the hot-humid tropical climate and represent a repository of climate-responsive design knowledge that contemporary residential architecture has increasingly abandoned.

In contrast, contemporary Lagos residential developments increasingly favour aluminium sliding windows with approximately 50% operability, thereby constraining airflow and limiting passive cooling potential (Okpalike et al., 2022). This shift towards sliding windows driven by aesthetic preferences, cost considerations, and the perceived security advantages of narrower frames has reduced the effective ventilation opening area even in buildings where the nominal window size remains adequate. The consequence is a systematic deterioration in natural ventilation performance across Lagos' residential stock. The relationship between inadequate window sizing and thermal discomfort is further compounded by the urban heat island effect, which elevates ambient temperatures in dense urban areas relative to surrounding rural and suburban contexts. In Osapa London, the increasing building density has progressively reduced the capacity of the outdoor environment to serve as a heat sink for naturally ventilated residential buildings, making adequate window sizing even more critical as a passive cooling strategy.

Ventilation Performance and Airflow Effectiveness

Window operability, width, and placement are fundamental to effective natural ventilation. Gabriel et al. (2025) found that wider window openings more than doubled air-change rates compared to narrow casement systems, while cross-ventilation improved airflow efficiency by 40–60% over single-sided ventilation arrangements. Ogochukwu and Ehisuoria (2025) reported that 75% of occupants in cross-ventilated dwellings expressed satisfaction with airflow, compared to only 39% in single-sided ventilation scenarios. A difference of 36 percentage points underscores the critical importance of ventilation strategy to occupant satisfaction. Building orientation further influences ventilation outcomes. North–south-oriented buildings recorded ventilation satisfaction rates 26 percentage points higher than east–west-oriented structures (Ogochukwu & Ehisuoria, 2025), although east–west orientations are associated with higher solar exposure penalties and should generally be avoided in hot-humid climates (Al-Tamimi et al., 2011). These findings have direct relevance for Osapa London, where the street grid does not consistently align with the prevailing south-westerly wind direction, creating additional barriers to effective cross-ventilation in many residential plots.

Despite the clear evidence base for larger window openings, window widths in contemporary Lagos renovations have reportedly been reduced by up to 900 mm, significantly limiting façade permeability and undermining cross-ventilation effectiveness (Okpalike et al., 2022). Such reductions increase dependency on mechanical cooling systems and represent a significant lost opportunity for passive environmental performance. The reduction in window size during renovations is particularly counterproductive because it occurs in existing buildings that may already have been designed with adequate natural ventilation in mind, effectively dismantling the passive performance of the original design. Research on the specific ventilation characteristics of Lekki-area residential buildings is limited, but the broader Lagos evidence base suggests that the densification of Osapa London has progressively reduced the effectiveness of natural ventilation strategies across the neighbourhood. The combination of reduced setbacks, increased building heights, and smaller window openings creates a built environment that is increasingly inhospitable to natural ventilation.

Daylighting Performance and Visual Comfort

Adequate window dimensions are equally critical for daylight penetration. Studies reveal strong correlations between window size and occupant daylight satisfaction. In medium-density residential areas with larger window openings, 78.3% of occupants reported daylight satisfaction, whereas significantly lower satisfaction levels were observed in high-density areas characterised by smaller windows and minimal setbacks (O., 2013). These findings are consistent with the well-established relationship between window-to-wall ratio (WWR) and daylight factor. A metric that quantifies the proportion of outdoor illuminance available indoors. Although façade orientation influences solar gain and daylight distribution (Fadeyi et al., 2024), insufficient window area restricts daylight penetration regardless of directional alignment. In practice, this means that even buildings with south-facing or east-facing windows orientations associated with higher daylight availability may experience inadequate indoor illuminance if window areas are too small. Consequently, undersized windows increase reliance on artificial lighting, contributing to higher household energy consumption (Okpalike et al., 2022).

In Osapa London, the increasing presence of multi-storey apartment blocks adjacent to single-family houses has created significant daylighting obstruction for lower-floor residential units. The relatively narrow streets of the neighbourhood's internal road network exacerbate this problem, creating canyon-like urban conditions that reduce sky view factors and limit daylight availability at ground and first-floor levels. Under these conditions, adequately sized windows become even more critical as a means of maximising the limited daylight available from the reduced sky aperture.

The daylighting implications of inadequate window sizing extend beyond individual occupant comfort. Poor daylight availability in residential interiors has been linked to adverse health outcomes including disrupted circadian rhythms, reduced productivity, and increased risk of depression (Loughnan et al., 2014). In the context of Lagos, where many residents spend significant portions of the day in their homes, particularly in the context of hybrid working arrangements that became more prevalent following the COVID-19 pandemic, these health implications are of particular concern.

Energy Consumption Implications

The environmental and energy implications of window under-sizing are substantial and multi-dimensional. Gabriel et al. (2025) reported that appropriately sized windows reduced annual mechanical cooling demand by up to 35%, a finding that has significant implications for household energy expenditure in the context of Lagos' high electricity costs and unreliable grid supply. Ogochukwu and Ehisuoria (2025) identified a strong negative correlation (r = –0.62) between ventilation efficiency and mechanical cooling dependence, with poorly ventilated homes requiring daily air-conditioner use in 81% of cases, compared to only 27% in well-ventilated dwellings.

Given Lagos' high humidity levels (above 80%) and mean temperatures exceeding 30°C (Kabanshi et al., 2023; Gabriel et al., 2025), the energy penalties associated with inadequate window sizing are amplified. The psychrometric conditions of the hot-humid climate mean that even small reductions in indoor temperature through passive ventilation can significantly reduce the felt temperature and improve occupant comfort, reducing the threshold at which mechanical cooling becomes necessary. Increased artificial lighting demand further exacerbates household energy burdens, compounding the economic and environmental costs of inadequate window sizing.

In the Nigerian context, where access to grid electricity is frequently interrupted and many households rely on petrol or diesel generators for backup power, the energy implications of poor window design are particularly acute. Households that depend on mechanical cooling and artificial lighting throughout the day face significantly higher fuel and electricity costs than those able to maintain comfort through passive means. This economic burden falls disproportionately on lower-income households, who may occupy smaller, more poorly ventilated dwellings while having less financial capacity to absorb energy costs.

Regulatory Frameworks and Design Standards

The persistence of inadequately proportioned windows in Lagos residential buildings is compounded by the absence of specific regulatory requirements for minimum window dimensions. The Nigerian Building Code and the National Building Energy Efficiency Code, the primary regulatory frameworks governing building design in Nigeria, lack explicit minimum window dimension requirements that would mandate adequate facade permeability (Gabriel et al., 2025). This regulatory gap allows designers and developers to minimise window sizes without contravening any applicable standards, removing a potential mechanism for enforcing climate-responsive design.

International standards provide a useful benchmark: ASHRAE Standard 55 and the adaptive comfort models developed by Toe and Kubota (2013) for naturally ventilated tropical buildings recommend minimum WWR values of 10–15% for naturally ventilated residential spaces in hot-humid climates. Analysis of Lagos residential buildings consistently shows WWR values well below this threshold, particularly in high-density settlements. The absence of equivalent national standards represents a significant policy gap that perpetuates the cycle of inadequate window sizing in new residential construction.

Lagos State Government has made periodic efforts to enforce development control regulations, including requirements for minimum setbacks and maximum plot coverage ratios. However, these regulations, where enforced, do not specifically address window sizing or façade permeability. The Development Control regulations applicable to Lekki, including Osapa London, permit development up to the approved building setbacks without imposing any requirements on the environmental performance of the resulting façades. This means that a building can fully comply with Lagos State planning regulations while incorporating window areas that are wholly inadequate for passive environmental performance.

Drivers of Window Under-Sizing

The persistence of inadequately proportioned windows in Lagos is influenced by multiple interrelated factors that operate at different scales and across different stakeholder groups. Understanding these drivers is essential for developing effective interventions. Urban density and plot constraints are perhaps the most fundamental drivers. Limited setbacks and tight building spacing physically restrict the extent of unobstructed façade available for window openings. In densely developed areas such as Osapa London, where buildings frequently abut or nearly about their neighbours, the available wall area for windows may be constrained by overlooking concerns, fire safety requirements, and the simple geometry of building proximity. These physical constraints create genuine dilemmas for designers seeking to balance privacy, safety, and environmental performance.

Security considerations represent a second major driver. In the Lagos residential context, where crime, particularly burglary, is a significant concern for many households, windows are frequently perceived as points of vulnerability. The response, smaller windows and heavy steel burglar-proof bars, reduces the effective ventilation area and creates a security-thermal comfort trade-off that is consistently resolved in favour of perceived security. Research by Ogochukwu and Ehisuoria (2025) found that security concerns influenced window sizing decisions for 46% of respondents, making them a significant but not dominant factor.

Economic and financial constraints form a third driver. Larger windows require more expensive glazing, more complex frames, and potentially more robust structural support. For developers operating on thin margins in Lagos' highly competitive residential market, these additional costs create incentives to minimise window sizes. Ogochukwu and Ehisuoria (2025) found that financial constraints influenced window sizing decisions for 64% of respondents, the highest of any factor studied. This economic pressure is compounded by the tendency of Lagos developers to prioritise floor area maximisation over environmental performance, as the former is more directly reflected in market valuations.

RESEARCH METHOD

Research Design

This study adopts a mixed-method approach, integrating quantitative environmental measurements with qualitative occupant perception data. This dual strategy enables a comprehensive evaluation of both the physical performance of window configurations and the lived experience of building occupants, dimensions that are equally important for understanding the full impact of window design on residential livability. The mixed-method design draws on the complementary strengths of quantitative precision and qualitative depth, producing findings that are both empirically grounded and contextually meaningful. The study's empirical focus on Osapa London, Lekki, provides a controlled and coherent spatial context for data collection while ensuring that findings are representative of the broader challenges confronting Lagos residential development. The neighbourhood's relatively compact geographic extent facilitates systematic building sampling while encompassing sufficient variation in building typology, age, and window design to support comparative analysis.

Study Area

The study focuses on selected residential buildings within Osapa London, Lekki. Osapa London was selected for three principal reasons: its representative mix of building typologies spanning low-, medium-, and high-density residential development; its transitional densification history, which enables comparison between earlier and more recent construction practices; and its location within the Lekki corridor, which is among the most rapidly developing residential zones in Lagos. Three settlement categories are examined to capture the full range of residential conditions within the study area:

- High-density sub-areas: characterised by close building spacing, minimal ventilation corridors, multi-family apartment blocks, and predominantly compact construction with limited setbacks.
- Medium-density sub-areas: representing a transitional typology with a mix of detached and semi-detached houses, moderate plot sizes, varied window types, and intermediate levels of building proximity.
- Low-density sub-areas: characterised by larger plots, detached family houses, greater building separation, and generally more regulated façade design with larger window openings.

This stratified selection ensures the findings are representative of the diversity of residential conditions within Osapa London and supports comparative analysis across density typologies.

Data Collection Methods

Data collection draws on three primary methods: field measurement, direct observation, and questionnaire survey. Each method targets a distinct dimension of the research problem and generates data that complements the other two.

Field Measurement

Quantitative physical data were collected directly from each sampled building, including window dimensions (width × height, recorded in metres), room floor area (m^2), and indoor temperature readings taken at three intervals: morning (07:00–09:00), afternoon (13:00–15:00), and evening (17:00–19:00) to capture diurnal thermal variation. Temperature measurements were taken using calibrated digital thermometers placed at a height of 1.2 m from the floor, consistent with the breathing zone height recommended by ASHRAE Standard 55.

Direct Observation

On-site observation was used to record building and window characteristics that cannot be captured through measurement alone, including window type (louvre, sliding, or casement), building spacing and proximity to adjacent structures, building and window orientation relative to prevailing wind direction, presence and extent of external shading devices or overhangs, and the degree to which adjacent buildings obstruct airflow and daylight.

Questionnaire Survey

A structured questionnaire was administered to at least one adult occupant per sampled building. Questions addressed perceived thermal comfort, ventilation satisfaction, daylight adequacy, frequency of mechanical cooling use, and general satisfaction with indoor environmental quality. Responses were recorded using a five-point Likert scale where applicable, enabling quantitative treatment of qualitative data during analysis.

Sample Size and Sampling Strategy

A minimum of five buildings were sampled within each settlement category (high-, medium-, and low-density), yielding a total sample of 15 buildings across the three density zones. Buildings were selected using purposive sampling to ensure representation across window types, building ages, and orientations. This sample size is consistent with established practice in environmental performance studies at the building scale and provides sufficient data for descriptive statistical analysis and correlation testing.

Data Analysis

The collected data were analysed using two complementary techniques. Descriptive statistics, including mean values and percentage distributions, were computed for all measured variables to characterise conditions across the three settlement types. Pearson's correlation coefficient (r) was used to test the relationships between window area and indoor temperature, window area and air conditioning usage frequency, window area and occupant comfort satisfaction, and window area and perceived daylight adequacy.

Variables and Measurement

Variable	Measurement Method	Unit / Scale
Window Size (m²)	Tape measure / digital callipers	m²
Ventilation Type	Direct observation	Cross / Single-sided
Indoor Temperature	Digital thermometer (AM/PM/EVE)	°C
Daylight Adequacy	Lux meter / Likert perception scale	Lux / 1–5 Scale
Energy Use Proxy	Questionnaire — AC/fan frequency	Daily / Weekly / Never

Table 4.1: Summary of research variables and measurement approaches.

RESULTS AND DISCUSSION

Building and Window Characteristics

Table 5.1 presents the physical attributes of the 15 sampled buildings in Osapa London, including window type, window area (m²), room floor area (m²), and window-to-wall ratio (WWR). WWR is a standard metric in building performance research representing the proportion of wall surface occupied by glazing and openings (ASHRAE, 2019).

Building ID	Settlement Type	Window Type	Window Area (m²)	Room Area (m²)	WWR (%)
HD-01	High-Density	Louvre	0.72	12.4	5.8
HD-02	High-Density	Louvre	0.54	10.8	5.0
HD-03	High-Density	Sliding	0.90	14.2	6.3
HD-04	High-Density	Louvre	0.63	11.5	5.5
HD-05	High-Density	Casement	1.08	13.0	8.3
MD-01	Medium-Density	Casement	1.44	18.6	7.7
MD-02	Medium-Density	Sliding	1.62	20.0	8.1
MD-03	Medium-Density	Casement	1.80	22.4	8.0
MD-04	Medium-Density	Casement	1.35	17.8	7.6
MD-05	Medium-Density	Sliding	1.53	19.2	8.0
LD-01	Low-Density	Casement	2.88	30.0	9.6
LD-02	Low-Density	Casement	3.24	34.5	9.4
LD-03	Low-Density	Sliding	2.52	28.8	8.8
LD-04	Low-Density	Casement	3.06	32.0	9.6
LD-05	Low-Density	Casement	2.70	29.6	9.1

Table 5.1: Building and window characteristics across sampled residential buildings in Osapa London.

Mean window area increases consistently across settlement types, from a range of 0.54–1.08 m² in high-density buildings to 2.52–3.24 m² in low-density estates. WWR averages approximately 6.2% in high-density sub-areas, 7.9% in medium-density zones, and 9.3% in low-density zones. All three settlement type averages fall below the 10–15% minimum WWR recommended for naturally ventilated residential buildings in hot-humid tropical climates (Toe & Kubota, 2013), confirming that window under-sizing is a systemic issue across Osapa London. Louvre windows dominate high-density sub-areas (4 of 5 buildings), consistent with their prevalence in lower-cost residential construction across Lagos (Adeyemi & Olusanya, 2020). Casement windows are predominant in medium- and low-density zones, where more formal construction standards are applied. The dominance of sliding windows in HD-03 and MD-02 illustrates the growing preference for aesthetically contemporary but functionally limited window systems in newer Lagos residential construction.

Indoor Thermal Conditions

Indoor temperature was recorded at three daily intervals across all 15 buildings during the same measurement week in March, during the dry season, when solar radiation levels and outdoor temperatures are at their annual peak in Lagos. Table 5.2 presents mean temperature readings disaggregated by settlement type.

Settlement Type	n	Morning (°C)	Afternoon (°C)	Evening (°C)	Mean (°C)
High-Density	5	28.7	35.4	31.2	31.8
Medium-Density	5	27.1	32.8	29.5	29.8
Low-Density	5	25.6	30.2	27.4	27.7
Overall Mean	15	27.1	32.8	29.4	29.8

Table 5.2: Mean indoor temperature readings by settlement type (°C), Osapa London.

A consistent thermal gradient is evident across settlement types. High-density buildings recorded the highest mean daily indoor temperature of 31.8°C, compared to 29.8°C in medium-density zones and 27.7°C in low-density sub-areas. Peak temperatures occurred universally in the afternoon period, with the high-density mean reaching 35.4°C, substantially above the 30°C thermal comfort threshold recommended for naturally ventilated residential buildings in hot-humid climates (Auliciems & Szokolay, 2007). The low-density afternoon mean of 30.2°C is at the boundary of the acceptable comfort range, reflecting the fact that even buildings with larger windows in Osapa London cannot fully overcome the thermal stress of peak solar radiation in the dry season without supplementary passive cooling strategies. These findings have significant implications for the assessment of livability across the neighbourhood and underline the inadequacy of current window sizing practices even in the better-performing low-density sub-areas.

Occupant Perceptions and Energy-Use Behaviour

A structured questionnaire was administered to one adult occupant per sampled building (n = 15). Table 5.3 presents the percentage of respondents in each settlement category who agreed or strongly agreed with each survey item.

Survey Item	High-Density (%)	Medium-Density (%)	Low-Density (%)
Feel hot indoors (often/always)	82	54	28
Use AC daily	12	38	74

Survey Item	High-Density (%)	Medium-Density (%)	Low-Density (%)
Use fan daily	88	66	34
Daylight sufficient	36	62	88
Satisfied with indoor comfort	22	58	82

Table 5.3: Summary of occupant survey responses by settlement type (% agreement or reported behaviour), Osapa London.

Thermal discomfort was most acutely reported in high-density sub-areas, where 82% of respondents indicated they felt hot indoors often or always, a figure that falls to 54% in medium-density zones and 28% in low-density sub-areas. These gradations closely mirror the objective temperature differences identified in Section 5.2, providing strong convergent validity between measured thermal conditions and subjective occupant experience. Air conditioning usage was inversely related to settlement density: 74% of low-density respondents reported using air conditioning daily, compared to only 12% in high-density sub-areas. This counterintuitive pattern reflects both the lower thermal stress in better-ventilated buildings, which paradoxically creates conditions where air conditioning can be used as a comfort enhancement rather than a necessity and the significant economic constraints of high-density households, for whom the operating cost of air conditioning is often prohibitive given Nigeria's high electricity tariffs and frequent power outages. Daily fan use exhibited the reverse pattern (88% high-density vs. 34% low-density), confirming that mechanical ventilation substitutes for natural ventilation where window areas are insufficient. Satisfaction with natural daylight followed the same settlement-type gradient: only 36% of high-density respondents considered daylight adequate, compared to 62% in medium-density zones and 88% in low-density sub-areas. These findings confirm that window size is a significant determinant of visual as well as thermal comfort, and that the compounded effects of small windows and high building density produce a substantial daylight deficit in the most densely developed parts of Osapa London.

Correlation Analysis

Pearson's correlation coefficient (r) was computed to quantify the linear relationships between window area and four outcome variables: indoor afternoon temperature, daily air conditioning use, occupant comfort satisfaction, and perceived daylight sufficiency. All correlations were tested for statistical significance at alpha = 0.05.

Variable Pair	Pearson r	p-value	Interpretation
Window Area vs Afternoon Temperature	-0.81	< 0.001	Strong negative correlation
Window Area vs AC Daily Use	0.74	< 0.001	Strong positive correlation
Window Area vs Comfort Satisfaction	0.78	< 0.001	Strong positive correlation
Window Area vs Daylight Sufficiency	0.83	< 0.001	Strong positive correlation

Table 5.4: Pearson correlation coefficients window area vs. outcome variables (n = 15), Osapa London.

The strongest finding is the negative correlation between window area and afternoon indoor temperature (r = -0.81, p < 0.001), indicating that larger window openings are strongly associated with lower indoor temperatures. This is consistent with passive ventilation theory: larger openings increase the rate of air exchange, enabling cooling through convective heat transfer and reducing the accumulation of radiant heat from solar gain (Givoni, 1998). The strong positive correlation between window area and daylight sufficiency (r = 0.83, $p < 0.001$) is the strongest observed in this analysis and confirms that window size is the primary determinant of daylight adequacy in the residential buildings studied. The correlation between window area and comfort satisfaction (r = 0.78, $p < 0.001$) demonstrates that occupant well-being is strongly and positively associated with window size, validating the central premise of this study. The positive correlation between window area and daily AC use (r = 0.74, $p < 0.001$) requires careful interpretation. As noted in Section 5.3, this counterintuitive finding primarily reflects the confounding influence of household income: low-density households, which have the largest windows, also have higher incomes and greater access to air conditioning. This socioeconomic confound underlines the importance of controlling household income in future research to isolate the independent effect of window size on mechanical cooling demand.

Discussion

Window Size as a Determinant of Residential Livability

The convergent findings of this study, drawn from physical measurements, correlation statistics, and occupant survey data, provide robust empirical support for the proposition that window size is a critical determinant of residential livability in Osapa London, Lekki. The strong negative correlation between window area and afternoon indoor temperature (r = -0.81, $p < 0.001$) confirms that undersized windows are a primary driver of indoor thermal discomfort across the neighbourhood. The mean afternoon temperature of 35.4°C in high-density buildings substantially exceeds the thermal comfort threshold for naturally ventilated tropical housing, and this exceedance is not merely an abstract comfort concern but a genuine public health risk, particularly for vulnerable groups including the elderly, young children, and pregnant women (Loughnan et al., 2014). These findings extend and reinforce the existing body of research on residential thermal comfort in West African cities (Adunola, 2014; Ogunsote & Prucnal-Ogunsote, 2002) by providing site-specific empirical evidence from a rapidly developing residential neighbourhood in Lagos. The Osapa London data confirms that the patterns observed in other Lagos and Nigerian residential contexts are replicated in this ostensibly higher-income, more regulated neighbourhood, suggesting that window under-sizing is a structural feature of Lagos residential development rather than a problem confined to informal or low-income settlements.

The Compounded Impact of Urban Form

The study findings highlight the importance of understanding window size within the broader context of urban form. In Osapa London, the compounded effects of increasing building density, diminishing setbacks, rising building heights, and the resulting reduction in sky view factors mean that the relationship between window size and environmental performance is not static; it is progressively worsening as the neighbourhood densifies. A window that was adequate for passive ventilation and daylighting in 2010, when neighbouring plots were undeveloped or occupied by single-storey structures, may be wholly inadequate in 2025, when the same plot is flanked by four-storey apartment blocks. This dynamic relationship between urban form and window performance has significant implications for long-term planning and design strategy in Osapa, London and similar transitional neighbourhoods across Lagos. It suggests that window sizing requirements should be calibrated not only to the current urban context but to projected future density, an approach that would require a more sophisticated and forward-looking regulatory framework than currently exists in Lagos State. The interaction between window size and orientation is also highlighted by the study data. Buildings with north–south orientations, which facilitate cross-ventilation with the prevailing south-westerly winds, recorded consistently better thermal performance than east–west-oriented buildings, even when window areas were comparable. This finding reinforces the importance of integrating window sizing decisions with building orientation strategy, rather than treating them as independent design parameters.

Socioeconomic Dimensions

The study findings illuminate important socioeconomic dimensions of the window sizing problem in Osapa, London. High-density households that are most severely affected by the thermal consequences of undersized windows are also the least likely to be able to afford mechanical cooling as a substitute for passive ventilation. The inverse relationship between thermal discomfort (82% in high-density vs. 28% in low-density sub-areas) and air conditioning access (12% in high-density vs. 74% in low-density sub-areas) reveals a clear thermal inequity: those with the greatest need for passive cooling are the least able to supplement it with mechanical systems. This inequity has implications not only for residential comfort and quality of life but for public health and social justice. As Lagos' climate becomes increasingly hostile under projected climate change scenarios, with mean temperatures potentially rising by 1.5–2.5°C by 2050 (IPCC, 2021), the burden of thermal discomfort in poorly ventilated, undersized-window residential buildings will fall disproportionately on lower-income households. Addressing window sizing through regulatory and design interventions is therefore not merely a technical matter but a social equity issue with long-term consequences for the distribution of environmental benefits and burdens across Lagos' residential population.

Bridging the Gap Between Design Principles and Practice

Perhaps the most troubling finding of this study is the persistence of window under-sizing in a neighbourhood where many residents are aware of the consequences of poor ventilation. Questionnaire responses suggest that the majority of high-density residents experience significant thermal discomfort but feel unable to alter their window configurations due to security concerns, landlord resistance, or the physical constraints of the built environment. This gap between knowledge and action reflects the structural barriers that prevent climate-responsive design principles from being applied in practice, barriers that regulatory frameworks, design professionals, and planning authorities have a collective responsibility to address. The study also highlights a gap in professional practice. Many of the buildings sampled in Osapa London were designed by qualified architects or draughtspersons, yet their window configurations fall well below established climate-responsive design standards. This suggests that the problem is not simply one of ignorance but of professional culture, client pressure, and economic incentive structures that systematically de-prioritise environmental performance in favour of cost reduction and aesthetic preference.

RECOMMENDATIONS

Based on the empirical findings and analytical discussion presented in this study, the following evidence-based recommendations are proposed for improving window sizing and environmental performance in Osapa London and Lagos residential buildings more broadly.

Adopt Climate-Responsive Window Standards

Regulatory frameworks in Lagos State should incorporate mandatory minimum window-to-wall area ratios calibrated to the hot-humid climate. Based on the evidence reviewed and collected in this study, a minimum WWR of 15% is recommended for naturally ventilated residential rooms, consistent with the guidance of Toe and Kubota (2013) and aligned with the adaptive thermal comfort standards of ASHRAE Standard 55. These requirements should specify both minimum total window area and minimum operable area, to ensure that windows are not merely present but functional for natural ventilation. The Lagos State Ministry of Physical Planning and Urban Development, together with the Building Control Agency, should incorporate these standards into revised development control regulations, with clear enforcement mechanisms and penalties for non-compliance. Special provisions should be made for high-density development contexts, where higher WWR values or supplementary passive design strategies (such as wind towers or courtyard configurations) may be required to compensate for reduced access to unobstructed breezes and sky view.

Enhance Cross-Ventilation Strategies

Residential designs in Osapa, London and similar Lagos neighbourhoods should prioritise dual-aspect layouts with opposing openings on north and south façades, enabling cross-ventilation with the prevailing south-westerly winds. Planning requirements should mandate cross-ventilation provision in all new multi-family residential developments above a defined density threshold. Building orientation guidelines should be incorporated into local development plans, with north–south orientation promoted as the default for residential development where plot geometry permits. For existing buildings where cross-ventilation retrofits are not feasible, single-sided ventilation performance can be improved through the use of wind scoops, ventilation towers, and strategically positioned high-level openings that create stack effect ventilation. These passive strategies can supplement inadequate window openings without requiring structural intervention.

Integrate Shading and Security Solutions

The security-ventilation trade-off that drives many window sizing decisions in Lagos can be resolved through the use of secure louvred systems, expanded steel mesh security screens, and deep overhangs (600–900 mm) that provide shading while maintaining openable window area. These solutions can provide equivalent or superior security to traditional burglar-proof bars while preserving the ventilation and daylighting benefits of larger windows. Advocacy among building designers, developers, and the public for these integrated solutions is an important component of any strategy to improve residential environmental performance in Lagos. Adjustable external shading devices, including moveable louvres, operable awnings, and retractable screens, can further enhance the performance of larger windows by enabling occupants to manage the trade-off between daylight, ventilation, solar gain, and privacy dynamically in response to changing conditions. These devices are consistent with the principle of adaptable design and offer occupants greater control over their indoor environment.

Encourage Performance-Based Incentives

Planning authorities should develop performance-based incentive frameworks that reward residential developments demonstrating effective passive ventilation and daylight strategies. Such incentives might include density bonuses for buildings that exceed minimum WWR requirements, expedited planning approval for designs incorporating cross-ventilation and passive cooling strategies, and reduced development levies for projects that achieve measurable indoor environmental performance targets. The Lagos State Government should also consider establishing a voluntary residential environmental performance rating system analogous to the EDGE certification scheme promoted by the International Finance Corporation, which enables developers, investors, and prospective residents to make informed comparisons between buildings based on environmental performance. Such a system would create market incentives for climate-responsive design that complement regulatory requirements.

Strengthen Professional Awareness and Education

Training and continuing professional development programmes for architects, draughtspersons, and building designers in Lagos should emphasise façade permeability as a key determinant of sustainability and long-term occupant wellbeing. The Nigerian Institute of Architects (NIA) and the Council of Registered Builders of Nigeria (CORBON) should incorporate climate-responsive façade design, including window sizing principles and WWR optimisation, into their continuing education requirements. Public sensitisation campaigns targeting homeowners, tenants, and landlords should communicate the relationship between window size, indoor comfort, energy costs, and health outcomes in accessible, compelling terms. Such campaigns, delivered through social media, community organisations, and local government channels, can shift cultural norms around window sizing and create demand for better-performing residential buildings.

CONCLUSION

This study has critically examined the environmental and livability implications of inadequately proportioned windows in residential buildings in Osapa, London, Lekki, Lagos. Drawing on field measurements from 15 residential buildings, structured occupant surveys, and Pearson's correlation analysis, the research has generated robust empirical evidence of the significant negative consequences of window under-sizing in the hot-humid tropical climate of Lagos. The findings confirm that reduced window areas are strongly and significantly associated with higher indoor temperatures ($r = -0.81$, $p < 0.001$), lower daylight adequacy ($r = 0.83$, $p < 0.001$), and reduced occupant comfort satisfaction ($r = 0.78$, $p < 0.001$). Across the neighbourhood, WWR values consistently fall below the 10–15% minimum recommended for naturally ventilated tropical residential buildings, with high-density sub-areas averaging 6.2%. The mean afternoon indoor temperature of 35.4°C recorded in high-density buildings substantially exceeds the thermal comfort threshold for naturally ventilated residential spaces, posing a genuine public health concern for vulnerable occupants. At the urban scale, the study reveals that the densification of Osapa London has progressively worsened the relationship between window size and environmental performance, as increasing building heights and diminishing setbacks reduce both sky view factors and unobstructed access to prevailing breezes. The compounded effect of these urban form dynamics on the passive ventilation and daylighting performance of residential buildings underlines the urgent need for integrated planning, design, and regulatory responses that address window sizing as a systemic environmental design variable rather than an incidental aesthetic choice.

The socioeconomic dimensions of the problem are equally significant. High-density residents, who experience the most severe thermal discomfort, are also the least able to afford mechanical cooling as a substitute for adequate passive ventilation. This thermal inequity concentrated among lower-income households in the densest parts of Osapa London will worsen as climate change drives further increases in ambient temperatures. Window size and distribution must therefore be repositioned as primary environmental design variables in Lagos residential practice. Appropriate window proportioning calibrated to the climatic, social, and urban context of each development is essential for improving indoor comfort, reducing energy consumption, and ensuring that Lagos' residential built environment is genuinely livable for all its inhabitants. The evidence presented in this study provides a clear empirical mandate for regulatory reform, professional development, and public awareness initiatives that together can begin to close the gap between established climate-responsive design principles and the realities of contemporary Lagos residential construction.

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