



## RESIDENTIAL BUILDING TYPES AS ENVIRONMENTAL ENVELOPES: AN ASSESSMENT OF BIOCLIMATIC PERFORMANCE AND OCCUPANTS' PERCEPTION IN ILORIN, NIGERIA

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### ABSTRACT

This study evaluates residential building types as environmental envelopes and examines their relationship with occupants' perceptions of bioclimatic performance in Ilorin, Nigeria. Recognizing buildings as mediators between outdoor climate and indoor conditions, the research assesses how typological differences and physical characteristics influence perceived thermal comfort, ventilation, indoor air quality, humidity, daylighting and noise levels. A quantitative approach was adopted using a structured questionnaire administered across high-, medium-, and low-density residential zones within the three Local Government Areas of Ilorin metropolis. From a sample of 597 households, 484 valid responses were analyzed using descriptive statistics, Chi-square tests, and Spearman's rank-order correlation. Chi-square analysis was used to examine associations between physical building characteristics and residential density categories, while Spearman's correlation assessed relationships between building type and perceived environmental performance indicators. Findings reveal weak but statistically significant positive correlations between residential building type and perceptions of temperature, humidity, and air quality, whereas no significant relationships were observed for ventilation, daylighting, noise, or artificial lighting. The study highlights the need for occupant-centered, climate-responsive housing strategies that integrate physical design attributes with adaptive behaviours to advance sustainable residential development in tropical urban contexts.

**Keywords:** Climate Adaptation; Indoor Comfort Assessment; Occupant Behavior

### INTRODUCTION

Buildings provide shelter for humans and support various activities; however, the provision of a conducive indoor environment is of paramount importance, as it defines the quality of interior spaces. In residential buildings, where occupants spend a significant amount of their time, indoor environmental quality becomes particularly critical to health, comfort, and overall well-being. One key aspect of this environment is the thermal condition, which is strongly influenced by effective ventilation. Studies have shown that ventilation systems play a vital role in maintaining indoor air quality and achieving thermal comfort, thereby directly affecting occupants' health, productivity, and overall well-being (Sinacka, 2023; Sekartaji *et al.*, 2023; Mba *et al.*, 2023; Benachir *et al.*, 2023). Buildings act as environmental envelopes that regulate exchanges of heat, light, and air between the outdoor climate and indoor spaces. In regions with tropical climates, such as much of Nigeria, the environmental envelope is a primary determinant of indoor thermal comfort, ventilation efficiency, energy consumption, and occupant satisfaction. Contemporary research in climate-responsive architecture emphasizes the importance of integrating bioclimatic design strategies such as orientation, shading, natural ventilation, and appropriate materials to optimize indoor environmental quality while reducing dependency on mechanical cooling systems (Taing *et al.*, 2025).

In the context of tropical residential environments, thermal comfort and indoor environmental quality are shaped both by measurable environmental variables and by occupants' adaptive behaviors and perceptions. This is evident in studies conducted in similar Nigerian contexts, where ventilation, building form, and passive design features have been shown to significantly influence occupants' thermal comfort

perception, highlighting the importance of climate-responsive design in residential buildings (Haruna *et al.*, 2018). Moreover, integrating user perception into performance assessment enables more socially responsive design solutions that align with how residents experience heat, airflow, daylight, and indoor air quality in their homes.

Recent empirical work in Nigeria and similar contexts highlights the relevance of bioclimatic principles and occupant perception in residential environments. For example, research evaluating bioclimatic design performance in Nigerian settings reported positive relationships between passive strategies such as natural ventilation and daylighting and occupant satisfaction (Akadiri, 2025). Additionally, studies across West African cities indicate that passive design features and residents' adaptive behaviors significantly influence thermal comfort outcomes, even where mechanical cooling is absent or minimal.

Despite these insights, there are gaps in the integrated assessment of residential building typologies as environmental envelopes and how these physical attributes interface with occupants' perceptions in Nigerian cities. Much of the current research either focuses primarily on isolated performance indicators without typological differentiation or examines perception independently of building form. Addressing this limitation, recent climate-responsive housing research suggests that systematic, evidence-based evaluation of building morphology, environmental performance metrics, and user responses yields richer insights for sustainable design and policy interventions.

Ilorin, the capital city of Kwara State, experiences the typical hot tropical climate of the Nigerian interior, characterized by high solar radiation and seasonal temperature extremes. Yet there is limited empirical research that jointly evaluates climatic conditions, diverse residential building types, and

residents' perceptions of the built environment as conditioned by bioclimatic performance. By conceptualizing residential building types as environmental envelopes, this study assesses bioclimatic performance indicators, including thermal comfort, natural ventilation, indoor air quality, and daylighting and examines the occupants' perception of these factors across different neighborhoods in Ilorin

This integrated focus not only aligns with emerging global research on climate-adaptive residential design but also addresses specific socio-environmental challenges in Nigerian urban contexts. The findings are expected to contribute to evidence-based strategies for climate-responsive housing design, enhancing occupant wellbeing while advancing sustainable architectural practice in tropical cities.

## MATERIALS AND METHODS

This study adopted a quantitative research design utilizing a structured questionnaire to evaluate residents' perceptions of bioclimatic performance in residential buildings within Ilorin. The initial sample size was 1,193, determined using Slovin's formula ( $n = N / (1 + N (e)^2)$ ) at a 95% confidence level and 5% margin of error. After conducting a feasibility review to ensure practical field administration and efficient resource utilization, the sample size was adjusted to 597 households (see Table 1), which remained statistically adequate for robust analysis. Out of the 597 questionnaires distributed, 484 were completed and deemed valid, yielding a response rate of approximately 81%.

A stratified sampling technique was employed to ensure proportional representation across high-, medium-, and low-

density residential zones, as well as across the three Local Government Areas of the metropolis. In each selected household, the household head or an adult representative was surveyed. The questionnaire collected data on socio-demographic and occupancy characteristics, including gender, age, marital status, educational attainment, occupation, income level, tenure status, duration of residence, type of space evaluated, and household size. In addition, respondents provided assessments of bioclimatic performance indicators such as overall indoor comfort, effectiveness of natural ventilation, adequacy of daylighting, shading practices, and adaptive behaviours.

Data were analysed using descriptive and non-parametric inferential statistical methods. Frequencies, percentages, and cross-tabulations were used to summarise respondent profiles and perception trends. To examine associations between physical characteristics of residential building typologies and categorical variables, Chi-square ( $\chi^2$ ) tests were employed to determine whether significant relationships existed among building form attributes across residential density zones. Furthermore, to assess the relationships between residential density, physical building characteristics, and perceived bioclimatic performance indicators, Spearman's rank-order correlation ( $\rho$ ) was applied due to the ordinal nature of the Likert-scale variables. Statistical significance for all inferential tests was evaluated at  $p < 0.05$ . Participation in the study was voluntary, and informed consent was obtained from all respondents. Anonymity and confidentiality were strictly maintained throughout the research process.

**Table 1: Sample Size**

LGA	2023 Household Projections	Sample Size at (95%) Confidence Level	50% of the original size
Ilorin east	61,474	299	150
Ilorin south	63,342	308	154
Ilorin west	120,574	586	293
Total	245,390	1,193	597

Source :( i) National Population Commission (NPC) (2006)  
(ii) Author's Compilation (2025)

## RESULTS AND DISCUSSION

### Respondents' Demographic Profile

#### Gender of Respondents

Figure 1 indicates that the respondents consist of 253 males (52.3%) and 231 females (47.7%), reflecting an almost even gender distribution. This balanced representation helps to limit potential gender-related bias in the dataset. Gender differences can influence thermal perception, as variations in

physiological responses, metabolic rates, and thermal sensitivity may result in differences in preferred comfort conditions (Xu *et al.*, 2024; Zhao *et al.*, 2023; Zhang *et al.*, 2023). The relatively equal participation of both males and females therefore strengthens the reliability of the findings by ensuring that the results capture a diverse range of comfort experiences rather than being disproportionately influenced by one gender group.

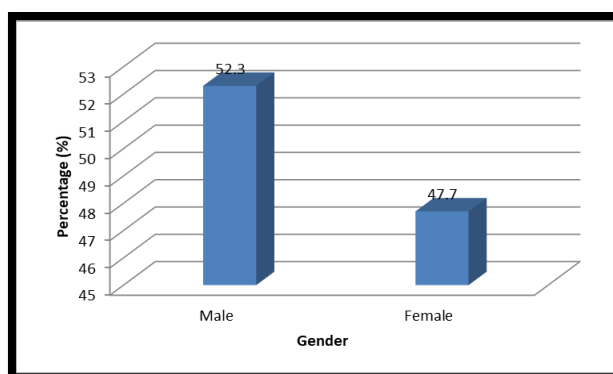


Figure 1: Gender of the Workers  
Source: Author's Field Survey, 2025

### Age of Respondents

Most respondents fall within the working-age category, with individuals aged 31–45 years forming the largest group (43.0%). This is followed by those aged 46–60 years (27.3%) and 18–30 years (20.7%), while participants aged 61 years and above account for only 9.1% of the sample. This distribution indicates that the findings largely reflect the perspectives and behavioural patterns of economically active

adults, who are typically key decision-makers regarding household energy consumption, cooling practices, and environmental adjustments (Schweiker *et al.*, 2020). However, the relatively limited representation of older adults suggests that age-related thermal sensitivities and vulnerabilities to extreme heat or cold may not be fully captured in the study Outcomes.

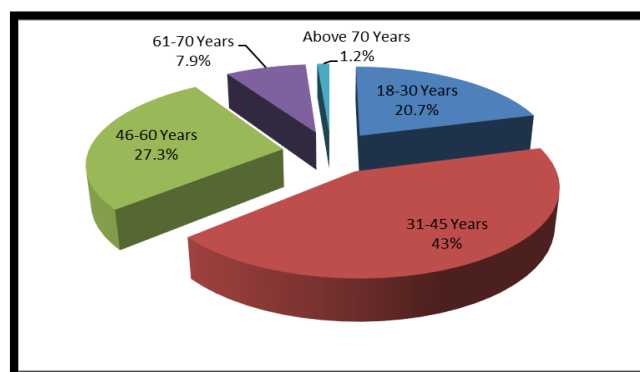


Figure 2: Age of the Respondents  
Source: Author's Field Survey, 2025

### Marital Status of Respondents

A substantial proportion of the respondents were married (63.4%), whereas single individuals make up 26.0% and divorced respondents account for 10.5%. The predominance of married participants suggests that perceptions of comfort and adaptive practices are likely influenced by household

dynamics, where decisions regarding indoor environmental conditions are often negotiated collectively among occupants (Chen *et al.*, 2023). Such household structures may shape responses concerning space utilization, occupancy behaviour, and decisions related to home modifications or environmental adjustment

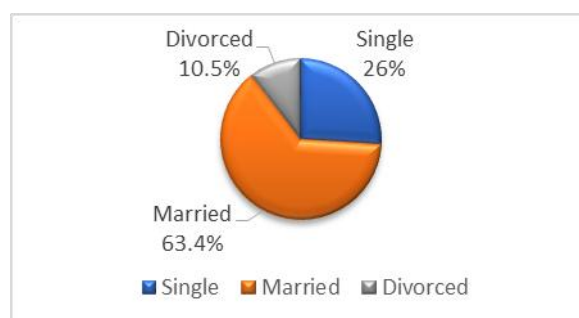


Figure 3: Age of the Respondents  
Source: Author's Field Survey, 2025

### Educational Status of Respondents

The educational background of respondents is heterogeneous, although it trends toward higher academic attainment. The largest proportion of participants have completed tertiary education (37.2%), followed by those with secondary education (22.7%), while 39.5% possess primary education or less. The relatively strong representation of tertiary-educated individuals suggests a potentially higher level of

environmental awareness and familiarity with bioclimatic principles, which may translate into more informed adaptive behaviours and more reflective survey responses (Chen *et al.*, 2020). At the same time, the substantial inclusion of respondents with lower educational attainment ensures that the study captures a broad spectrum of viewpoints and lived experiences.

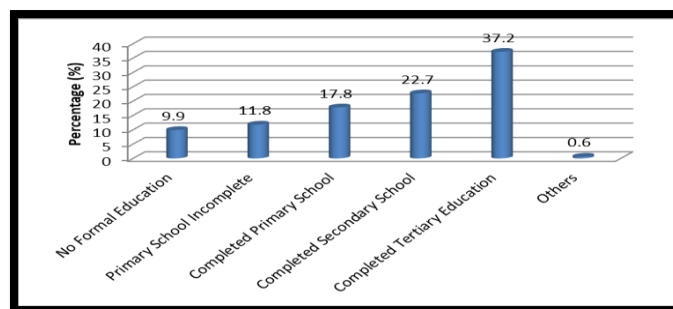


Figure 4: Educational Status of the Respondents  
Source: Author's Field Survey, 2025

### Occupation of Respondents

Respondents are predominantly engaged in stable income-generating activities: civil servants (28.3%), followed by those in trading/business (27.9%) and the self-employed (25.2%). Artisans, farmers, and students together account for 18.5%. The high representation of both formal and informal sector workers suggests that most respondents have relatively

regular income streams, which can influence their capacity to invest in cooling technologies or housing improvements. Occupation also affects daily occupancy patterns; for instance, civil servants may be away from home during peak heat periods, which can shape their perception and experience of indoor thermal conditions (Yan *et al.*, 2023).

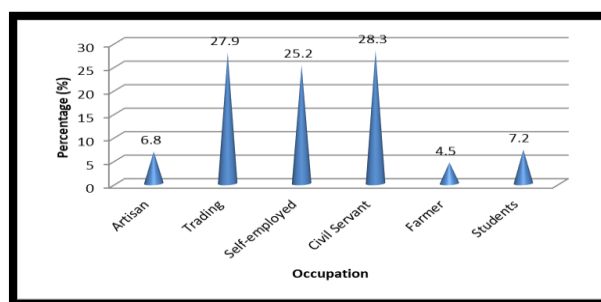


Figure 5: Occupation of the Respondents  
Source: Author's Field Survey, 2025

### Monthly Income of Respondents

Income distribution shows clustering in the middle to lower-middle ranges. The largest segment earns N70,000–N80,000 monthly (31.0%), followed by N81,000–N90,000 (26.0%). Those earning below N70,000 constitute 19.2%, while only 7.2% earn above N100,000. This income profile is critical for interpreting adaptive capacity. Financial constraints may limit

the ability of many respondents to afford air conditioning, energy-efficient appliances, or retrofits, pushing them toward behavioural adaptations (e.g., natural ventilation, clothing adjustment) as primary comfort strategies (Bednar and Reames, 2020). The predominance of middle-income households aligns with the focus on typical residential buildings in Ilorin.

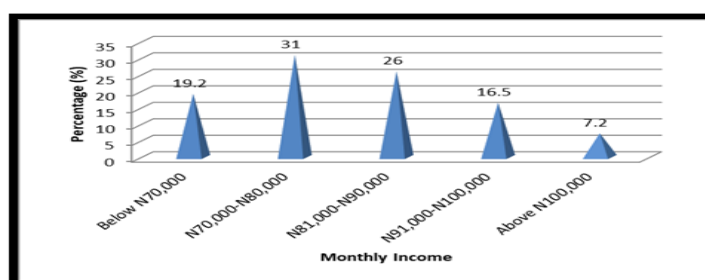


Figure 6: Income of the Respondents  
Source: Author's Field Survey, 2025

### Tenure Status of Respondents

Figure 7 shows that nearly half of the respondents live in rented accommodation (45.2%), while 28.7% reside in free housing (likely family-owned or employer-provided), and 22.3% are owner-occupiers. This tenure profile has profound implications for bioclimatic adaptation. Tenants often face a

“split-incentive” problem: they bear the discomfort and energy costs but lack the authority or motivation to make structural improvements to the building (e.g., installing external shading, improving insulation). This may explain a greater reliance on low-cost, reversible adaptive behaviours observed in earlier sections (Eichholtz *et al.*, 2018).

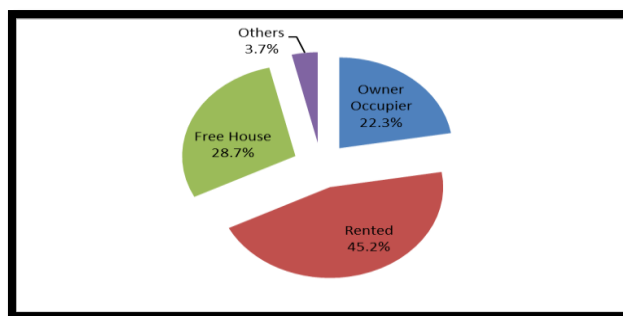


Figure 7: Tenure status of Respondents  
Source: Author's Field Survey, 2025

### Length of Stay in the House

As indicated in Figure 8, a large proportion of respondents have lived in their current home for 2–5 years (42.1%), with another 29.8% staying 6–10 years. Only 10.5% have lived there over 10 years, and 17.6% for less than 2 years. This indicates a moderately settled but not permanently rooted

population. Residents with several years of tenure have likely developed seasonal adaptation routines and are familiar with the bioclimatic quirks of their dwellings. Newer residents (under 2 years) may provide less acclimatized, and potentially more critical, assessments of indoor conditions (Luo *et al.*, 2023).

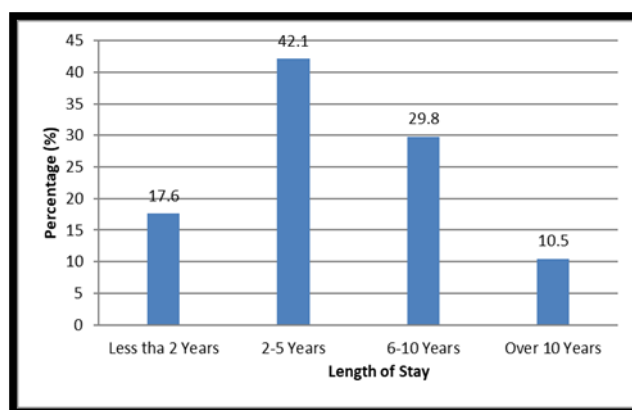


Figure 8: Length of Stay of the Residents  
Source: Author's Field Survey, 2025

### Usage of the Space

Respondents were surveyed regarding specific spaces within their homes. The largest group was surveyed in bedrooms (44.2%), followed by living rooms (39.7%), and kitchens (16.1%). This distribution is methodologically significant because thermal and lighting requirements vary by room type.

Bedrooms are critical for night-time comfort and ventilation, living rooms for daytime occupancy and social use, and kitchens for intermittent high heat and moisture loads. Findings related to comfort and behaviour must be interpreted in light of which space was being evaluated (Wang *et al.*, 2018).

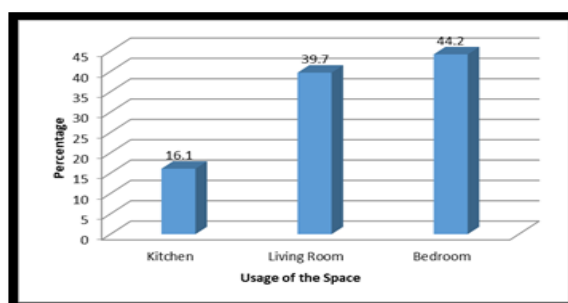


Figure 9: Residents' Usage of Space  
Source: Author's Field Survey, 2025

### Physical Characteristics and Typologies of Residential Buildings within Ilorin Metropolis

#### Building Orientation

Table 2 shows that building orientations in Ilorin Metropolis are predominantly North–South (37.4%) and Northeast–

Southwest (25.6%), while Northwest–Southeast (24.4%), East–West (11.6%), and Circular (1.0%) orientations are less common. The dominance of the North–South orientation aligns with bioclimatic principles for tropical climates, as it reduces solar heat gain on longer façades. Ilorin South

recorded the highest proportion of North–South orientation (44.0%), suggesting stronger consideration of passive design in newer developments. Conversely, Ilorin West displayed more varied orientation patterns, likely influenced by irregular plot configurations or non-climatic planning

priorities. However, the Chi-square result ( $\chi^2 = 7.904$ ,  $p = 0.443$ ) indicates no significant association between LGA and building orientation, implying that orientation decisions are more site-specific or developer-driven than administratively determined.

**Table 2: Building Orientation**

Name of Local Governments	Building Orientation					Total
	Circular	East-West	Northwest-Southeast	Northeast-Southwest	North-South	
Ilorin East F	0	17	38	36	42	133
% of R	0.0	12.8	28.6	27.1	31.6	100.0
% of C	0.0	30.4	32.2	29.0	23.2	27.5
Ilorin South F	2	12	27	34	59	134
% of R	1.5	9.0	20.1	25.4	44.0	100.0
% of C	40.0	21.4	22.9	27.4	32.6	27.7
Ilorin West F	3	27	53	54	80	217
% of R	4.4	12.4	24.4	24.9	36.9	100.0
% of C	60.0	48.2	44.9	43.5	44.2	44.8
Total F	5	56	118	124	181	484
% of R	1.0	11.6	24.4	25.6	37.4	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
( $\chi^2 = 7.904$ ,  $df = 8$ ,  $p > 0.05 = 0.443$ )

### Accommodation Type

Table 3 indicates that bungalow flats (35.5%) and compound houses (20.5%) are the dominant residential typologies in Ilorin Metropolis. Ilorin East is largely characterized by bungalow flats (47.4%), while Ilorin West shows greater diversity, including Brazilian bungalows (16.1%) and duplexes (4.1%). Ilorin South records a higher proportion of semi-detached houses (26.1%), reflecting transitional urban housing forms. The persistence of compound houses in Ilorin

West (17.1%) and Ilorin South (25.4%) suggests continued extended family living patterns that may influence spatial organization and ventilation. The Chi-square result ( $\chi^2 = 42.387$ ,  $p = 0.000$ ) confirms a significant association between LGA and accommodation type, likely shaped by socioeconomic factors, land availability, and historical urban development patterns, consistent with findings on Nigerian housing typologies (Omole *et al.*, 2022).

**Table 3: Accommodation Type**

Name of Local Governments	Accommodation Type						Total
	Compound Houses	Brazilian Bungalow	Semi-detached house	Brazilian storey	Bungalow flat	Duplex	
Ilorin East F	28	5	16	21	63	0	133
% of R	21.1	3.8	12.0	15.8	47.4	0.0	100.0
% of C	28.3	10.0	18.6	32.3	36.6	0.0	27.5
Ilorin South F	34	10	35	20	32	3	134
% of R	25.4	7.5	26.1	14.9	23.9	2.2	100.0
% of C	34.3	20.0	40.7	30.8	18.6	25.0	27.7
Ilorin West F	37	35	35	24	77	9	217
% of R	17.1	16.1	16.1	11.1	35.5	4.1	100.0
% of C	37.4	70.0	40.7	36.9	44.8	75.0	44.8
Total F	99	50	86	65	172	12	484
% of R	20.5	10.3	17.8	13.4	35.5	2.5	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
( $\chi^2 = 42.387$ ,  $df = 10$ ,  $p < 0.05 = 0.000$ )

### Building Form

Table 4 shows that compact enclosing courtyard (38.4%) and linear (21.7%) forms are the most prevalent building configurations in Ilorin Metropolis. Ilorin South demonstrates a strong dominance of compact courtyard forms (53.0%), which support microclimatic regulation through shaded spaces and enhanced cross-ventilation, consistent with vernacular tropical design principles (Nguyen *et al.*, 2021).

Ilorin West presents a more balanced distribution between compact (28.1%) and courtyard forms (33.6%), though the higher presence of broad, deep interior layouts (18.0%) may limit daylight penetration and natural ventilation. The Chi-square result ( $\chi^2 = 43.735$ ,  $p = 0.000$ ) indicates significant variation in building form across LGAs, likely shaped by cultural practices, plot configuration, and development patterns.

**Table 4: Building Form**

Name of Local Governments		Building Form				Linear	Total
		Circular	Broad with deep interior spaces	Compact	Compact enclosing courtyard		
Ilorin East	F	1	12	28	42	50	133
	% of R	0.8	9.0	21.1	31.6	37.6	100.0
	% of C	12.5	19.0	23.0	22.6	47.6	27.5
Ilorin South	F	3	12	33	71	15	134
	% of R	2.2	9.0	24.6	53.0	11.2	100.0
	% of C	37.5	19.0	27.0	38.2	14.3	27.7
Ilorin West	F	4	39	61	73	40	217
	% of R	1.8	18.0	28.1	33.6	18.4	100.0
	% of C	50.0	61.9	50.0	39.2	38.1	44.8
Total	F	8	63	122	186	105	484
	% of R	1.7	13.0	25.2	38.4	21.7	100.0
	% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column

( $\chi^2 = 43.735$ ,  $df = 8$ ,  $p < 0.05 = 0.000$ )

#### Wall Materials

Table 5 indicates that sandcrete blocks (50.8%) and mud (41.3%) are the predominant wall materials in Ilorin Metropolis. Mud is most common in Ilorin West (49.8%), offering beneficial thermal mass but requiring maintenance in humid conditions, while Ilorin East relies largely on sandcrete blocks (65.4%), which may increase indoor heat gain without

proper insulation. Brick (5.4%) and timber (1.4%) are minimally used, reflecting cost and availability constraints. The Chi-square result ( $\chi^2 = 28.605$ ,  $p = 0.000$ ) confirms that wall material choice varies significantly across LGAs, influenced by local resources, socioeconomic conditions, and construction practices, in line with findings on Nigerian urban housing (Adevuyi *et al.*, 2023).

**Table 5: Wall Materials**

Name of Local Governments	Wall Materials					Total	
	Stone	Timber	Mud	Sand crete block	Brick		
Ilorin East	F	1	2	38	87	5	133
	% of R	0.8	1.5	28.6	65.4	3.8	100.0
	% of C	20.0	28.6	19.0	35.4	19.2	27.5
Ilorin South	F	0	0	54	74	6	134
	% of R	0.0	0.0	40.3	55.2	4.5	100.0
	% of C	0.0	0.0	27.0	30.1	23.1	27.7
Ilorin West	F	4	5	108	85	15	217
	% of R	1.8	2.3	49.8	39.2	6.9	100.0
	% of C	80.0	71.4	54.0	34.6	57.7	44.8
Total	F	5	7	200	246	26	484
	% of R	1.0	1.4	41.3	50.8	5.4	100.0
	% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column

( $\chi^2 = 28.605$ ,  $df = 8$ ,  $p < 0.05 = 0.000$ )

#### Wall Colour

Table 6 shows that cool wall colours (35.5%) are most common in the study area, followed by dull (17.1%) and bright tones (16.1%). Ilorin East records a high proportion of unpainted walls (36.1%), possibly reflecting economic or maintenance constraints. Ilorin South exhibits a stronger preference for bright colours (23.1%), which can enhance solar reflectance and reduce heat absorption, serving as a

simple passive cooling strategy. Ilorin West demonstrates a relatively balanced use of cool (36.9%) and bright (21.2%) colours, suggesting both climatic and aesthetic considerations. The Chi-square result ( $\chi^2 = 88.844$ ,  $p = 0.000$ ) confirms a significant association between wall colour and LGA, likely influenced by cultural preferences, socioeconomic factors, and climate responsiveness.

**Table 6: Wall Color**

Name of Local Governments	Wall Colour					Total	
	No paint	Dark	Dull	Cool	Bright		
Ilorin East	F	48	16	22	46	1	133
	% of R	36.1	12.0	16.5	34.6	0.8	100.0
	% of C	64.0	21.1	26.5	26.7	1.3	27.5
Ilorin South	F	15	28	14	46	31	134
	% of R	11.2	20.9	10.4	34.3	23.1	100.0
	% of C	20.0	36.8	16.9	26.7	39.7	27.7
Ilorin West	F	12	32	47	80	46	217
	% of R	5.5	14.7	21.7	36.9	21.2	100.0
	% of C	16.0	42.1	56.6	46.5	59.0	44.8

Name of Local Governments	Wall Colour					Total
	No paint	Dark	Dull	Cool	Bright	
Total F	75	76	83	172	78	484
% of R	15.5	15.7	17.1	35.5	16.1	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
 $(\chi^2 = 88.844, df = 8, p < 0.05 = 0.000)$

### Wall Finishes

Table 7 indicates that cement-sand finishes (28.7%) and emulsion paint (24.2%) are the most common interior wall treatments. Ilorin East predominantly uses cement-sand finishes (39.1%), which are durable but may contribute to thermal discomfort without insulation. Ilorin South shows a marked preference for wall tiles (29.1%), which can enhance cooling through radiant heat exchange but at higher cost.

Ilorin West records greater use of gloss paint (26.3%), which improves light reflectance but has limited thermal impact. The Chi-square result ( $\chi^2 = 88.850, p = 0.000$ ) confirms a significant association between interior finishes and LGA, likely shaped by market access, income levels, and perceptions of modernity, consistent with findings in urban housing studies (Altamonte *et al.*, 2020).

**Table 7: Wall Finishes (Indoor)**

Name of Local Governments	Wall Finishes (Indoor)					Total
	Cement-sand finishes	Gloss paint	Emulsion paint	Wall paper	Wall tiles	
Ilorin East F	52	15	38	24	4	133
% of R	39.1	11.3	28.6	18.0	3.0	100.0
% of C	37.4	17.6	32.5	35.3	5.3	27.5
Ilorin South F	54	13	14	14	39	134
% of R	40.3	9.7	10.4	10.4	29.1	100.0
% of C	38.8	15.3	12.0	20.6	52.0	27.7
Ilorin West F	33	57	65	30	32	217
% of R	15.2	26.3	30.0	13.8	14.7	100.0
% of C	23.7	67.1	55.6	44.1	42.7	44.8
Total F	139	85	117	68	75	484
% of R	28.7	17.6	24.2	14.0	15.5	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
 $(\chi^2 = 88.850, df = 8, p < 0.05 = 0.000)$

### Floor Finishes

Table 8 shows that cement and screed (41.3%) and floor tiles (32.9%) are the predominant floor finishes across Ilorin Metropolis. Ilorin West demonstrates a strong preference for floor tiles (52.5%), which can improve thermal comfort through cooler surface temperatures, while Ilorin East largely depends on cement and screed (65.4%), a more affordable

option that may retain heat. The continued use of animal dung (7.6%), particularly in Ilorin East (9.8%) and Ilorin West (8.3%), reflects traditional practices with limited thermal advantage. The Chi-square result ( $\chi^2 = 113.759, p = 0.000$ ) confirms a significant association between floor finish and LGA, likely influenced by economic capacity, material availability, and cultural practices.

**Table 8: Floor Finishes**

Name of Local Governments	Floor Finishes				Total
	Animal dung	Cement & screed	Terrazzo	Floor tiles	
Ilorin East F	13	87	20	13	133
% of R	9.8	65.4	15.0	9.8	100.0
% of C	35.1	43.5	22.7	8.2	27.5
Ilorin South F	6	76	20	32	134
% of R	4.5	56.7	14.9	23.9	100.0
% of C	16.2	38.0	22.7	20.1	27.7
Ilorin West F	18	37	48	114	217
% of R	8.3	17.1	22.1	52.5	100.0
% of C	48.6	18.5	54.5	71.1	44.8
Total F	37	200	88	159	484
% of R	7.6	41.3	18.2	32.9	100.0
% of C	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
 $(\chi^2 = 113.759, df = 6, p < 0.05 = 0.000)$

### Window Location (Starting level)

Table 9 reveals that a normal 0.9 m window starting height (46.7%) is most prevalent, followed by top windows (27.5%). Ilorin East records the highest proportion of 0.9 m windows (58.6%), supporting effective cross-ventilation at occupant

level. Ilorin South shows relatively higher use of windows below 0.9 m (13.4%), which may improve low-level airflow but reduce privacy and security. Ilorin West has the highest incidence of buildings without windows (3.7%), indicating serious limitations in natural ventilation and daylighting. The

Chi-square result ( $\chi^2 = 38.730$ ,  $p = 0.000$ ) confirms a significant association between window placement and LGA, likely shaped by design practices, security considerations, and regulatory control.

**Table 9: Window Location (Starting level)**

Name of Local Governments	Window Location (Starting level)					Total
	No window	Over 0.9m	Top window	Normal 0.9m	Less than 0.9m	
Ilorin East F	0	8	45	78	2	133
% of R	0.0	6.0	33.8	58.6	1.5	100.0
% of C	0.0	12.3	33.8	34.5	3.9	27.5
Ilorin South F	1	21	39	55	18	134
% of R	0.7	15.7	29.1	41.0	13.4	100.0
% of C	11.1	32.3	29.3	24.3	35.3	27.7
Ilorin West F	8	36	49	93	31	217
% of R	3.7	16.6	22.6	42.9	14.3	100.0
% of C	88.9	55.4	36.8	41.2	60.8	44.8
Total F	9	65	133	226	51	484
% of R	1.9	13.4	27.5	46.7	10.5	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
( $\chi^2 = 38.730$ ,  $df = 8$ ,  $p < 0.05 = 0.000$ )

**Window Type**

Table 10 indicates that louvre (34.7%) and sliding (27.9%) windows are the most common types across Ilorin Metropolis. Ilorin East predominantly uses louvre windows (50.4%), which permit adjustable ventilation and suit tropical climates. Ilorin South records a higher proportion of casement windows (28.4%), offering wider openings but less directional airflow

control. Ilorin West shows a more balanced distribution, with sliding windows (40.1%) being most prevalent, likely due to convenience and contemporary preference. The Chi-square result ( $\chi^2 = 65.810$ ,  $p = 0.000$ ) confirms a significant association between window type and LGA, reflecting variations in construction practices, material access, and climatic considerations.

**Table 10: Window Type**

Name of Local Governments	Window Type					Total
	Projected	Wood shutters	Sliding	Louvre	Casement	
Ilorin East F	3	22	38	67	3	133
% of R	2.3	16.5	28.6	50.4	2.3	100.0
% of C	30.0	25.9	22.6	49.6	3.5	27.5
Ilorin South F	4	22	43	27	38	134
% of R	3.0	16.4	32.1	20.1	28.4	100.0
% of C	40.0	25.9	25.6	20.0	44.2	27.7
Ilorin West F	3	41	87	41	45	217
% of R	1.4	18.9	40.1	18.9	20.7	100.0
% of C	30.0	48.2	51.8	30.4	52.3	44.8
Total F	10	85	168	135	86	484
% of R	2.1	17.6	34.7	27.9	17.8	100.0
% of C	100.0	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
( $\chi^2 = 65.810$ ,  $df = 8$ ,  $p < 0.05 = 0.000$ )

**Window Size**

Table 11 shows that window-to-wall ratios of 40–59% (40.3%) and 60–74% (34.5%) are most prevalent in Ilorin Metropolis. Ilorin East records the highest proportion within the 40–59% range (53.4%), supporting a balance between daylight access and heat control. Ilorin South has a notable share of windows below 20% of wall area (17.2%), suggesting possible limitations in natural lighting and

ventilation. Ilorin West demonstrates a broader distribution, with substantial use of larger windows (60–74%: 36.9%), which may improve daylighting but increase solar heat gain if not shaded. The Chi-square result ( $\chi^2 = 37.892$ ,  $p = 0.000$ ) confirms a significant association between window size and LGA, likely influenced by design trends, energy awareness, and regulatory factors.

**Table 11: Window Size**

Name of Local Governments	Window Size				Total
	Less than 20% of the wall area	Between 20-30% of the wall area	Between 40-59% of the wall area	Between 60-74% of the wall area	
Ilorin East F	1	18	71	43	133
% of R	0.8	13.5	53.4	32.3	100.0
% of C	2.6	21.7	36.4	25.7	27.5
Ilorin South F	23	30	37	44	134
% of R	17.2	22.4	27.6	32.8	100.0
% of C	59.0	36.1	19.0	26.3	27.7

Name of Local Governments	Window Size				Total
	Less than 20% of the wall area	Between 20-30% of the wall area	Between 40-59% of the wall area	Between 60-74% of the wall area	
Ilorin West F	15	35	87	80	217
% of R	6.9	16.1	40.1	36.9	100.0
% of C	38.5	42.2	44.6	47.9	44.8
Total F	39	83	195	167	484
% of R	8.1	17.1	40.3	34.5	100.0
% of C	100.0	100.0	100.0	100.0	100.0

F = Frequency, % of R= Percentage of Row, % of C= Percentage of Column  
 $(\chi^2 = 37.892, df = 6, p < 0.05 = 0.000)$

The findings reveal significant spatial variation in residential building typologies and physical characteristics across Ilorin East, South, and West LGAs, as confirmed by statistically significant Chi-square results. These differences are shaped by socioeconomic conditions, cultural practices, material availability, and levels of urbanization. While some features demonstrate climate-responsive tendencies such as North-South orientation, porches, and louvre windows others reflect cost-driven or convenience-based compromises, including unprotected openings, corrugated iron roofing, and limited shading. This pattern underscores the need for context-sensitive bioclimatic design strategies that reconcile environmental performance with prevailing local realities (Abdulrahim *et al.*, 2022; Nguyen *et al.*, 2021). Subsequent sections examine how these attributes influence environmental performance and occupant comfort.

#### Relationship between Residential Building Types, and Residents' Perceptions of Bioclimatic Strategies in Ilorin Metropolis

The variable of accommodation type was used as Residential Building Types. Its types as obtained from Ilorin are: Compound Houses, Brazilian Bungalow, Semi-detached house, Brazilian Storey, Bungalow flat and Duplex.

#### Spearman Rank Correlation Analysis of the Relationship between Residential Building Types, and Residents' Perceptions of Bioclimatic Strategies

The Spearman rank correlation analysis conducted on a sample of 484 residents in Ilorin Metropolis as shown in Table 12 reveals a nuanced and largely limited relationship between residential building type and residents' perceptions of various bioclimatic strategies. Overall, the analysis indicates that while certain environmental perceptions are weakly associated with dwelling typology, the built form alone is not a strong predictor of occupant experience in this urban context.

A statistically significant but weak positive correlation was found between accommodation type and perceptions of Temperature ( $r = 0.143, p = 0.002$ ). This suggests that residents of different building types such as Compound Houses, Brazilian-style homes, or Duplexes perceive indoor thermal conditions differently. This finding aligns with recent studies in tropical regions, such as those by Ogbonna and Opoko (2023) in Southeastern Nigeria and Kumar *et al.*, (2024) in India, which highlight how building morphology,

materiality, and layout influence microclimates and subjective thermal assessments, even within the same city.

Similarly, perceptions of Humidity ( $r = 0.102, p = 0.024$ ) and Air Quality ( $r = 0.099, p = 0.030$ ) also showed weak but significant positive correlations. Recent research, including work by Adegun and Taiwo (2024) on ventilation in Nigerian residential buildings, underscores that building typology particularly the presence and design of openings, ceiling heights, and spatial organization can affect air movement and moisture retention, thereby shaping residents' sensitivity to stuffiness and humidity.

In contrast, perceptions of Thermal Comfort ( $p = 0.054$ ) and Ventilation ( $p = 0.083$ ) did not reach conventional statistical significance, though coefficients were positive. This implies that factors beyond physical building type such as adaptive behaviors, personal characteristics status, use of mechanical aids, or cultural norms may play a more decisive role. This observation resonates with contemporary socio-thermal studies, such as those by Bouzarovski and Simcock (2024), which emphasize the "energy practices" and "thermal adaptation" of households as critical mediators between building design and comfort perception.

Notably, no meaningful relationship was found between building type and perceptions of Noise Level ( $p = 0.889$ ), Daylighting ( $p = 0.961$ ), and Artificial Lighting ( $p = 0.053$ ). The lack of correlation with noise is particularly interesting, as it suggests that in Ilorin, noise infiltration may be more strongly influenced by neighborhood context, traffic patterns, or community density than by building typology alone a point supported by recent urban soundscape research in West African cities (Fadare and Ogunleye, 2023). Similarly, the non-significant result for daylighting implies that factors such as window placement, external shading, and interior color schemes which can vary even within the same building type might be more impactful than the building category itself.

In summary, the analysis indicates that in Ilorin Metropolis, residential building type exerts only a modest influence on environmental perception, with the strongest associations found for temperature, humidity, and air quality. These findings underscore the importance of moving beyond typological generalizations in bioclimatic design and toward a more occupant-centered, adaptive approach that considers behavioral, socio-economic, and locational variables a perspective increasingly advocated in recent sustainable architecture literature (Stevenson & Baborska-Narozny, 2024).

**Table 12: Spearman Rank Correlation Analysis of the Relationship between Residential Building Types, and Residents' Perceptions of Bioclimatic Strategies**

Perceptions of Bioclimatic Strategies	Accommodation Type
	Correlation Coefficient
	1.000
	Sig. (2-tailed)
	.
	N
	484
<b>Thermal Comfort</b>	Correlation Coefficient
	.088

Perceptions of Bioclimatic Strategies	Accommodation Type
	Correlation Coefficient
	Sig. (2-tailed)
	N
	Sig. (2-tailed)
	N
<b>Temperature</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Humidity</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Ventilation</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Air quality (fresh/stuffy)</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Noise level</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Daylighting</b>	Correlation Coefficient
	Sig. (2-tailed)
	N
<b>Artificial lighting</b>	Correlation Coefficient
	Sig. (2-tailed)
	N

Correlation is significant at the 0.01 level (2-tailed).

Correlation is significant at the 0.05 level (2-tailed).

## CONCLUSION

This study examined residential buildings in Ilorin as environmental envelopes and evaluated how dwelling typologies relate to residents' perceptions of indoor environmental conditions. The findings indicate that building type has only a modest influence on perceived environmental performance, with weak but statistically significant relationships observed for temperature, humidity, and indoor air quality, while no significant associations were found for ventilation, daylighting, noise, artificial lighting, or overall thermal comfort. Overall, the results suggest that physical building morphology alone does not strongly determine indoor environmental satisfaction. Instead, occupants' adaptive behaviours, socio-economic conditions, tenure status, and neighbourhood context play more decisive roles in shaping their lived indoor environmental experiences.

The predominance of rental housing further reinforces this outcome, as it limits occupants' ability to implement structural modifications, thereby increasing reliance on behavioural and short-term adaptive strategies to achieve comfort. This highlights the importance of viewing residential buildings not only as physical structures but also as socio-spatial systems where user behaviour and environmental control are closely intertwined. Consequently, an integrated, occupant-centred approach is essential for understanding and improving indoor environmental quality in tropical urban housing contexts.

The study therefore recommends that passive climate-responsive strategies such as appropriate building orientation, effective shading systems, optimized window-to-wall ratios, and suitable material selection be more strongly integrated into housing design and regulatory frameworks. In addition, policymakers should encourage affordable and flexible

retrofit interventions, particularly within rental housing stock, to improve indoor environmental performance without requiring major structural alterations. Future research should further strengthen this area by combining subjective perception surveys with objective environmental measurements, enabling a more robust and evidence-based evaluation of bioclimatic performance in residential buildings.

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