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EVALUATING THERMAL COMFORT AND VENTILATION IN PUBLIC MARKET ADMINISTRATIVE OFFICES IN ABUJA

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Abstract

Indoor environmental quality is an important determinant of comfort, health, and productivity in office buildings, particularly in tropical climates where high temperature, humidity, and inadequate ventilation are common. This study evaluates thermal comfort and ventilation in selected administrative offices within Wuye Ultra-Modern Market, Abuja, Nigeria. A field-based, multi-method case study approach was adopted using indicative environmental measurements, tissue deflection airflow testing, building observation, sun-path assessment, window-to-wall ratio analysis, and occupant questionnaires. Five offices — Administrative, Accounts, ICT, Facility, and Managing Director's — were studied. Average indoor temperatures ranged from 25.9°C to 29.3°C and relative humidity from 78.0% to 85.3%, both exceeding recommended comfort limits. Window-to-wall ratios ranged from 10.5% to 16.7%. Tissue testing confirmed cross-ventilation in the ICT, Accounts, and Facility offices through west-facing openings, while the Administrative and MD offices showed negligible airflow due to exclusively lobby-facing windows. Questionnaire results showed 46.1% of occupants felt warm, and all respondents identified the afternoon as the hottest period. The study concludes that thermal discomfort is driven by high humidity, afternoon solar heat gain, top-floor exposure, internal-facing windows, and absent cross-ventilation, and recommends reconfigured openings, external shading, roof insulation, and coordinated mixed-mode ventilation.

Keywords: Abuja, Administrative Offices, Indoor Environment Quality, Thermal Comfort, Ventilation

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1. INTRODUCTION

Indoor environmental quality (IEQ) significantly influences the comfort, health, and productivity of building occupants. In office environments, thermal comfort and ventilation are especially critical because workers remain indoors for extended periods, and poor conditions lead to fatigue, reduced concentration, and lower performance (Al Horr et al., 2016; Bawa & Ukpabia, 2025; Frontczak & Wargocki, 2011). Thermal comfort is the condition of the mind expressing satisfaction with the thermal environment (ASHRAE, 2020), influenced by air temperature, relative humidity, air movement, radiant heat, clothing, and activity level (Fanger, 1970). In tropical climates, high temperature and humidity increase heat stress and impair natural body cooling (Nicol & Humphreys, 2002).

In Nigeria, passive cooling is rarely well-integrated, and Abuja's tropical savannah climate intensifies thermal problems in buildings exposed to direct solar radiation and roof heat gain. Office buildings in this climate regularly experience discomfort from inadequate ventilation, poor envelope design, and solar heat gain (Bawa et al., 2024; Koh et al., 2018; Ogbonna & Harris, 2008). Public market buildings are designed primarily for commercial activity, yet their administrative offices require stable indoor comfort for full working-day occupancy.

This study evaluates thermal comfort and ventilation in selected administrative offices within Wuye Ultra-Modern Market, Abuja, combining environmental measurements, tissue deflection airflow testing, physical building assessment, window-to-wall ratio analysis, and occupant questionnaires. The objectives are to assess indoor temperature and humidity; evaluate air movement and ventilation performance; examine the influence of office size, Window-Wall-Ratio (WWR), and orientation; assess occupant thermal perception; benchmark against ASHRAE Standard 55; and recommend design strategies for improved comfort.

1.1 Study Area

The study was conducted at Wuye Ultra-Modern Market, Plot 1116, Idris Gidado Street, Wuye District, Abuja, Figure 1. The market is a purpose-built complex of shops, offices, corridors, and parking areas. The administrative block occupies the upper floor, exposing offices to roof heat gain and solar radiation. The building is largely brick-constructed, increasing thermal mass that stores and later releases heat into occupied spaces. The building’s longer facades run along the east and west elevations, with shorter facades on the north and south, exposing the west face to the most intense afternoon solar radiation throughout the working day.

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Figure 1: Map of Wuye Ultra-Modern Market, Abuja. Source: Google Earth Location (2026)

2. METHODS

A field-based case study design was adopted, combining indicative environmental measurements, physical building assessment, Table 1, sun-path, Figure 2, observation, window-to-wall ratio analysis, and occupant questionnaires consistent with exploratory diagnostic assessments where the objective is to identify relative differences in indoor thermal conditions rather than establish absolute psychrometric values. Indoor air temperature and relative humidity were recorded across morning, afternoon, and evening periods at approximately 1.5 m above floor level, representing the seated breathing zone, using portable digital sensing instruments supported by systematic observation. All readings are treated as indicative of relative spatial and temporal differences and interpreted alongside physical building data and occupant responses to provide a triangulated assessment.

Table 1: Description of Selected Offices

Office	Size (m)	Area (m²)	Occupants	Windows	Cooling	Key Ventilation Issue
Administrative Office	5.5×4.4	24.2	6	2	1 AC+fan	Both windows face lobby
Accounts Office	3.6×3.0	10.8	2	2	1 AC	One window faces lobby
ICT Office	2.8×5.0	14.0	2	2	1 AC	One window faces lobby
Facility Office	3.6×3.4	12.2	3	2	None	Poor ventilation
MD Office	10.0×3.6	36.0	1	2	1 AC	Limited effective

Office	Size (m)	Area (m²)	Occupants	Windows	Cooling	Key Ventilation Issue
						ventilation due to non-usage of passive ventilation

Although all offices have windows, several open onto internal corridors or the lobby rather than directly outdoors, weakening effective cross-ventilation regardless of window quantity.

Air movement was assessed through two complementary field methods: structured direct observation informed by window configuration, opening position, and occupant feedback (Ogbonna & Harris, 2008); and the tissue deflection method, a recognized qualitative technique for identifying airflow paths and cross-ventilation performance in occupied buildings (Allard & Santamouris, 1998).

A lightweight tissue strip was held at each window opening and at the room center to observe deflection direction, magnitude, and consistency, providing reliable directional airflow data at individual office resolution. Physical observation and sun-path assessment confirmed the east-west facade orientation. WWR was calculated as: WWR = (Window Area / Wall Area) × 100, with each window approximately 1.2 m× 1.2 m (1.44 m²). A structured questionnaire was administered to 13 occupants across the five offices. Data were analyzed using descriptive statistics and benchmarked against ASHRAE Standard 55.

Figure 2: Sun-Path VR App and Orientation Diagram at different times of the day. Source: Google Earth Location (2026)

3. RESULTS

3.1 Temperature and Relative Humidity

The readings of the indoor air temperature, Table 2, and relative humidity, Table 3.

Table 2: Indoor Air Temperature (°C)

Office	Morning (°C)	Afternoon (°C)	Evening (°C)	Average (°C)
ICT Office	24.7	26.4	26.7	25.9
Accounts Office	26.4	27.0	27.3	26.9
Facility Office	27.9	29.4	30.6	29.3
MD Office	26.6	27.7	30.0	28.1
Administrative Office	26.6	27.0	31.1	28.2

Table 3: Relative Humidity (%)

Office	Morning (%)	Afternoon (%)	Evening (%)	Average (%)
ICT Office	95	80	80	85.0
Accounts Office	80	80	80	80.0
Facility Office	80	77	77	78.0
MD Office	84	80	77	80.3
Administrative Office	95	84	77	85.3

The ICT office recorded the lowest average temperature (25.9°C) and the Facility office the highest (29.3°C). The Administrative office peaked at 31.1°C in the evening, indicating heat retention from poor cross-ventilation, lobby-facing windows, and thermal mass. All offices recorded average relative humidity of 78.0%- 85.3% far exceeding the recommended range with the administrative office the highest (85.3%). Elevated humidity reduces evaporative body cooling, compounding perceived warmth and explaining why all respondents identified the afternoon as the hottest period as seen in the comparison charts, Figure 3.

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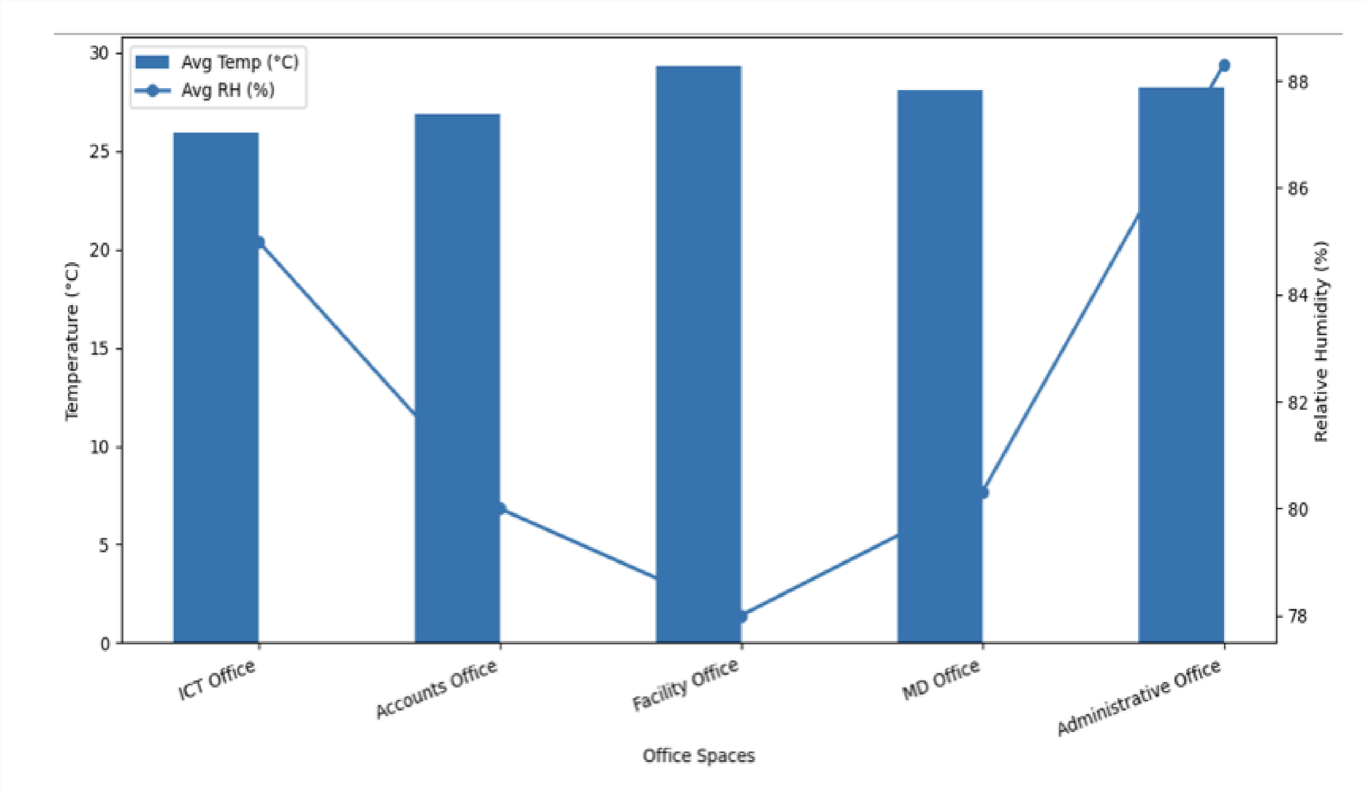

Figure 3: Temperature and Humidity Comparison Charts

3.2 Window-to-Wall Ratio, Ventilation and Airflow

The Window-to-Wall Ratio (WWR) readings, Table 4 of the building is as shown.

Table 4: Window-to-Wall Ratio

Office	WWR (%)	Interpretation
ICT Office	13.6	Moderate
Accounts Office	16.7	Moderate-high
Facility Office	13.9	Moderate
Administrative Office	10.5	Low
MD Office	14.3	Moderate

The Administrative office recorded the lowest WWR (10.5%) alongside the highest evening temperature and humidity values. Tissue deflection testing revealed distinct airflow patterns: in the ICT, Accounts, and Facility offices, tissue deflection confirmed active airflow entering through west-facade openings — the building's longer elevation — traversing the office and exiting through lobby windows, demonstrating a functional pressure differential. In the Administrative and MD offices, negligible tissue deflection at all window positions confirmed the near-total absence of effective air movement. As both offices have

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windows opening exclusively onto the internal lobby, no pressure differential exists to drive cross-ventilation. This provides direct empirical evidence that window orientation, not window quantity or size is the primary determinant of ventilation effectiveness in this building. The survey observation checklist, Table 5.

Table 5: Observation Checklist Summary

Office	Windows	Cross Vent.	Fan	AC	Overcrowded	Shading
Administrative Office	Yes	No	Yes	Yes	No	Yes
Accounts Office	Yes	Yes	No	Yes	No	No
ICT Office	Yes	Yes	No	Yes	No	No
Facility Office	Yes	Yes	No	No	No	No
MD Office	Yes	Yes	No	Yes	No	Yes

3.3 Survey Findings and ASHRAE Comparison

The survey covered the thermal sensation, cooling sources, Table 6, and ASHRAE standard 55 Compliance, Table 7.

Tables 6 & 7: Thermal Sensation, Cooling Source, and ASHRAE Standard 55 Compliance

Thermal Sensation	Freq.	%	Cooling Source	Freq.	%
Very Cold	4	30.8%	Natural ventilation	6	46.1%
Cold	1	7.7%	Combination	4	30.8%
Neutral	2	15.4%	Air conditioner	2	15.4%
Warm	6	46.1%	Fan	1	7.7%
Total	**13**	**100%**	**Total**	**13**	**100%**

Parameter	Measured Finding	ASHRAE Benchmark	Compliance
Indoor temperature	24.7–31.1°C	23–26°C (typical office)	Mostly non-compliant
Relative humidity	77–95%	Below 60% recommended	Non-compliant
Air movement	Low–moderate (observed)	Adequate movement required	Partially compliant
Thermal sensation	46.1% warm	Neutral sensation preferred	Partially non-compliant
Hottest period	100% afternoon	Stable comfort all day	Non-compliant

Forty-six percent of occupants reported feeling warm, while 30.8% reported very cold conditions reflecting localized AC overcooling in smaller offices alongside heat build-up elsewhere. Natural ventilation was the most reported cooling source (46.1%), followed by combined ventilation and AC (30.8%), indicating uncoordinated mixed-mode operation. Temperature and humidity were the primary areas of ASHRAE non-compliance: measured temperatures (24.7- 31.1°C) exceeded the 23–26°C comfort range, and humidity (77–95%) far exceeded the recommended threshold of below 60%.

4. DISCUSSION

Thermal discomfort across the five offices results from a compound interaction of temperature, humidity, solar exposure, room geometry, window orientation, and cooling method. The Facility office recorded the highest average temperature (29.3°C) from the absence of mechanical cooling, while the administrative office with the lowest WWR (10.5%) and exclusively lobby-facing windows reached 31.1°C in the evening, directly demonstrating that limited opening area and absent airflow paths drive heat retention. Humidity values of 78.0–85.3% compound discomfort by impairing sweat evaporation, consistent with comparable tropical office findings (Koh et al., 2018; Ogbonna & Harris, 2008).

The tissue deflection results provide important spatial resolution. The west facade, the building's longer elevation and most solar-stressed face simultaneously function as the primary air inlet for the three better-ventilated offices. This reveals a critical design tension: the same facade driving the highest heat gain also enables the most effective natural ventilation. External shading on the west facade would reduce solar penetration while preserving the cross-ventilation openings, simultaneously addressing both deficiencies. For the Administrative and MD offices, the tissue results confirm that window reconfiguration to provide at least one external-facing opening is the single most impactful available intervention; no increase in window size or mechanical capacity can substitute for the pressure differential that lobby-facing openings are structurally unable to provide.

The uneven thermal sensation responses 46.1% warm alongside 30.8% very cold confirm that the building operates as an unoptimized mixed-mode environment. Adaptive comfort theory suggests that occupants may tolerate slightly elevated temperatures when they control windows and fans (Nicol & Humphreys, 2002), but high humidity and restricted cross-ventilation in this building constrain such adaptation. The

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top-floor position and brick construction further amplify the problem as stored heat is released into occupied spaces during the afternoon and evening.

5. CONCLUSION AND RECOMMENDATIONS

This study evaluated thermal comfort and ventilation in five administrative offices at Wuye Ultra-Modern Market, Abuja. Indoor comfort was consistently uneven: ICT and Accounts offices performed relatively better, while the Facility, Administrative, and MD offices showed higher temperatures and greater discomfort potential. All offices recorded humidity well above comfort thresholds (78.0–85.3%). Tissue deflection testing confirmed that cross-ventilation exists in three offices through west-facade openings, while the Administrative and MD offices showed no measurable airflow due to exclusively lobby-facing windows. The primary causes of discomfort are high humidity, afternoon solar heat gain, top-floor exposure, absent cross-ventilation, lobby-facing windows, uncoordinated mixed-mode cooling, and thermal mass heat storage. The following interventions are recommended:

1. Reconfigure window orientation in the Administrative and MD offices to provide at least one opening on an external facade, establishing the pressure differential required for cross-ventilation.
2. Install external shading devices (vertical fins, overhangs, or screens) on the west facade to reduce afternoon solar gain while preserving ventilation openings.
3. Increase operable window area in offices with low WWR, particularly the administrative office.
4. Introduce roof insulation or reflective roof coating to reduce top-floor heat gain.
5. Adopt a coordinated mixed-mode cooling strategy using windows, fans, and AC together to eliminate localized overcooling and overheating simultaneously.
6. Conduct periodic indoor temperature and humidity monitoring, particularly in the Administrative and Facility offices.
7. IEQ parameters such as illuminance, noise, CO_2, particulate matter, and VOCs fell outside the scope of this investigation, despite their recognized relevance to occupant health and comfort (World Health Organization, 2018). Future studies should employ extended seasonal monitoring, and broader multi-building samples to enable quantitative comfort modelling and statistical generalization.

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