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RESEARCH ARTICLE

The Passive Cooling Strategies in the Architectural Design of Retail Hubs in Osogbo, Nigeria

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Abstract
Retail hubs are increasingly complex, extending beyond retail sales to serve as urban development centres offering shopping, entertainment, leisure, and recreation. In Nigeria, many hubs rely solely on mechanical cooling systems, which significantly increase operational costs related to purchase, installation, and maintenance. This study aimed to explore the use of passive cooling techniques in retail hub design. Twenty candidate sites were identified through random sampling, from which thirteen (13) were validated for analysis (N = 13). Data were collected using a structured observation checklist aligned with the variables for each objective and analysed using the Statistical Package for the Social Sciences (SPSS). A descriptive survey method was applied to determine the percentages of variables related to retail hub architecture and the cooling strategies employed. Findings revealed that Nigerian retail hubs predominantly rely on active cooling systems, with mechanical cooling used in 76.9% of sampled hubs, while only 23.1% combined mechanical and passive strategies. Features such as lakes, pools, and fountains were present in only 7.7% of sampled hubs, and 76.9% lacked evaporative cooling provisions entirely. These results highlight the limited adoption of passive cooling strategies in Nigerian retail hub design. The study concludes that integrating passive cooling into retail hub architecture significantly improves thermal comfort and energy performance while reducing dependence on mechanical systems. It recommends that retail hub designs incorporate passive cooling strategies through proper building orientation, adequate landscaping and green elements, effective shading devices, and thermally efficient building materials.

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1.0 INTRODUCTION

Retail hubs encompassing shopping malls, commercial plazas, and large-format markets are focal points of urban economic activity in tropical developing countries. They attract high volumes of users, operate for extended periods, and generate substantial thermal loads owing to occupant density, lighting, and equipment heat gain. In hot-humid climates, mechanical air-conditioning systems dominate as the primary thermal comfort strategy, contributing significantly to operational energy costs and greenhouse gas emissions (IEA, 2023). With rising energy prices and growing awareness of environmental sustainability, passive cooling, the design of buildings to minimise heat gain and maximise natural cooling without active energy input, has emerged as a critical strategy for reducing energy consumption while maintaining occupant comfort (Niles & Kenneth, 1980; Ford, 2001).

In Nigeria, this challenge is especially acute. Unreliable municipal electricity supply makes the operational costs of fully mechanical HVAC systems financially unsustainable for retail hub operators, while rapid urban growth continues to increase commercial cooling demand. Osogbo, the capital city of Osun State, exemplifies this condition: the city has experienced significant urban expansion over the past two decades, driven by its administrative status, cultural tourism significance, and growing commercial activity (World Bank, 2021; UN-Habitat, 2022). This growth has increased demand for modern retail facilities; however, existing and emerging retail hubs in Osogbo largely follow conventional design models that are poorly adapted to the city's hot-humid tropical climate. Consequently, these facilities depend excessively on mechanical cooling, incurring high energy costs and contributing to localised urban heat island effects (PwC Nigeria, 2023).

Despite the recognized potential of passive cooling, its application within retail hub architecture remains relatively underexplored in academic literature and professional practice. Much existing research has focused on residential or institutional buildings, with limited investigation into large commercial spaces where occupant density, varied thermal loads, and spatial complexity present distinct design challenges (Al-Sallal & Judd, 2002). The interplay between architectural form, urban microclimate, and passive cooling performance in retail settings is poorly understood, particularly in emerging economies where resource constraints and rapid urban growth make efficient design solutions essential. In the Nigerian context specifically, there is a shortage of empirical, field-based studies that document how and to what extent passive cooling strategies are currently integrated into retail hub design. This study addresses that gap.

This study aims to evaluate architectural design considerations for integrating passive cooling strategies into retail hubs in Osogbo, Nigeria, by addressing four specific objectives. First, it examines the design characteristics of existing retail hubs in Nigeria, and second, it assesses the cooling strategies currently employed within these sampled facilities. Third, the research evaluates the architectural design considerations used for passive cooling in retail hub design, ultimately aiming to develop evidence-based recommendations for climatically responsive and energy-efficient retail hubs in Osogbo.

This study makes an empirical contribution to the sustainable architecture discourse in sub-Saharan Africa by providing a documented baseline of passive cooling provision and its absence in Nigerian retail buildings. Its findings have direct practical implications for architects, developers, facility managers, and planning authorities responsible for commercial building design in the hot-humid tropical zone of Southwest Nigeria. By demonstrating the scale of the passive cooling deficit and linking it to specific architectural design variables, the study provides an evidence base for improving design practice, informing building regulations, and reducing the energy intensity of retail hub operations across the region.

2.0 LITERATURE REVIEW

2.1 Concept and Development of Retail Hubs

A retail hub is defined as a planned and managed collection of retail outlets, service facilities, and ancillary amenities within a shared built environment, developed under unified management to serve a defined catchment population (ICSC, 2008). The typology has evolved from early open-air trading spaces to the contemporary enclosed, climate-controlled megastructure, reflecting shifts in urbanisation patterns, consumer behaviour, and commercial investment priorities (Coleman, 2006). The modern enclosed shopping mall emerged in the United States during the post-World War II period, driven by suburbanisation and automobile culture. The Southdale Center in Edina, Minnesota (1956) is widely regarded as the first fully enclosed, mechanically cooled mall, establishing the prototype that spread globally through the latter half of the 20th century (Gerend, 2012; Johnson, 2010). In Nigeria, the modern retail hub typology emerged with the opening of the Palm Shopping Mall in Lagos in 2005, the country's first purpose-built enclosed mall, followed by rapid sector expansion across Abuja, Ibadan, Port Harcourt, Enugu, and other major urban centres (PwC Nigeria, 2023). Most Nigerian retail hubs adopt enclosed, fully mechanised configurations originally designed for temperate climates, representing a significant design mismatch with the hot-humid tropical conditions of cities such as Osogbo.

2.2 Classification of Retail Hubs

The International Council of Shopping Centers (ICSC, 2008) classifies retail hubs into general-purpose and specialised-purpose categories based on gross leasable area (GLA) and commercial function.

2.2.1 General-Purpose Centres

Five subtypes are defined. The super-regional centre (GLA > 800,000 sq. ft. / 74,000 m²) is anchored by three or more department stores and serves a broad regional catchment. The regional centre (GLA: 400,000–800,000 sq. ft.) offers a wide merchandise mix, typically in an enclosed format with perimeter parking (Agarwal, 2021). The community centre (GLA: 125,000–400,000 sq. ft.) is a mid-scale format laid out in strip, L-shape, or U-shape configurations. The neighbourhood centre (GLA: 30,000–125,000 sq. ft.) primarily serves daily convenience needs, anchored by a supermarket or pharmacy. The strip/convenience centre (GLA < 30,000 sq. ft.) is the smallest typology, an open-air row of retailers with frontage parking (ICSC, 2008).

2.2.2 Specialised-Purpose Centres

Specialised centres are defined by a dominant commercial function. The power centre (GLA: 250,000–600,000 sq. ft.) is anchored by category-dominant retailers such as wholesale clubs and discount stores. The lifestyle centre (GLA: 150,000–500,000 sq. ft.) features upscale specialty retail alongside outdoor food and entertainment. The factory outlet centre (GLA: 50,000–400,000 sq. ft.) sells branded merchandise at a discount. The theme or entertainment centre (GLA: 80,000–250,000 sq. ft.) integrates retail with experiential leisure attractions, often within architecturally distinctive structures (Gerend, 2012; ICSC, 2008).

2.2.3 European Size Classification

The European Council of Shopping Places classifies retail centres by size into four typologies: very large (GLA > 80,000 m²), large (GLA: 40,000–79,999 m²), medium (GLA: 20,000–39,999 m²), and small (GLA: 5,000–19,999 m²), applicable to both enclosed and open-air configurations (Beatrice, 2014).

2.3 Thermal Comfort Challenges in Tropical Retail Environments

The thermal performance of retail buildings in hot-humid tropical climates is a critical determinant of occupant comfort, energy consumption, and commercial viability. Osogbo falls within the Köppen Aw climate classification (tropical savanna), characterised by mean annual temperatures of 26–32°C and relative humidity of 60–90% year-round (Manshour & Lehmann, 2026). These conditions generate substantial cooling loads in enclosed commercial buildings, particularly where solar heat gained through glazed façades and impermeable roof surfaces is unmitigated.

Thermal comfort in retail spaces is assessed using the Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) indices, standardised in ASHRAE 55 and ISO 7730 (ASHRAE, 2004). Achieving neutral PMV values (−0.5 to +0.5) in hot-humid tropical climates requires either mechanical cooling or carefully integrated passive design. Recent empirical studies in comparable tropical commercial contexts demonstrate that well-calibrated passive cooling strategies can reduce indoor operative temperatures by 3–6°C and decrease mechanical cooling energy loads by 20–40% (Suhendri *et al*., 2020; Malaysian Construction Research Journal, 2017). The urban heat island (UHI) effect further intensifies these challenges: rapid urbanisation in Nigerian cities raises ambient temperatures in commercial districts by 2–3°C above surrounding rural baselines (Bulbaai & Halman, 2021), compounding the cooling demands placed on retail buildings and reducing the efficacy of natural ventilation.

A growing body of contemporary research confirms that the integration of passive cooling measures into commercial building design in sub-Saharan Africa and comparable developing-country tropical contexts is both technically feasible and economically justified, yet remains systematically underimplemented in practice (Abdullahi *et al*., 2024; Ali *et al*., 2023; Manshour & Lehmann, 2026). This implementation gap is particularly pronounced in Nigeria, where no mandatory passive design standards exist for commercial buildings and where the rapid growth of the retail sector has prioritised speed of delivery over climate-responsive design quality.

2.4 Passive Cooling Strategies in Retail Architecture

Passive cooling encompasses architectural design strategies that reduce internal heat gain and facilitate heat dissipation without active mechanical energy input (Niles & Kenneth, 1980; Ford, 2001). In retail buildings, passive cooling must address a distinct set of challenges compared to residential or institutional contexts: high occupant density, extended operating hours, diverse and unevenly distributed thermal load zones (food courts, cinema halls, anchor stores), and large, often column-free floor plates that limit natural airflow paths (Leo Samuel *et al*., 2013). The following sub-sections review the principal passive cooling strategies relevant to the design of retail hubs in hot-humid tropical climates.

2.4.1 Building Orientation

Building orientation is the positioning of a structure relative to the seasonal sun path and prevailing wind patterns. In hot-humid tropical climates, orienting the major building axis east–west minimises solar exposure on the longer north and south façades, which receive lower sun angles and are more amenable to shading (Chris, 2013). This principle is especially significant at Osogbo's latitude of approximately 7.8°N, where east and west façades are exposed to intense low-angle morning and afternoon radiation for most of the year. Studies in comparable hot-humid West African commercial building contexts confirm that correct orientation reduces cooling loads by 10–15% compared to sub-optimal configurations and substantially improves the potential for wind-driven cross-ventilation (Ali *et al*., 2023).

2.4.2 Natural Ventilation

Natural ventilation exploits wind-driven and buoyancy-driven (stack effect) airflow to remove heat from occupied spaces without mechanical energy. In retail buildings, stack ventilation is facilitated by atria, high-volume spaces, and operable roof vents that allow warm air to rise and exhaust while drawing cooler air in at lower levels (Kamal, 2012). Robertson (2009) identifies wind towers, double façades, and central atria as particularly effective natural ventilation elements in large commercial typologies. Contemporary computational fluid dynamics (CFD) studies confirm that naturally ventilated atria in tropical retail buildings can achieve air change rates of 5–15 ACH under moderate wind conditions, significantly reducing peak internal temperatures without mechanical assistance (Manshour & Lehmann, 2026).

2.4.3 Solar Shading

External solar shading is the most impactful single passive cooling measure available to retail building designers in tropical climates. Direct solar radiation through unshaded glazing constitutes the dominant heat gain pathway in enclosed retail buildings, with measured values of 200–400 W/m² reported for east- and west-facing unshaded glass in Nigerian commercial buildings (Abdullahi *et al*., 2024). Effective external shading devices, such as horizontal brise-soleil, vertical fins, deep overhangs, and perforated screens calibrated to local solar geometry, can reduce façade solar heat gain by 40–60% (Freewan, 2019). Internal shading (blinds, fritted glazing) alone is substantially less effective, as solar energy has already entered the building envelope before being intercepted. Shading design must be differentiated by façade orientation: south-facing façades are most effectively shaded by horizontal overhangs, while east- and west-facing façades require vertical fins or combined devices.

2.4.4 Evaporative Cooling and Water Features

Evaporative cooling harnesses the latent heat of water vaporisation to reduce ambient air temperature, providing passive thermal relief without electrical energy input. In retail environments, water features such as courtyard fountains, reflecting pools, water walls, and planted water gardens generate measurable microclimatic cooling of 1–3°C within their immediate vicinity (Hatamipour & Abedi, 2008). More recent studies confirm similar cooling magnitudes in enclosed and semi-enclosed retail atria equipped with water features in tropical climates (Malaysian Construction Research Journal, 2017). Despite this documented performance, evaporative features are largely absent from Nigerian retail hub design, as confirmed by the present study's field observations.

2.4.5 Vegetation and Landscaping

Strategic landscaping reduces solar heat gain at the building envelope, lowers surface temperatures in adjacent paved areas, and attenuates the urban heat island effect at the site scale. Canopy trees positioned within 15 metres of a building reduce envelop surface temperatures by up to 8°C through combined shading and evapotranspiration (Freewan, 2019). Recent systematic reviews confirm that vegetation-integrated commercial building sites in hot-humid climates achieve measurably lower ambient temperatures and reduce HVAC energy consumption compared to fully paved equivalents (Manshour & Lehmann, 2026). Green walls and planted rooftops provide supplementary thermal insulation while contributing to biodiversity and urban stormwater management.

2.4.6 Thermal Mass and Building Envelope

Thermal mass refers to the capacity of building materials to absorb, store, and release heat, attenuating diurnal temperature fluctuations in occupied spaces (Lechner, 2014). High-thermal-mass construction using concrete, brick, or stone reduces peak internal temperatures and is most effective when combined with night-time ventilation to purge stored heat before the following day's cooling cycle. Building envelope performance is further improved through insulated wall systems, thermally broken low-emissivity glazing, and high-reflectance external finishes that minimise solar absorptance (Springer, 2014). Abdullahi *et al*. (2024) demonstrate that envelope upgrades in Nigerian commercial buildings, including wall insulation and reflective roofing, can reduce annual cooling energy consumption by 15–25% relative to standard construction practice.

3.0 RESEARCH METHODOLOGY

This section describes the research design, data sources, population, sampling procedure, data collection instruments, and analytical methods employed in this study. The chapter is structured to provide sufficient methodological transparency for the study to be replicated by future researchers in comparable tropical commercial building contexts.

3.1 Research Design

This study adopted a descriptive survey research design. The descriptive approach was selected because it enables systematic documentation and analysis of existing conditions, in this case, the passive cooling characteristics of retail hubs without manipulation of variables (Veal, 2006). A case study strategy was employed as the operative method of inquiry, consistent with established practice in architectural and built environment research (Oluigbo, 2010). Data collection combined direct field observation with cross-referencing of available architectural layouts and facility management records, providing a dual layer of empirical verification for each sampled hub.

3.2 Data Types and Sources

Both primary and secondary data were collected to address the study's objectives.

3.2.1 Primary Data

Primary data were collected directly by the researcher through structured field observation. A purpose-designed observation checklist was administered at each sampled retail hub to record variables relating to design characteristics, cooling systems, passive cooling elements, and site microclimate features. Observations were accompanied by photographic documentation of key architectural features, including façade conditions, shading provisions, landscaping, and ventilation elements to support the qualitative interpretation of checklist findings.

3.2.2 Secondary Data

Secondary data was sourced from peer-reviewed journal articles, institutional reports, architectural drawings, and facility management documentation where accessible. Secondary sources were used to establish the theoretical framework for passive cooling design (reviewed in Chapter 2), to contextualise field findings within the broader literature, and to supplement site-specific data where direct observation was limited.

3.3 Population of Study

The target population for this study comprised all formal retail hubs in Nigeria, defined as purpose-built, managed commercial facilities with a gross leasable area of 5,000 m² or greater, inclusive of shopping malls, commercial plazas, and large-format retail centres. Two international retail hubs were additionally included as design benchmarking comparators to provide a reference frame for best-practice passive cooling integration.

3.4 Sampling Method and Sample Size Determination

Simple random sampling was used to identify an initial pool of twenty (20) candidate retail hubs from geographically distributed locations across Nigeria, supplemented by two international comparator sites. In simple random sampling, every member of the population has an equal and independent probability of selection, ensuring that the resulting sample is free from deliberate bias (Veal, 2006). Of the twenty (20) candidate sites initially identified, seven (7) were subsequently excluded from quantitative analysis for the following documented reasons: three sites refused observation access through their facility management;

two sites had undergone recent major renovation that rendered their passive cooling configurations non-representative of standard Nigerian retail practice; and two sites could not provide sufficient architectural documentation for cross-referencing with checklist data. These exclusions are recorded in Table 1.
The final validated analytical sample, therefore, comprised thirteen (13) retail hubs (N = 13). All descriptive statistics and percentage figures reported in Chapter 4 are computed exclusively on this validated sample of N = 13. This resolution reconciles the initial candidate poll of 20 with the analytical sample of 13 used throughout the results section.

Table 1. Sample size and location

S/N	**Sample size**	**Location**	Included in Analysis	Reason if excluded
1	Ikeja City Mall	Alausa, Ikeja, Lagos	✓	—
2	Novare Lekki Mall	Sangotedo, Lekki-Epe Expressway, Lagos State	✓	—
3	Lagos City Mall	Catholic Mission Street, Lagos Island, Lagos State.	✓	—
4	Jabi Lake Mall	Jabi, Abuja.	✓	—
5	Next Cash & Carry Mall	Jahi District, Abuja.	✓	—
6	Novare Gateway Mall	Lugbe, Airport Road, Abuja.	✓	—
7	The Palms Mall	Abuja, Jabi. Abuja	✓	—
8	Banex Plaza	Wuse II, Abuja.	✓	—
9	Sky Memorial Complex	Wuse zone 5, Abuja.	✓	—
10	Novare Apo Mall,	Apo District, Abuja.	✓	—
11	Palms Shopping Mall, Ibadan	Ring Road, New GRA, Ibadan, Oyo State.	✓	—
12	Akure Mall	Alagbaka, Akure, Ondo State.	✓	—
13	Tinapa Shopping Mall	Calabar, Cross River State, Nigeria	✓	—
14	Market Square Mall	Peter Odili Road, Port Harcourt, Rivers State.	✗	Facility management refused observation access
15	Polo Park Mall	GRA, Enugu, Enugu State.	✗	Facility management refused observation access
16	Palms Shopping Mall	Ilorin, Ilorin, Kwara State	✗	Insufficient architectural documentation
17	Kaduna Shopping Mall,	Independence Way, Kaduna, Kaduna State.	✗	Insufficient architectural documentation
18	Delta Mall	Osubi, near Warri, Delta State.	✗	Facility management refused observation access
19	Canal walk	Century city, Cape town, South Africa.	✗	Recent major renovation; non-representative
20	City mall	Kota, Rajasthan, India	✗	Recent major renovation; non-representative

Source: Author compilation/field survey (2026)

3.5 Data Collection Instrument: Observation Checklist

The primary data collection instrument was a structured observation checklist developed by the researcher from a synthesis of passive cooling and retail design literature. The checklist was organised into four thematic sections aligned directly with the study's four objectives. To enable replication of this methodology in other tropical commercial building contexts, the full checklist parameters, physical indicators, and categorical metrics are tabularised below.

Table 2. Observation Checklist — Section A: Retail Hub Design Characteristics (Objective 1)

Variable	Variable	Categorical Metric
Number of anchor stores	Count of large-format anchor retail units	1 / 2 / 3 / 4 / 5 or more
Number of department stores	Count of individual retail tenants	< 50 / 50–100 / > 100
Car park capacity	Estimated or documented number of spaces	< 300 / 300–600 / 601–900 / > 900
Number of entrances	Count of primary public entry/exit points	1 / 2 / 3 / > 3
Cinema screens	Count of operational screen units	None / 1–2 / 3–4 / 5–6 / 7+
Multipurpose hall	Presence of a dedicated event/function space	Present / Absent
Grocery stores	Count of grocery anchor units	1 / 2 / > 2
Games arcade	Count of dedicated games/entertainment zones	None / 1 / 2 / 3+
Vertical mechanical circulation	Count of escalator, elevator, and travellator systems	0 / 1 / 2 / 3 / 4+
Number of floors	Count of occupied above-ground floor levels	1 / 2 / 3 / 4+

Source: field survey (2026)

Table 3. Observation Checklist — Section B: Cooling Strategies in Use (Objective 2)

Variable	Physical Indicator Observed	Categorical Metric
Primary cooling system type	Type of installed cooling technology observed	Active HVAC only / Passive only / Combined active and passive
HVAC system visibility	External condensing units, ducts, and diffusers are visible	Present / Absent
Evaporative cooling systems	Presence of misting systems, water walls, evaporative pads	Present / Absent
Natural ventilation provisions	Observable operable vents, louvres, or stack outlets	Present / Absent
Fan-assisted ventilation	Ceiling fans or destratification fans present	Present / Absent

Source: field survey (2026)

Table 4. Observation Checklist — Section C: Passive Cooling Architectural Elements (Objective 3)

Variable	Physical Indicator Observed	Categorical Metric
Building orientation	Direction of major building axis relative to north	North–south / East–west / Oblique
Glazing-to-wall ratio	Estimated proportion of glazing on primary façades	< 30% / 30–60% / > 60%
External shading devices	Presence and type of brise-soleil, fins, overhangs, screens	None / Partial / Comprehensive
Internal shading only	Blinds or curtains as sole shading provision	Present / Absent
Wall insulation	An observable insulated wall system or cavity construction	Present / Absent / Unknown
Roof type and finish	Roof material and surface reflectance quality	Flat uninsulated / Flat insulated / Pitched / Green roof

Variable	Physical Indicator Observed	Categorical Metric
Courtyard provision	Presence of an internal open courtyard or atrium	Present / Absent
Water bodies/features	Lakes, pools, fountains, and water walls are present on site	Present / Absent
Stack ventilation provisions	Atria, high-level vents, or ventilation towers observable	Present / Absent

Source: field survey (2026)

Table 5. Observation Checklist — Section D: Site Microclimate and Landscaping (Objective 3)

Variable	Physical Indicator Observed	Categorical Metric
Tree canopy coverage	Estimated proportion of site area shaded by mature trees	None (0%) / Low (1–15%) / Moderate (16–30%) / High (> 30%)
Proximity of trees to the building	Distance of nearest canopy tree from building envelope	> 15 m / 5–15 m / < 5 m
Green walls or planted surfaces	Presence of vertical or horizontal planted envelope elements	Present / Absent
Proportion of paved surface	Estimated proportion of the site covered by impervious paving	< 40% / 40–70% / > 70%
Surface material type	Dominant ground surface material around the building	Concrete / Asphalt / Paving block / Planted / Mixed

Source: field survey (2026)

3.6 Data Collection Procedure

Field observations were conducted by the researcher between 10:00 and 16:00 hours local time at each sampled hub to capture peak solar radiation conditions representative of maximum passive cooling demand. For each hub, the observation checklist was completed in full during a minimum of a two-hour site visit. Observable features were recorded against the categorical metrics in Tables 2–5. Where architectural floor plans or site layout drawings were accessible through facility management or publicly available sources, these were cross-referenced with checklist observations to verify building orientation, floor plate configuration, and shading device coverage.

3.7 Method of Data Analysis

All checklist data were entered into IBM SPSS Statistics (Version 26) and analysed using descriptive statistics, specifically frequency counts and percentages. Results are presented using summary tables, bar charts, and pie charts. Qualitative observational notes recorded during field visits are discussed narratively in support of quantitative findings. No inferential statistical tests were applied, consistent with the descriptive research design. The analysis is organised in Chapter 4 according to the four study objectives, with all percentage figures computed on the validated analytical sample of N = 13.

4.0 RESULTS AND DISCUSSION

This section presents and critically discusses the results of the observation checklist analysis, organised according to the study's four objectives. All percentage figures are computed on the validated analytical sample of N = 13. Results are discussed in relation to relevant tropical passive cooling and retail design literature to provide the analytical depth and comparative context required for a scholarly contribution. Where applicable, published empirical benchmarks are cited to contextualise the significance of observed passive cooling deficits and to quantify their implications for thermal performance and energy consumption.

4.1 Objective 1: Examination of Retail Hub Design Characteristics

The first objective examined the physical and spatial design characteristics of the sampled retail hubs, establishing a baseline profile of the Nigerian retail hub building stock against which passive cooling provisions are assessed in subsequent sections.

4.1.1 Number of Anchor Stores

Anchor stores are large-format retail units, typically department stores, hypermarkets, or cinemas that serve as primary footfall generators, drawing customers through the hub and sustaining pedestrian circulation past smaller tenants. The number of anchor stores is therefore a key determinant of both commercial performance and thermal load intensity within a retail hub. As presented in Figure 1, 38.5% of sampled hubs contained one anchor store, 30.8% had two, 15.4% had three, 7.7% had four, and 7.7% had five anchor stores. This distribution is consistent with the ICSC typological benchmarks for regional and community centre formats, which predominate in the Nigerian retail sector (ICSC, 2008; Agarwal, 2021). The finding confirms that larger hubs accommodate a greater number of anchor tenants, as expected from the relationship between GLA and commercial catchment size.

From a passive cooling perspective, this finding is significant: anchor stores generate disproportionately high internal heat loads compared to standard retail tenants, owing to their larger floor plates, higher occupant densities, and greater equipment and lighting power densities. A hub with five anchor stores will generate substantially higher peak cooling loads than a hub with one. Suhendri *et al*. (2020) note that anchor zones in tropical retail buildings can contribute up to 40% of total building cooling load despite occupying a proportionally smaller share of GLA. This underscores the importance of designing passive cooling strategies, particularly natural ventilation pathways and shading systems that specifically address the thermal zones surrounding anchor store entrances and adjacent circulation concourses.

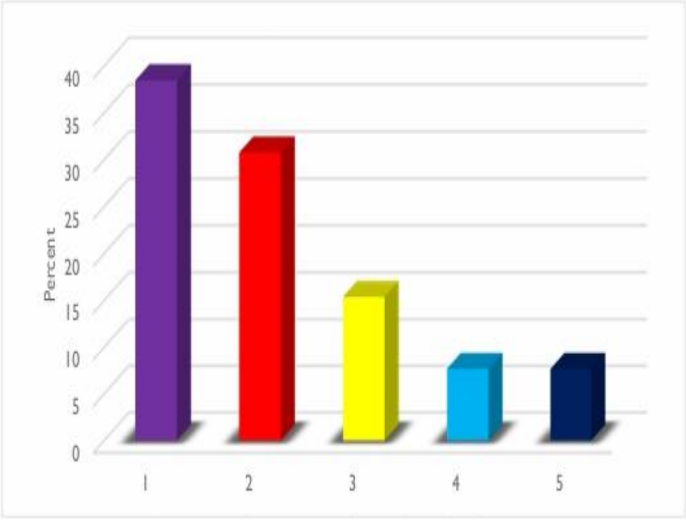

Figure 1. Distribution of anchor stores across sampled retail hubs

Source: field survey (2026)

4.1.2 Number of Department Stores

The number of department stores provides an indicator of retail hub capacity and commercial diversity. Results showed that 11% of sampled hubs had fewer than 50 department stores, 78% had between 50 and 100 stores, and 11% had more than 100 stores (Figure 2).

The predominance of mid-range store counts (50–100) reflects the regional shopping centre format that characterises most of the Nigerian sample. This finding is consistent with PwC Nigeria's (2023) retail sector analysis, which identifies the regional centre as the dominant commercial typology in the Nigerian formal retail sector. From a passive cooling standpoint, hubs with higher tenant counts generate greater cumulative internal heat loads from lighting, electronic point-of-sale equipment, refrigerated display units, and occupancy. In a 78-tenant hub operating at a typical retail lighting power density of 15–25 W/m² (ASHRAE, 2004), internal gains from lighting alone can add 3–5°C to indoor operative temperatures in the absence of effective heat dissipation strategies. Natural ventilation provisions such as atria, stack vents, and cross-ventilation openings are therefore proportionally more impactful in hubs with higher tenant densities.

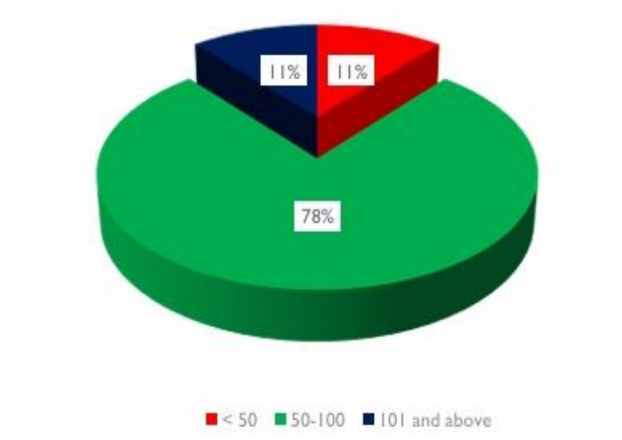

Figure 2. Distribution of department store counts across sampled retail hubs

Source: field survey (2026)

4.1.3 Parking Space Capacity

Car park capacity reflects both the scale of individual hubs and the spatial organisation of their sites. As shown in Table 1, 15.4% of sampled hubs had fewer than 300 car park spaces, 15.4% had 300–600, 23.1% had 601–900, and 15.4% had more than 900 spaces. Data were unavailable for the remaining 30.8% of hubs.

Beyond its functional significance, parking provision has a direct bearing on site microclimate and, by extension, on the ambient conditions available to passive cooling systems. The extensive impervious paved surfaces associated with large surface car parks — characteristic of most sampled hubs — are a well-documented contributor to the urban heat island (UHI) effect. Manshour and Lehmann (2026) report that unshaded asphalt parking surfaces in tropical climates can reach surface temperatures of 55–65°C under peak solar irradiance, raising ambient air temperatures in adjacent zones by 3–5°C above the general urban baseline. This elevated ambient temperature directly reduces the cooling potential of natural ventilation systems, which rely on a meaningful temperature differential between indoor and outdoor air. The predominance of large, unshaded car parks across the Nigerian sample therefore represents a passive cooling penalty at the site scale that compounds the building-level deficits identified in Sections 4.3 and 4.4.

Table 6. Parking Space Capacity of Sampled Retail Hubs

Parking Capacity	Frequency	Percent (%)
< 300 spaces	2	15.4
300–600 spaces	2	15.4
601–900 spaces	3	23.1
> 900 spaces	2	15.4
Data unavailable	4	30.8
Total	**13**	**100.**

Source: field survey (2026)

4.1.4 Number of Entrances

Entrance provision determines pedestrian accessibility, emergency egress capacity, and, critically for passive cooling, the extent to which controlled air infiltration and natural ventilation can be integrated into the building threshold design. As shown in Table 2, 76.9% of sampled hubs had two entrances, 15.4% had three, and 7.7% had one.

The dominance of two-entrance configurations indicates a general shortfall against best-practice recommendations, which advocate for a minimum of three clearly separated entrance/exit points in retail hubs of this scale to meet emergency egress standards and to distribute pedestrian loads (Coleman, 2006). From a passive cooling perspective, entrance design presents both a challenge and an opportunity. Frequent door operation creates significant air infiltration, disrupting pressurization and potentially undermining naturally ventilated zones near the building perimeter. However, strategically designed entrance lobbies incorporating vestibules, wind baffles, or planted buffer zones can attenuate solar heat gain at thresholds while creating transitional thermal zones that reduce the abruptness of the indoor–outdoor temperature differential. The near-total absence of such transitional entrance design features in the sampled hubs represents a missed passive cooling opportunity, particularly given that entrance lobbies in tropical retail buildings are among the highest solar-exposure zones in the building.

Table 7. Number of Entrances in Sampled Retail Hubs

No. of Entrances	Frequency	Percent (%)
1	**1**	**7.7**
2	**10**	**76.9**
3	**2**	**15.4**
Total	**13**	**100**

Source: field survey (2026)

4.1.5 Cinema Screens

Cinema provision is a significant footfall driver and thermal load generator in Nigerian retail hubs. Results showed that 39% of sampled hubs had 1–2 cinema screens, 23% had 3–4, 15% had 5–6, and 8% had seven or more (Figure 3).

Multiplex cinema zones present a distinct passive cooling challenge: projector equipment generates substantial radiant heat (a single digital cinema projector generates approximately 3–5 kW of waste heat), while high occupant densities during screenings produce significant metabolic heat loads of approximately 80–120 W per person (ASHRAE, 2004). These characteristics make cinema zones among the most thermally intensive spaces in a retail hub. While mechanical cooling remains the primary strategy for cinema auditoriums due to acoustic and humidity control requirements, the circulation zones, foyers, food and beverage areas surrounding cinema complexes present significant opportunities for passive cooling through stack ventilation, shaded glazing, and evaporative features. None of the sampled hubs demonstrated evidence of passive cooling integration specifically targeting cinema zone perimeter areas.

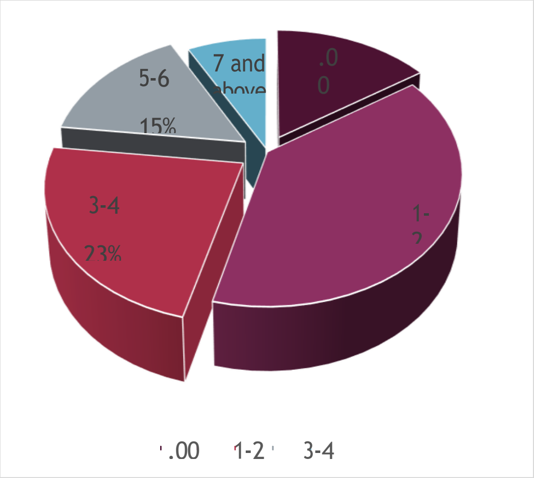

Figure 3. Distribution of cinema screens across sampled retail hubs

Source: field survey (2026)

4.1.6 Multipurpose Halls

Twelve of the 13 sampled hubs (92.3%) did not incorporate multipurpose halls. Only one hub contained such a facility (Figure 4). This finding indicates that multipurpose halls are not currently a standard design component of Nigerian retail hubs at the present stage of sector development, though their inclusion is recommended from a commercial diversification and community engagement perspective (Agarwal, 2021). From a passive cooling standpoint, multipurpose halls represent intermittently occupied high-volume spaces that offer substantial passive cooling potential. High ceilings facilitate stack ventilation; large floor plates can accommodate thermal mass strategies; and flexible use patterns mean these spaces can be cooled passively during periods of lower occupancy. Their near-universal absence from the Nigerian sample limits the potential for volume-based passive cooling strategies in existing retail hubs.

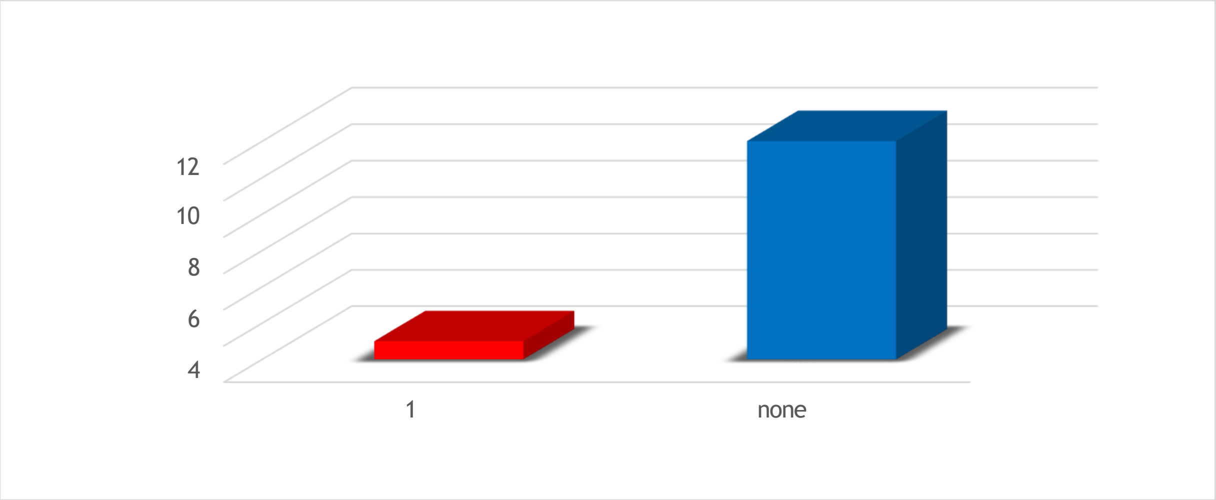

Figure 4. Multipurpose hall provision in sampled retail hubs

Source: Field survey (2026

4.1.7 Grocery Stores

Table 3 shows that 84.6% of the sampled had one grocery store, while 15.4% had two. The single grocery store was predominantly occupied by ShopRite during the study period, reflecting the franchise's dominant market position in the Nigerian formal retail sector.

Grocery stores are thermally significant hub zones due to the concentrated heat output of refrigerated display cabinets, cold storage plant rooms, and continuous high-intensity lighting. A standard supermarket refrigeration system generates condenser heat loads of 150–300 W/m² of sales floor area (IEA, 2023), the majority of which is rejected into the surrounding building if condenser units are located internally. This makes grocery zones a priority target for passive cooling integration, particularly through enhanced natural ventilation of service corridors and roof-level condenser areas, yet no sample hub demonstrated evidence of passive design measures specifically addressing grocery store thermal management.

Table 8. Number of Grocery Stores in Sampled Retail Hubs

No. of Grocery Stores	Frequency	Percent (%)
1	11	84.6
2	2	15.4
Total	13	100

Source: field survey (2026

4.1.8 Games Arcades

Fifty-five percent of sampled hubs had one dedicated games arcade space, 7% had three, and the remainder had none (Figure 5). Games arcades generate high equipment heat loads from electronic gaming machines, combined with the metabolic heat of active occupants, particularly children, resulting in thermal load densities comparable to computer server rooms in the most intensively equipped zones.

Despite this thermal intensity, games arcades in the sampled hubs were uniformly served by centralised mechanical HVAC without any supplementary passive cooling provision. The zoning of games arcades within retail hub layouts, typically in interior positions without access to external walls or roof surfaces, limits the applicability of natural ventilation strategies. However, thermal zoning design, which segregates high-load zones from lower-load retail corridors using buffer spaces, could reduce the mechanical cooling demand in adjacent areas. This design principle, documented in tropical commercial building energy studies (Leo Samuel *et al*., 2013), was not evident in any of the sampled hubs.

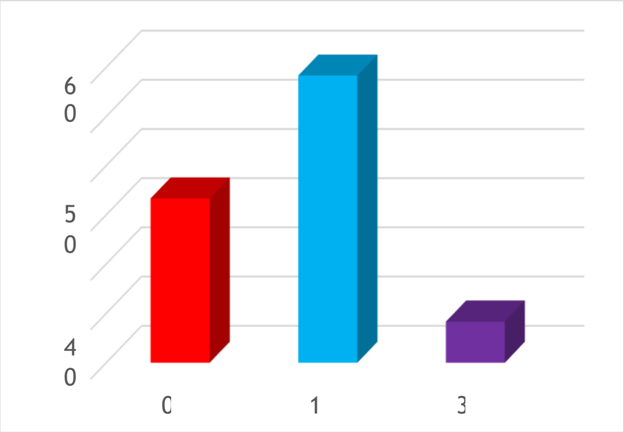

Figure 5. Games arcade provision in sampled retail hubs
Source: field survey (2026

4.1.9 Mechanical Vertical Circulation

As shown in Table 4, 38.5% of sampled hubs had no mechanical vertical circulation, 15.4% each had one, two, or three systems, and 7.7% had four systems. Figure 6 confirms a positive relationship between the number of occupied floors and the number of mechanical circulation systems provided, as expected from operational requirements.

The number of vertical mechanical circulation systems is relevant to passive cooling in two respects. First, escalator and elevator motor rooms are significant internal heat sources, generating heat loads that must be managed through ventilation. In hubs where these rooms are poorly ventilated, waste heat migrates to adjacent occupied spaces, increasing cooling loads. Second, multi-storey retail hubs offer greater potential for stack effect ventilation: the vertical height differential between lower-level intake openings and upper-level exhaust points generate buoyancy-driven airflow that can provide meaningful passive cooling in circulation zones and atria. Kamal (2012) documents stack ventilation air change rates of 5–8 ACH in tropical retail atria of 15–20 m height, sufficient to maintain acceptable thermal comfort conditions in circulation zones without mechanical assistance. This potential is unrealised in the sampled hubs, none of which incorporated observable stack ventilation provisions despite several having two or more occupied floors.

Table 9. Vertical Mechanical Circulation in Sampled Retail Hubs

No. of Systems	Frequency	Percent (%)
0	5	38.5
1	2	15.4
2	2	15.4
3	2	15.4
4	1	7.7
Total	12	92.3

Source: field survey (2026

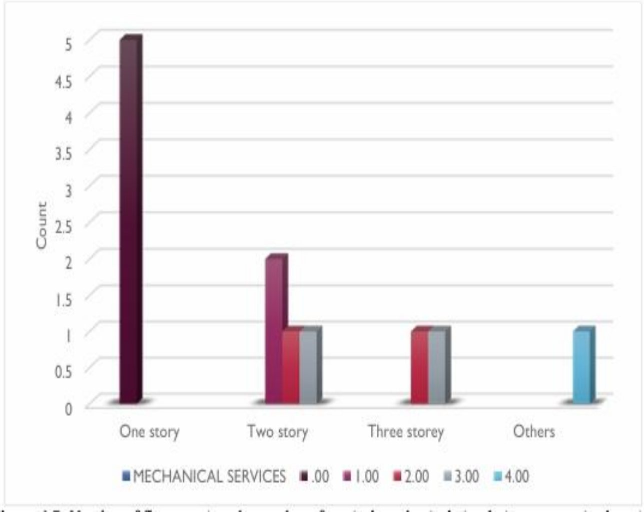

Figure 6. Relationship between number of floors and vertical mechanical circulation systems (N = 13
Source: field survey (2026

4.2 Objective 2: Assessment of Cooling Strategies in Sampled Retail Hubs

The second objective assessed the cooling strategies currently employed across the sampled retail hubs, distinguishing between active mechanical, passive, and combined approaches.

Results showed that 10 of the 13 sampled hubs (76.9%) relied exclusively on active mechanical HVAC systems, while 3 hubs (23.1%) employed a combination of mechanical and passive strategies. No hub in the sample relied solely on passive cooling.

This finding reveals a pronounced systemic bias toward fully mechanised cooling in Nigerian retail architecture. It is consistent with the broader pattern documented in sub-Saharan African commercial building research: Bulbaai and Halman (2021) report that over 80% of commercial buildings in comparable tropical West African urban centres rely exclusively on centralised mechanical cooling, attributing this to the widespread adoption of imported building design prototypes, the absence of passive design mandates in national building codes, and limited client and architect awareness of passive cooling performance in large commercial formats.

The implications for energy consumption are substantial. IEA (2023) estimates that mechanical space cooling in commercial buildings in tropical developing countries accounts for 40–60% of total building energy use. In the Nigerian context, where grid electricity supply is unreliable and expensive, this dependency translates directly into high operating costs and frequent service disruption during power outages. Hubs that combine passive and mechanical strategies, the 23.1% minority in this sample are better positioned to maintain baseline thermal comfort during power interruptions, demonstrating a practical operational resilience advantage in addition to the energy cost reduction benefits documented in the passive cooling literature (Manshour & Lehmann, 2026).

The complete absence of purely passive cooling solutions across the sample is unsurprising given the scale and occupancy characteristics of the building typology; however, the near-universal absence of even partial passive integration in 76.9% of hubs indicates a significant missed opportunity. Studies in comparable tropical commercial contexts, including Malaysian shopping centres (Malaysian Construction Research Journal, 2017) and commercial buildings in hot-humid Gulf states (UAE Study, 2014) demonstrate that hybrid passive-mechanical approaches consistently achieve 20–40% reductions in mechanical cooling energy consumption relative to fully active baselines, without compromising occupant thermal comfort.

4.3 Objective 3: Evaluation of Passive Cooling Architectural Elements

The third objective evaluated the extent to which specific passive cooling architectural features were incorporated into the sampled retail hubs, assessed against the adequacy thresholds established in the climatic evaluation framework (Section 3.6.2).

4.3.1 Water Bodies and Evaporative Cooling Features

Only 1 of 13 sampled hubs (7.7%) incorporated a macro water feature specifically, a reflecting pool as a passive cooling element. The remaining 12 hubs (92.3%) contained no evaporative feature of this type. Furthermore, 76.9% of sampled hubs (10 of 13) lacked any form of evaporative cooling provision, including smaller-scale features such as water walls, planted water gardens, or misting systems.

This near-total absence of evaporative cooling is particularly notable given the well-documented thermal performance of water features in hot-humid tropical retail environments. Hatamipour and Abedi (2008) measured ambient temperature reductions of 2–4°C in building courtyards equipped with fountains under hot-humid conditions comparable to Osogbo's climate. More recent studies confirm that retail atria with integrated water features in tropical Southeast Asian shopping centres achieve indoor operative temperature reductions of 1.5–3°C compared to equivalent atria without water features, reducing mechanical cooling demand by an estimated 10–15% in affected zones (Malaysian Construction Research Journal, 2017). The capital cost of incorporating a modest courtyard fountain or water wall is marginal relative to total retail hub construction cost, making this one of the most cost-effective passive cooling interventions available. The near-zero adoption rate in Nigeria, therefore, reflects a design awareness gap rather than a technical or economic constraint.

4.3.2 Building Orientation

Visual assessment and plan cross-referencing indicated that most sampled retail hubs positioned their largest glazed façades along the east and west elevations, the orientations most vulnerable to low-angle solar radiation in tropical climates. At Osogbo's latitude of 7.8°N, east- and west-facing glazed façades are exposed to direct solar radiation at angles of 10–35° above horizontal during morning and afternoon peak hours, making external shading of these façades particularly difficult without deep overhangs or vertical fins (Chris, 2013).

This sub-optimal orientation is typical of Nigerian retail hub design practice, in which commercial visibility from major roads and signage exposure take precedence over solar heat gain performance in site layout decisions. Ali *et al*. (2023), in a study of commercial buildings in a comparable hot-humid West African context, found that incorrectly oriented commercial buildings consumed 12–18% more cooling energy annually than equivalent east–west-oriented counterparts. Extrapolating this benchmark to the Nigerian retail sample, the sub-optimal orientation observed across most sampled hubs may be generating an avoidable annual cooling energy penalty of this magnitude, a significant operational cost burden that could be substantially reduced through orientation-informed master planning and site layout design.

4.3.3 Shading and Building Envelope

Ten of 13 sampled hubs (76.9%) featured large unshaded glazed façades as a dominant architectural element. Only 3 hubs (23.1%) incorporated external shading devices, and none of these achieved comprehensive shading coverage defined as external shading present on 60% or more of solar-exposed glazed area across all solar-critical elevations.

The thermal performance implications of this finding are quantitatively significant. Abdullahi *et al*. (2024) document solar heat gain values of 200–400 W/m² through unshaded clear glazing in Nigerian commercial buildings during peak solar hours. For a retail hub with a total glazed façade area of 2,000 m² a conservative estimate for a mid-scale regional centre this represents a peak solar heat gain of 400,000–800,000 W (400–800 kW) entering the building envelope in the absence of external shading. Freewan (2019) demonstrates that correctly calibrated external brise-soleil can reduce façade solar heat gain by 40–60%, representing a potential reduction of 160–480 kW in peak cooling load from shading alone, equivalent to the output of 50–150 standard 3 kW split-system air-conditioning units. These figures illustrate that the shading deficit observed across 76.9% of the Nigerian sample is not merely an aesthetic shortcoming but a quantifiable and addressable source of building energy inefficiency. Wall insulation was absent or unverifiable in most sampled facilities. The predominance of single-skin concrete block or glass curtain wall construction without cavity insulation or thermal brake systems allows direct conduction of solar-absorbed heat into occupied spaces, further increasing cooling loads beyond the contribution of direct solar radiation through glazing.

4.3.4 Vegetation and Landscaping

Only 4 of 13 sampled hubs (30.8%) incorporated meaningful tree canopy coverage within or immediately surrounding their sites. The majority were surrounded predominantly by extensive exposed paved car parking areas with negligible vegetation. No sample hub met the minimum 30% canopy coverage adequacy threshold within 15 metres of the building envelope established in the climatic evaluation framework (Section 3.6.2). This finding has compounding passive cooling implications at both the site microclimate and building scales. At the site scale, unshaded impervious surfaces surrounding retail hubs create a localised heat island effect that raises ambient air temperature by 3–5°C above the urban baseline (Manshour & Lehmann, 2026), degrading the quality of outdoor air available to natural ventilation systems. At the building scale, the absence of canopy shading on perimeter walls and roof surfaces allows direct solar absorption, raising enveloped surface temperatures and increasing conductive heat gain into the building. Freewan (2019) reports that mature canopy trees within 15 metres of a building reduce envelope surface temperatures by up to 8°C through combined shading and evapotranspiration, a passive cooling contribution that requires no operational energy and delivers compounding benefits over the building's lifetime as trees mature. The near-universal absence of strategic landscaping across the Nigerian retail sample therefore represents both a significant thermal performance deficit and a low-cost remediation opportunity.

4.4 Objective 4: Architectural Design Recommendations for Passive Cooling Integration

The fourth objective synthesises the findings of the preceding sections into evidence-based architectural design recommendations for passive cooling integration in retail hub design in Osogbo. These recommendations are grounded in the specific deficits identified through field observation (Sections 4.2 and 4.3) and supported by quantitative performance benchmarks from the tropical passive cooling literature.

4.4.1 Building Orientation

Retail hub sites in Osogbo should be planned with the major building axis-oriented east–west (within 15° of true east–west alignment), minimizing solar exposure on the longer north and south façades and aligning primary ventilation openings with the prevailing south-westerly trade winds. Where road frontage constraints make full east–west alignment impractical, oblique orientations should incorporate compensatory shading systems specifically designed for the resulting solar exposure profile. This single measure has the documented potential to reduce annual mechanical cooling energy consumption by 10–15% relative to sub-optimal configurations (Ali *et al*., 2023).

4.4.2 External Shading Systems

External shading devices should be provided on all solar-exposed glazed façades, achieving a minimum coverage of 60% of glazed areas on east, west, and south elevations. Device type should be calibrated to façade orientation: horizontal brise-soleil at 0.5–0.8 m projection depth for south-facing façades; vertical fins at 300–600 mm spacing for east- and west-facing façades; and combined horizontal-vertical egg-crate systems for oblique-facing façades. At Osogbo's latitude of 7.8°N, south-facing horizontal overhangs with a projection-to-window-height ratio of 0.5–0.7 provide adequate shading during peak solar hours while admitting diffuse daylight. Implementation of adequate external shading has the potential to reduce peak solar heat gain through affected façades by 40–60%, equivalent to removing 160–480 kW of peak cooling load in a mid-scale retail hub (Freewan, 2019; Abdullahi *et al*., 2024).

4.4.3 Natural Ventilation and Stack Effect Design

Retail hub designs in Osogbo should incorporate central atria or courtyard configurations with operable high-level vents to facilitate stack effect ventilation in general circulation areas, food courts, and entrance lobbies. Atrium heights of 12–20 metres generate sufficient buoyancy-driven pressure differentials to achieve 5–10 air changes per hour in adjacent circulation zones under typical Osogbo wind conditions (Kamal, 2012). Wind towers or Venturi-effect roof ventilators should be considered for anchor store service corridors and cinema foyers, where mechanical ventilation currently operates at full capacity throughout operating hours. Even partial natural ventilation of these high-load zones, reducing mechanical ventilation run hours by 30–40%, would generate measurable energy savings and reduce the frequency of comfort failures during grid power interruptions.

4.4.4 Courtyard Integration and Water Features

Retail hub layouts should incorporate at a minimum one open courtyard of 200–400 m² area, positioned to intercept prevailing south-westerly airflow and channel cooled air into adjacent occupied zones. Courtyards should be equipped with reflecting pools or fountain features of at minimum 20 m² water surface area, capable of delivering 1–3°C of ambient air temperature reduction in adjacent spaces through evaporative cooling (Hatamipour & Abedi, 2008). Water features in entrance courtyards additionally provide the transitional thermal buffer between the hot outdoor environment and the cooled interior that is currently absent from the entrance design of all sampled hubs.

4.4.5 Landscaping Standards

A minimum of 30% tree canopy coverage should be achieved within 15 metres of all building elevations, using species with high canopy density and drought tolerance appropriate to the Southwest Nigerian climate, such as Terminalia mantaly, Ficus benjamina, or Azadirachta indica (neem). Structured tree planting in car parking areas, using reinforced grass or permeable paving systems, would simultaneously reduce surface temperatures, improve stormwater infiltration, and lower the ambient air temperature available to natural ventilation intakes by an estimated 3–5°C compared to fully paved equivalents (Manshour & Lehmann, 2026).

4.4.6 Building Envelope Performance

All retail hub envelopes in Osogbo should incorporate: (i) insulated external wall systems with a minimum U-value of 0.45 W/m²K; (ii) low-emissivity double-glazing with a maximum solar heat gain coefficient (SHGC) of 0.25 on east- and west-facing elevations; and (iii) high-reflectance roof finishes with a minimum solar reflectance index (SRI) of 78. Abdullahi *et al*. (2024) demonstrate that envelope upgrades of this specification in Nigerian commercial buildings reduce annual cooling energy consumption by 15–25% relative to standard single-skin construction, with payback periods of 4–7 years at current Nigerian commercial electricity tariff rates.

5.0 Conclusion and Recommendation

This study investigated passive cooling strategies in the architectural design of retail hubs in Osogbo, Nigeria. Thirteen retail hubs (N = 13) were assessed through structured field observation, revealing a systemic deficit in passive cooling integration across the Nigerian retail building stock. Key findings confirmed that 76.9% of sampled hubs rely exclusively on active mechanical HVAC systems. Water bodies and evaporative cooling features were present in only 7.7% of hubs; external shading systems were absent or inadequate in 76.9%; building orientation was sub-optimal in most sampled facilities; and meaningful tree canopy coverage was recorded in only 30.8% of sites. These deficits are particularly consequential in Osogbo's hot-humid tropical climate, where unmitigated solar heat gain, elevated ambient temperatures, and humidity generate substantial cooling loads that are currently addressed almost entirely through energy-intensive mechanical means. Published evidence confirms that integrated passive cooling strategies can reduce mechanical cooling energy consumption by 20–40% in comparable tropical commercial buildings without compromising occupant thermal comfort. Given Nigeria's chronic electricity supply challenges and rising energy costs, passive cooling integration represents both an environmentally and commercially rational design priority.

The study recommends that retail hub designs in Osogbo incorporate optimal building orientation, comprehensive external shading systems, courtyard configurations with water features, strategic landscaping meeting minimum 30% canopy coverage, and thermally efficient building envelopes. Planning authorities should mandate passive cooling assessments for all commercial developments above 5,000 m² GFA, and the National Building Code should be amended to include minimum passive design performance requirements for commercial buildings in Nigeria's hot-humid climate zones.

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