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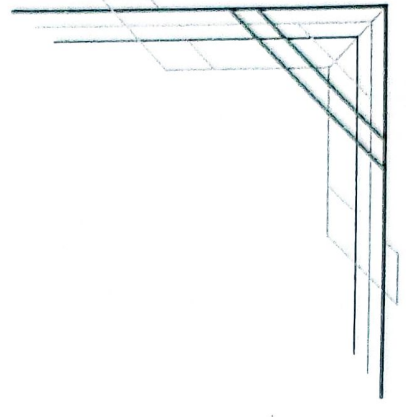
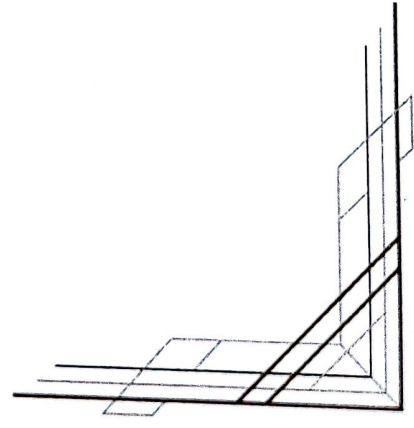


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*Passive Cooling and Indigenous Identity: Towards a Climate-Responsive Recreational Centre for Ilorin, Kwara State,
Nigeria*

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PASSIVE COOLING AND INDIGENOUS IDENTITY: TOWARDS A CLIMATE-RESPONSIVE RECREATIONAL CENTRE FOR ILORIN, KWARA STATE, NIGERIA

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Abstract

Buildings account for nearly 40 percent of global energy consumption, with mechanical cooling among the fastest-growing contributors across sub-Saharan Africa's rapidly urbanising cities. In Nigeria's Guinea savanna zone, public recreational facilities remain insufficient and heavily reliant on-air conditioning despite passive design strategies embedded in indigenous architecture. This paper proposes a climate-responsive recreational centre at the Adeta Baseball Court, Ilorin, Kwara State, achieving year-round thermal comfort through passive design. A mixed-method approach combined quantitative psychrometric analysis of ten-year NIMET data (2016–2026) processed through Climate Consultant 6.0 with qualitative review of Ilorin's Yoruba-Islamic built heritage and six case studies in comparable tropical climates. Findings identify six indigenous passive strategies — courtyard compound organisation, laterite thermal mass walls, deep eave overhangs, ode-ile transitional veranda, Islamic geometric brise-soleil screens, and indigenous canopy tree planting — collectively addressing Ilorin's dual-season thermal challenge without mechanical cooling dependency. The study recommends broader passive-first design adoption for public buildings across Nigeria's Guinea savanna zone.

Keywords: climate-responsive design, indigenous architecture, passive cooling, Ilorin, Yoruba-Islamic heritage, Ilorin.

1. INTRODUCTION

Despite the success of passive climatic techniques in indigenous design, air conditioning is becoming more and more necessary in Nigeria's modern public buildings (Ruqayya and Idil, 2025). This reliance results in high operating costs, carbon emissions, and susceptibility to Nigeria's erratic electricity supply in the Guinea savanna zone (Emusa, 2025). Kwara State's capital, Ilorin, is a prime example of this paradox: despite having a rich Yoruba-Islamic architectural legacy that includes perforated geometric screens, laterite walls, and inward-facing courtyards, it lacks a public recreational or cultural facility that would serve its population of over 1.2 million people (Abdulraheem et al., 2022). The annual Durbar festival — the city's most significant public cultural event, held in honour of the Emir during Eid celebrations — currently has no permanent architectural setting (Owoseni, 2023). A dual thermal challenge of

hot-dry harmattan and warm-humid monsoon is defined by NIMET data (2016–2026), which shows mean maximum temperatures exceeding 36°C, solar radiation peaking at 6.9 kWh/m²/day, and seasonal humidity varying from 12 to 91 percent (NIMET, 2026). This climatic reality is largely ignored in modern structures, which raises energy expenditures and carbon emissions (Alabi *et al.*, 2025). The lack of a climate-responsive recreational facility in Ilorin, the dearth of evidence-based passive design guidelines for public buildings in the Guinea savanna (Mukiga and Venter, 2025) and the paucity of research incorporating Ilorin's indigenous architectural knowledge into modern institutional design are the three concurrent gaps that this paper attempts to fill.

2. LITERATURE REVIEW

2.1 Theoretical Framework

Through passive design like orientation, natural ventilation, thermal mass, solar shading, and landscape, climate-responsive architecture combines building design with regional climate conditions to promote thermal comfort (Michael *et al.*, 2026). Passive methods immediately address energy consumption and carbon emissions in tropical areas by reducing heat gain and removing the need for mechanical cooling (Ruqayya and Idil, 2025). Through material selection, ornamental vocabulary, and spatial organisation, architecture simultaneously serves as a cultural expression that conveys communal values (Owoseni, 2023). Drawing on frameworks of critical regionalism, reflexive modernism, and heritage-informed design, successful climate-responsive design in culturally relevant places necessitates treating both goals as mutually reinforcing (Rashdan and Ashour, 2024). As a direct reaction to the environment of the tropical savanna, indigenous Yoruba-Islamic architecture in Ilorin evolved over centuries of empirical refinement, integrating climatic performance into traditional building practices (Adeoye *et al.*, 2024).

2.2 Ilorin's Climatic Context

At latitude 8.50°N and 306 meters above sea level, Ilorin is categorised as having a tropical savanna (Aw) climate. It is distinguished by a north-easterly harmattan dry season from November to March and a south-westerly monsoon wet season from April to October (NIMET, 2026). Natural cross-ventilation and solar shading are the two most important passive techniques, according to Climate Consultant 6.0 study of NIMET data (2016–2026). Together, they address over 71% of yearly thermal discomfort hours without mechanical cooling (Bazafkan *et al.*, 2019). The dry-season diurnal temperature range of 12 to 15°C facilitates an additional 14% contribution from high thermal mass with night-flush ventilation (Yoon and Wu, 2024). When relative humidity drops to 12 to 18 percent during the dry season, evaporative cooling from plant and water adds 12 percent (Al-Hajri *et al.*, 2025). While north-easterly harmattan winds at 2.1 to 4.3 m/s necessitate vegetal dust filtering, south-westerly monsoon winds from 3.2 to 5.1 m/s offer a free ventilation resource (SoneyeArogundade *et al.*, 2024).

2.3 Ilorin's Yoruba-Islamic Passive Design Heritage

Ilorin's unique Yoruba-Islamic built environment uses deep eave overhangs, Islamic geometric ornamental screens, shaded transitional verandas (ode-ile), inward-facing courtyard compounds (agbo-ile), and laterite thermal mass wall construction, in contrast to other Yoruba cities run by an Oba (Owoseni, 2023). The agbo-ile courtyard arranges space around a central open void that simultaneously promotes evaporative cooling, stack-effect thermal regulation, and cross-ventilation. Field measurements confirm that during peak afternoon hours (2–3pm), courtyard air temperatures are 2 to 4°C below street-level ambient (Akhlaghinezhad *et al.*, 2024). According to (Abdullahi *et al.*, 2025), massive laterite wall construction measuring 300 to 600

mm reduces peak indoor temperatures by 4 to 6°C and provides a thermal lag of 8 to 10 hours. While pitched roof forms of 25° to 35° allow stack-effect ventilation through ridge apertures, high ceilings of 3.5 to 4.5 meters enhance thermal stratification (Mba *et al.*, 2025). As a thermal buffer between the outer environment and enclosed interiors, the ode-ile veranda records temperatures that are 5 to 7°C lower than unshaded outdoor settings (Nyberg *et al.*, 2023). In addition to serving as passive climate devices and cultural identity expressions, Islamic geometric brise-soleil screens with 30 to 50 percent open-to-solid ratios reduce solar radiation by 55 to 65 percent while retaining 70 to 85 percent of unscreened ventilation performance (Okon *et al.*, 2021). By combining shading with water cooling and native canopy species such as *Parkia biglobosa*, *Vitellaria paradoxa*, and *Azadirachta indica* reduce ambient temperatures by 2 to 4°C (Al-Hajri *et al.*, 2025).

2.4 Case Study Precedents

Validated design lessons are provided by six modern structures in similar tropical settings. In a Nigerian public structure, the John Randle Centre for Yoruba Culture and History, Lagos (Am), serves both cultural expression and passive climate requirements with courtyard organisation and permeable brise-soleil façade (Mba *et al.*, 2025). According to Dr. Omololu Olunloyo Park in Ibadan (Aw), planting native canopy trees lowers the mean radiant temperature at ground level by 8 to 12°C, making it the most economical method of providing outdoor thermal comfort in West African savanna climates (Balogun and Daramola, 2018). Deep eave shading and courtyard-driven stack ventilation are validated for institutional Yoruba architecture at the Ijebu National Museum, Ijebu-Ode (Am) (Kazeem *et al.*, 2021). Open-sided structural canopies can lower interior temperatures by 4 to 6°C without the need for mechanical cooling, as demonstrated by the Backyard Community Club in Accra (Aw) (ArchDaily, 2025). The international standard is provided by the Jean-Marie Tjibaou Cultural Centre in New Caledonia (Af), where post-occupancy monitoring revealed a 70% cooling energy reduction using indigenous cultural forms that are structurally inseparable from passive ventilation performance (Langdon, 2015). A 7,000 m² green roof lowers the roof surface temperature from 65°C to 28–32°C with a 20–25% overall cooling energy savings, as demonstrated by the Marina Barrage, Singapore (Af) (Singapore Public Utilities Board, 2021).

3. METHODOLOGY

The interpretivist-constructivist paradigm serves as the foundation for the study's using a mixed-method research approach (Creswell & Creswell, 2023). The study combines quantitative meteorological analysis with qualitative cultural heritage documentary and case study evaluation. Phase One used Climate Consultant 6.0 to process 10 years' worth of NIMET Ilorin station data (2016–2026), to produce psychrometric charts, ranked passive strategy lists, sun route diagrams, and wind rose diagrams to guide all design choices. Phase two was a direct field observation and temperature measurements of traditional buildings in Ilorin's indigenous neighbourhoods. literature review of studies on the Ilorin's Yoruba-Islamic vernacular architecture starting from 2020 were also reviewed. Phase Three used a structured framework to examine the six-case study which are the program (functional spaces provided), cultural expression, climate context, passive design strategies, and lessons that could be applied elsewhere. The design synthesised all three phases and integrated it as a framework to the Adeta site. The use of solar, wind, topography, and context analysis, cross-referencing the NIMET passive strategy rankings against conventional architectural features and case study lessons.

4. RESULTS AND DISCUSSION

4.1 NIMET Climatic Analysis

Ilorin's Aw climate classification was validated by Climate Consultant 6.0 study of the NIMET 2016–2026 dataset, which also revealed six ranked passive methods that together address 86 percent of yearly heat discomfort hours without mechanical cooling (NIMET, 2026). The ranked techniques and their particular architectural uses in the proposed centre are shown in Table 1.

Table 1: Climate Consultant 6.0 Ranked Passive Strategies for Ilorin (NIMET, 2016–2026)

Rank	Passive Strategy	% Hours	Application in Proposed Centre
1	Natural cross-ventilation (SoneyeArogundade <i>et al.</i> , 2024)	24%	Courtyard orientation to SW monsoon; max 14 m room depth; operable high-level openings
2	Solar shading (Okon <i>et al.</i> , 2021)	21%	Deep eave overhangs 1.5–2.5 m; Islamic geometric brise-soleil screens on E, W, and S elevations
3	High thermal mass with night-flush ventilation (Abdullahi <i>et al.</i> , 2025)	14%	SCEB laterite walls ≥ 300 mm; operable openings for dry-season night-flush cooling
4	Evaporative cooling (Al-Hajri <i>et al.</i> , 2025)	12%	Central artificial pool ≈ 400 m ² ; indigenous canopy planting 40–60% site coverage at maturity
5	Internal heat gain reduction (Niza <i>et al.</i> , 2022)	8%	Daylit brise-soleil screens reduce artificial lighting load; natural ventilation reduces equipment heat
6	Stack-effect ventilation (Mba <i>et al.</i> , 2025)	7%	4 m+ ceiling heights; ventilated ridge openings; courtyard void driving thermal stratification

Source: Abdullahi *et al.*, 2025, Al-Hajri *et al.*, 2025, Mba *et al.*, 2025, Niza *et al.*, 2022, Okon *et al.*, 2021 and SoneyeArogundade *et al.*, 2024

The table reveals a clear hierarchy of passive priorities shaped by Ilorin's dual-season climate. Due to the steady south-westerly monsoon breezes that predominate from April to October, natural cross-ventilation ranks highest at 24% of discomfort hours (SoneyeArogundade *et al.*, 2024). This means that the two most important design choices for the proposed centre are the courtyard orientation and the maximum room depth of 14 meters. Due to Ilorin's near-overhead sun path at latitude 8.50°N, east and west elevations receive high oblique solar exposure, necessitating brise-soleil screens rather than overhangs alone. As a result, solar shading ranks second at 21% (Okon *et al.*, 2021). Spatial organisation and envelope shading are the fundamental passive interventions for this climate, as evidenced by the fact that the top two techniques together handle 45% of the yearly discomfort hours. Using the dry-season diurnal temperature range of 12 to 15°C, which permits wall-stored heat to be released overnight, high thermal mass with night-flush ventilation contributes 14% (Abdullahi *et al.*, 2025). As a result, building walls with at least 300 mm of SCEB laterite is now a structural necessity rather than a personal preference. In the dry harmattan months, when relative humidity drops to 12 to 18 percent and artificial pools and canopy planting offer significant temperature decrease, evaporative cooling from vegetation and water makes up 12 percent (Al-Hajri *et al.*, 2025). In

a climate where any internal heat source directly increases the cooling burden, it is crucial to minimise artificial lighting and equipment loads, as seen by the 8% reduction in internal heat gain. The courtyard void and high ceiling heights work together to create the stack pressure differential, which propels air movement during still-wind periods when wind-driven cross-ventilation is insufficient (Mba *et al.*, 2025). Stack-effect ventilation, at 7%, is the smallest contributor but is nevertheless architecturally significant. When taken as a whole, the six tactics cover 86% of the yearly discomfort hours, demonstrating that mechanical cooling is not required for the vast majority of the building's operational hours (Okonta, 2023).

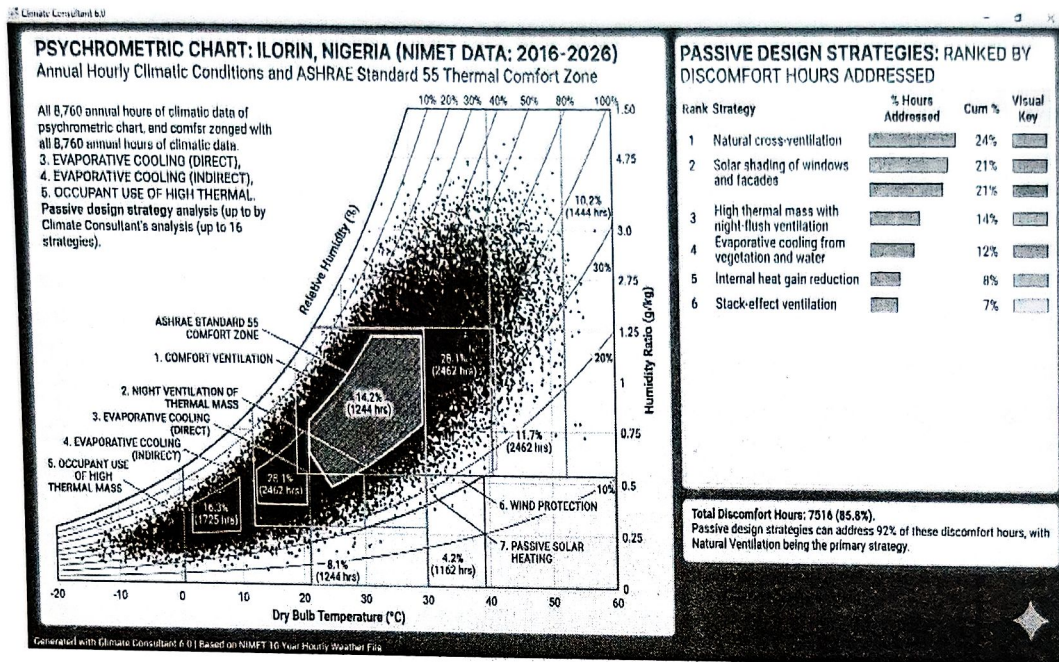


Figure 1: Psychrometric Chart for Ilorin Showing Annual Hourly Climatic Conditions and Ranked Passive Strategy Coverage (Source: Author, processed in Climate Consultant 6.0 from NIMET, 2026)

Plotting 87,600 hourly data points against the ASHRAE Standard 55 thermal comfort zone, the psychrometric chart produced by Climate Consultant 6.0 for the entire ten-year NIMET dataset shows that, in the absence of passive cooling intervention, about 61% of annual hours fall outside the comfort zone. According to (Bazafkan *et al.*, 2019), solar control strategies account for 29% of these discomfort hours; natural ventilation accounts for another 24%; high thermal mass with night-flush ventilation accounts for 9%; and the remaining 12% of discomfort hours, which are mostly during the most intense pre-rain hot period, call for additional evaporative cooling strategies from landscape elements like the artificial pool and native tree planting.

4.2 Indigenous Passive Strategies: Field Validation

The NIMET-ranked passive design priorities and the six passive strategies of Ilorin's Yoruba-Islamic heritage match exactly, demonstrating that indigenous architectural knowledge is an empirically grounded passive design system that developed directly in response to this climate. The top priority is natural ventilation, which is addressed by the agbo-ile courtyard; the second priority is solar shading, which is addressed by deep eave overhangs and Islamic screens; the third priority is thermal mass, which is addressed by laterite walls; and the fourth priority is evaporative cooling, which is addressed by indigenous canopy planting in conjunction with the courtyard water feature. Field measurements confirmed published performance data, such as

courtyard differentials of 2 to 4°C below ambient, indoor temperatures in laterite wall buildings that were 3 to 5°C below outdoor peaks, and ode-ile veranda temperatures that were 5 to 7°C below unshaded outdoor conditions. Peak surface temperatures of 61°C were observed on the bare compacted dirt at the Adeta site, demonstrating an excessive heat island situation that canopy planting and an artificial pool will significantly reduce.

4.3 Design Proposal: Ilorin Climate-Responsive Recreation Centre

Reinterpreting the agbo-ile typology at the institutional level, the proposed centre is arranged as a scattered cluster of pavilions around a central 60 × 40 m courtyard at the Adeta Baseball Court (1.8 hectares, Ilorin West LGA). The entire program is arranged in a hierarchical spatial progression from the public amphitheatre and plaza at the southern edge through shaded ode-ile veranda circulation to enclosed pavilion interiors at the courtyard core. This includes an amphitheatre for Durbar festival celebrations, children's park, adult sporting arena, museum and gallery, cinema, multipurpose hall, traditional retail stores, food court, chalets, mosque, horse stable, salons and spa, reflexology garden, shaded walkways and pergolas, and parking. With major masses on the northern and western site boundaries forming a courtyard exposed to south-westerly monsoon winds, buildings are orientated east-west to show thin profiles to the thermally important east and west elevations.

Stabilised compressed earth block (SCEB) walls that are at least 300 mm from local laterite and offer 8 to 10 hours of thermal lag are required by the building envelope as described by Real *et al.*, (2024). The building's most thermally exposed surface receives less solar heat when it has a vented double-pitch clay tile roof with a 150 mm insulated air gap. Islamic geometric brise-soleil screens in precast concrete with a 35 to 45 percent open-to-solid ratio on all east, west, and south fenestration simultaneously achieve 55 to 65 percent solar reduction and express Ilorin's Yoruba-Islamic cultural identity, while eave overhangs of 1.5 to 2.5 meters create shaded ode-ile veranda zones on all principal facades. In accordance with the Marina Barrage example, a green roof of planted substrate over the museum, gallery, and multipurpose hall volumes is expected to reduce roof surface temperatures from roughly 65°C to 28–32°C. According to Al-Hajri *et al.* (2025), a perimeter buffer of *Parkia biglobosa*, *Vitellaria paradoxa*, and *Azadirachta indica* at 6-meter intervals achieves 40–60% site canopy coverage, lowering ambient temperatures by 2–4°C. Localised evaporative cooling of 2 to 3°C is provided by a 400 m² central artificial pool. During Eid celebrations, the 2,500-seat Durbar amphitheatre is orientated to direct south-westerly monsoon winds across the crowd under a tensile fabric canopy.

4.4 DISCUSSION

Ilorin's Yoruba-Islamic built heritage is a climatically validated passive design system rather than just a storehouse of cultural forms, as demonstrated by the four-way correspondence between NIMET-ranked passive priorities, indigenous architectural strategies, case study evidence, and the proposed design. The Islamic brise-soleil screen is both a solar control device and a cultural identity expression; the agbo-ile is both a ventilation driver and a foundational cultural spatial type; and the ode-ile veranda is both a thermal buffer and an indigenous transitional typology. All of these traditional elements simultaneously address the NIMET-ranked passive priority and convey cultural continuity. This convergence is in line with the Tjibaou Cultural Centre model, where indigenous cultural forms that are structurally detachable from passive performance were used to reduce cooling energy by 70%. Brise-soleil façades, indigenous canopy planting and courtyard organisation are all established passive solutions in similar West African institutional buildings according to Nigerian precedents. There are three known limitations. Due to the climatic analysis's reliance on a single NIMET station, localised Adeta site microclimatic fluctuations may not be captured. This conceptual

study does not cover computational fluid dynamics modelling or EnergyPlus or IES-VE thermal simulation, which would have offered quantitative validation of passive strategy performance. There has been no construction or post-occupancy assessment of the design proposal.

5. CONCLUSION

This analysis shows that the Adeta Baseball Court site is both technically feasible and culturally suitable for a climate-responsive recreational centre that incorporates passive cooling techniques from Ilorin's Yoruba-Islamic indigenous architecture. According to the NIMET 2016–2026 analysis, 86% of the yearly hours of thermal discomfort without mechanical cooling are addressed by the combination of six conventional passive techniques. The suggested design shows that Yoruba-Islamic cultural expression and passive climatic performance are mutually reinforcing goals: each design element communicates cultural continuity and fulfils a thermal purpose at the same time. For the first time, Ilorin's most important annual public cultural event has a permanent architectural setting thanks to the Durbar amphitheatre. Three contributions are made by the study: a replicable research framework that can be applied to similar cities like Minna, Lokoja, and Lafia; a demonstrated methodology for adapting Ilorin's Yoruba-Islamic indigenous architecture to contemporary institutional scale; and an evidence-based passive design framework for Guinea savanna public recreational buildings based on NIMET-measured data (NIMET, 2026).

According to the result, architects in the Guinea savanna zone are hereby advised to use SCEB laterite walls of at least 300 mm as the standard thermal mass envelope, specify Islamic geometric brise-soleil screens with a 30 to 50 percent open ratio as the primary solar control device, and adopt the agbo-ile courtyard as the primary spatial organising typology.

To support evidence-based passive design practice throughout Nigeria, policymakers should require NIMET data-based passive design assessment as a prerequisite for planning approval for all publicly funded buildings in Kwara State. Additionally, NIMET should publish annual EPW files for all state capital stations. Future studies should apply this analytical framework to similar Guinea savanna zone sites, carry out post-occupancy thermal evaluation after construction, and expand this idea to EnergyPlus modelling.

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