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A Hybrid Bioclimatic Thermal Comfort Model for Warm-Humid Climates: Integrating Evans Scale and Mahoney Tables for Southwest Nigeria

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Abstract

Thermal discomfort in warm-humid climates remains a principal driver of excessive mechanical cooling energy demand, particularly in institutional buildings across sub-Saharan Africa. Existing comfort assessment frameworks often operate in isolation; offering either diagnostic analysis or prescriptive design recommendations without providing an integrated, location-specific decision-support tool. This study presents the YetOke Bioclimatic Comfort Model (YBCM), a novel hybrid analytical framework that systematically integrates the Evans Comfort Scale with the Mahoney Tables to produce context-calibrated thermal stress diagnoses and passive architectural design strategies for warm-humid climates. The model relies on secondary station-based meteorological data and serves primarily as a pre-design decision support tool. Monthly meteorological data (2016–2023) obtained from the Nigerian Meteorological Agency (NIMET) were analysed for three climatically representative cities in Southwest Nigeria. The cities are Ibadan (Oyo State), Abeokuta (Ogun State), and Lagos (Lagos State). Applying the Evans Scale, daytime thermal stress was found to peak at 'very hot' (++) for January–April and November–December across all three cities, while wet-season months (July–September) exhibited 'comfortable' to 'hot' conditions. Night-time stress was predominantly 'cold' (−) across the year, necessitating thermally responsive nocturnal ventilation strategies. The Mahoney Table analysis produced location-differentiated recommendations: Ibadan and Lagos require light wall construction with medium-to-large openings and well-insulated roofs, while Abeokuta demands heavy thermal mass walls and roofs with extended time lags to moderate the wider diurnal temperature range (up to 13.6°C). The synthesised YetOke Model provides a five-component decision support framework; thermal stress

diagnosis, climatic classification, indicator scoring, design prescription, and cross-location validation applicable to the planning, design, and retrofitting of public institutional buildings in tropical West Africa. These findings directly inform the revision of Nigeria's Building Energy Efficiency Code (N-BEEC) and contribute to the growing evidence base for passive, climate-responsive architecture in developing economies.

Keywords: YetOke Bioclimatic Comfort Model, Evans Comfort Scale, Mahoney Tables, Thermal Comfort, Passive Design, Southwest Nigeria, Bioclimatic Architecture, Building Energy Efficiency, Climate-Responsive Designs.

Introduction

The global building sector accounts for approximately 40% of total energy consumption and roughly 36% of direct carbon dioxide (CO_2) emissions, with a disproportionate share attributed to space cooling in hot climates (International Energy Agency [IEA], 2023). In tropical sub-Saharan Africa, where ambient temperatures frequently exceed 33°C and relative humidity surpasses 85%, the dependence on active mechanical cooling systems is both economically burdensome and environmentally unsustainable (Alegbe et al., 2025; Geissler et al., 2018). Nigeria, as Africa's most populous nation and one of its fastest-urbanising economies, faces an acute challenge: a housing deficit exceeding 24 million units is being addressed through a construction boom that largely ignores the principles of climate-responsive design, resulting in buildings structurally predisposed to thermal discomfort (Victor-Nuwomi et al., 2026; Society for Planet and Prosperity [SPP], 2024).

Institutional buildings particularly public university campuses represent a critical locus of this problem. University buildings in Southwest Nigeria are occupied for extended daily periods by large student populations, yet the majority were designed without systematic bioclimatic analysis. The consequence is a near-universal reliance on energy-intensive air conditioning, in contexts where the national electricity grid is unreliable and energy poverty is endemic (Alabi et al., 2025; Geissler et al., 2018). The environmental imperative is therefore clear: reducing cooling energy demand through passive architectural strategies requires a robust, empirically validated, site-specific thermal comfort assessment framework.

Two foundational bioclimatic tools have proven particularly well-suited to warm-humid tropical contexts. The Evans Comfort Scale, developed by Martin Evans in the 1970s, remains among the most accurate predictors of human thermal stress in Nigerian climatic conditions (Ogunsote & Prucnal-Ogunsote, 2003). Its granular five-tier classification ranging from 'very cold' to 'very hot' enables month-by-month diagnosis of diurnal thermal stress with precision not matched by simpler three-tier indices (Ayinla et al., 2021). The Mahoney Tables, originally developed for tropical housing by Carl Mahoney in 1967 and subsequently expanded

through publications of the Architectural Association's Department of Tropical Studies (Koenigsberger et al., 1974), translate integrated climatic data into prescriptive architectural design strategies including orientation, ventilation, wall construction, roofing, and opening ratios. Despite their respective strengths, these tools have rarely been formally integrated into a unified, replicable analytical model.

This study addresses that gap by presenting the YetOke Bioclimatic Comfort Model (YBCM), a hybrid analytical framework systematically combining the Evans Scale and Mahoney Tables to generate thermal stress diagnoses and passive design prescriptions calibrated to specific locations within warm-humid climates. The model is named 'YetOke' in recognition of the significant contribution of Late Dr Yetunde Okeyinka's work on indigenous Yoruba concept of thermal wellbeing and environmental responsiveness in the Professor Ayinla Abdulrasaq's IEQ Laboratory, Lautech, Ogbomoso Nigeria and also a reflection of the model's cultural grounding in the Bioclimatic building design research in Southwest Nigeria. The model was tested across three climatically distinct but regionally similar cities: Ibadan (Oyo State), Abeokuta (Ogun State), and Lagos (Lagos State), all situated within the warm-humid climatic zone of Southwest Nigeria. Climatic data were sourced from the Nigerian Meteorological Agency (NIMET) for the period 2016–2023.

The study pursues three primary objectives: (i) to quantify monthly thermal stress conditions across three cities using the Evans Comfort Scale; (ii) to derive location-specific passive bioclimatic design strategies using the Mahoney Tables; and (iii) to synthesise these outputs into the structured, reproducible YetOke Bioclimatic Comfort Model applicable to institutional building design in warm-humid climates. The findings contribute directly to the discourse on climate-responsive architecture, passive cooling, energy efficiency in the Global South, and the revision of Nigeria's Building Energy Efficiency Code (N-BEEC).

Literature Review

Thermal Comfort in Warm-Humid Climates

Thermal comfort in warm-humid climates is primarily governed by the combined effect of elevated air temperature and high relative humidity, which together reduce the body's capacity for evaporative cooling and substantially heighten perceived heat stress (Eludoyin et al., 2013). The classic definition of thermal comfort by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE Standard 55) identifies six primary variables: air temperature, radiant temperature, humidity, air velocity, metabolic rate, and clothing insulation. In tropical environments, however, the adaptive model which accounts for behavioural and physiological acclimatisation increasingly supersedes PMV-based analytical approaches (López-Pérez et al., 2018; Brager & de Dear, 1998 as cited in Patle & Ghuge, 2024).

In Nigeria specifically, the concurrent challenge of high mean temperatures (nationally averaging 27.1°C) and high relative humidity (mean 62%) creates persistent thermal stress across virtually all climatic zones (Eludoyin et al., 2013). A comprehensive long-term analysis

(1950–2023) of heat stress indices across Nigeria demonstrated that the warm-humid southern zones encompassing Lagos, Ibadan, and Abeokuta consistently record the highest frequencies of strong and severe thermal stress events, with the wet-bulb globe temperature (WBGT) and Universal Thermal Climate Index (UTCI) registering alarming trajectories under climate change projections (Nasara et al., 2026). This underscores the urgency of embedding climate-responsive design standards into institutional buildings.

Recent empirical studies on indoor thermal comfort in Nigeria's warm-humid zone reveal widespread dissatisfaction, particularly in low-income residential buildings where temperatures in the dry season (January–March) regularly exceed ASHRAE 55-2020 thresholds, peaking at 31.0–31.8°C with persistently high humidity (Patle & Ghuge, 2024). Similarly, assessments of residential buildings in Lagos have demonstrated that the absence of passive cooling features such as cross-ventilation, shading devices, and appropriate wall thermal mass forces occupants into near-total dependence on air conditioning, increasing energy expenditure by up to 60% relative to climate-responsive alternatives (Agbaje et al., 2024).

The Evans Comfort Scale: Applicability and Validation

The Evans Comfort Scale evaluates thermal stress by cross-referencing monthly mean maximum temperatures with monthly mean minimum relative humidity (daytime conditions) and monthly mean minimum temperatures with monthly mean maximum relative humidity (night-time conditions) against defined comfort bands that vary with humidity group (Ogunsote et al., 2003). Its five-tier output- very cold, cold, comfortable, hot, and very hot affords significantly greater diagnostic resolution than three-tier systems (Ayinla et al., 2021). The comparative superiority of the Evans Scale over other thermal indices in the Nigerian context was formally established by Ogunsote and Prucnal-Ogunsote (2003), whose empirical study of 203 cases using mental assessment tests demonstrated that the Evans Scale generated the highest percentage of accurate thermal stress predictions relative to the Mahoney scale, the bioclimatic chart, TSENS, and effective temperature indices. Subsequent scholars including Adebisi et al. (2018) and Ayinla et al. (2021) confirmed its validity across multiple Nigerian climatic zones. A recent comprehensive review of thermal comfort indices for tropical and subtropical regions further affirmed the Evans Scale's robustness for contexts combining high thermal load and elevated humidity (Patle & Ghuge, 2024). For the warm-humid zone of Southwest Nigeria, which is characterised by diurnal temperature ranges of 6–14°C and relative humidity regularly exceeding 80%, the Evans Scale's humidity-stratified comfort bands make it uniquely suited for accurate classification (Eludoyin et al., 2013).

The Mahoney Tables: Design Translation Capacity

The Mahoney Tables were first introduced by Carl Mahoney in 1967 as part of the International Development Association Educational Project in Nigeria, specifically for the determination of thermal comfort standards in tropical settings (Mahoney, 1967, as cited in

Ogunsote et al., 2003). Subsequently elaborated by Koenigsberger et al. (1974) in their seminal Manual of Tropical Housing and Building: Climatic Design, the Tables translate monthly climatic variables- temperature ranges, humidity groups, and rainfall data into prescriptive design indicators across eight architectural domains: layout/orientation, building spacing, air movement provision, opening sizes, wall construction, roof construction, outdoor sleeping, and rain protection.

Contemporary applications of the Mahoney Tables span diverse tropical contexts. Ghada (2021) applied the Tables in a hot-desert bioclimatic region in Egypt, recommending north-south orientation, 20–40% window-to-wall ratios, and open spacing for natural ventilation; findings consistent with the present study's results for the wet-season months in Southwest Nigeria. In tropical Indonesia, Santy et al. (2017) demonstrated that the Mahoney Tables, cross-validated against Olgyay and Givoni bioclimatic charts, yielded complementary design recommendations favouring single-banked rooms and permanent air movement provision. More recently, Agbaje et al. (2024) applied the Mahoney Tables to 2024 climate data for Lagos, specifically for a commercial high-rise building, demonstrating the tool's adaptability beyond its original low-rise scope. A 2024 vernacular architecture study in coastal China similarly affirmed the Tables' continued relevance as a pre-design climate analysis tool (Huang et al., 2024).

Notwithstanding this breadth of application, a recognised limitation of the Mahoney Tables is their relatively coarse, three-tier thermal stress classification (hot, comfortable, cold), which loses granularity in contexts such as Southwest Nigeria where conditions oscillate between 'hot' and 'very hot' within short seasonal windows (Ayinla et al., 2021). This limitation has been noted by Nadimia and Yaghoubzadeh (2014), who first recommended the integration of the Evans Scale with the Mahoney Tables as a means of combining diagnostic depth with prescriptive breadth- a methodological approach that the present study formalises into the YetOke Bioclimatic Comfort Model.

Passive Design Strategies and Building Energy Efficiency in Nigeria

Passive cooling strategies which are defined as design approaches that maintain thermal comfort through natural environmental forces without mechanical energy input have been extensively validated in warm-humid tropical settings (Kamal 2012; Adebisi, 2018). The principal strategies relevant to Southwest Nigeria include natural cross-ventilation through single-banked room configurations and appropriately sized openings; east-west building orientation to minimise solar exposure; reflective and well-insulated roof assemblies; thermally massive wall construction to dampen diurnal temperature swings; roof overhangs and vertical shading devices; and courtyard configurations that promote nocturnal airflow (Agbaje et al., 2024; Akubue & Adesina, 2023; Olawale-Johnson et al., 2020).

Simulation studies from analogous sub-Saharan contexts demonstrate that these strategies deliver measurable benefits: natural ventilation alone reduced annual discomfort hours by up to 40% in Burkina Faso office buildings (Zoure & Genovese., 2022), (Geissler et al., 2018).

Energy savings of 14.9% to over 23% in annual consumption have been documented where integrated passive cooling packages are applied (Zoure & Genovese., 2023; Al-Hajri et al., 2025). Despite this evidence, Nigeria's building sector continues to lag behind global benchmarks. The Nigerian Building Energy Efficiency Code (N-BEEC), launched in 2017, identified climate-adaptive design as central to reducing cooling energy demand; however, implementation has been inconsistent, and location-specific bioclimatic design guidelines particularly for the institutional building sector remain insufficiently developed (Alegbe et al., 2025; Ochedi & Taki, 2022; Geissler et al., 2018). The present study directly addresses this implementation gap by providing a validated, reproducible model for generating such guidelines.

Study Area and Climatic Context

The study area encompasses three state capitals in Southwest Nigeria, all situated within the warm-humid climatic zone as defined by the Nigerian climatic classification system. Southwest Nigeria is geographically bounded between longitudes 3°E and 7°E and latitudes 4°N and 9°N, flanked by the Republic of Benin to the west and the Atlantic Ocean to the south. The region's climate is characterised by high mean temperatures (often exceeding 33°C), relative humidity consistently above 85% in morning hours, double rainfall maxima in July and September, and a well-defined dry season associated with the northeasterly Harmattan winds from November to March (NIMET, 2025).

Ibadan (Oyo State)

Ibadan, located between longitudes 3.35°E–4.10°E and latitudes 7.20°N–7.40°N, is Nigeria's third most populous city and serves as the administrative capital of Oyo State. As the site of the University of Ibadan the country's premier university; the city holds particular significance for this study's focus on institutional buildings. The climate is warm and humid year-round, with a pronounced bimodal rainfall pattern and a diurnal temperature range of 5.9–10.9°C across the year.

Abeokuta (Ogun State)

Situated between longitudes 3.00°E–3.25°E and latitudes 7.25°N–7.31°N, Abeokuta is the capital of Ogun State. It hosts the Federal University of Agriculture Abeokuta (FUNAAB) and Moshood Abiola University of Science and Technology (MAUSTECH). The city exhibits a wider diurnal temperature range than the coastal cities reaching up to 13.6°C in January and experiences slightly more intense solar radiation intensity, necessitating heavier thermal mass in building envelopes.

Lagos (Lagos State)

Lagos, positioned between longitudes 2.45°E–4.20°E and latitudes 6.20°N–6.40°N, is Nigeria's commercial capital and most populous city. Its coastal location moderates extreme

temperature swings but sustains high year-round humidity. Major institutional facilities include the University of Lagos (UNILAG) and Lagos State University (LASU). The city's oceanic influence produces a narrower diurnal range (6.0–11.0°C) and a more persistent humidity load, making large openings and maximised natural ventilation particularly critical.



Plate 1: Map of Nigeria highlighting the study areas
Source: Google map © 2026

Methodology

Research Design and Data Collection

A quantitative secondary-data research design was adopted. Monthly climatic data for the eight-year period 2016–2023 were obtained from the Nigerian Meteorological Agency (NIMET, 2025) for all three study cities. The dataset included monthly mean maximum and minimum air temperatures (°C), morning and afternoon relative humidity (%), and total monthly rainfall (mm). These parameters constitute the complete input requirements for both the Evans Comfort Scale and the Mahoney Tables analyses.

Evans Comfort Scale Application

The Evans Comfort Scale was applied following the protocol established by Ogunsote et al. (2003) and Ayinla et al. (2021). Daytime comfort was assessed by cross-referencing monthly mean maximum temperature with monthly mean minimum relative humidity against the Evans comfort bands (Table 1). Night-time comfort was assessed using monthly mean minimum temperature against monthly mean maximum relative humidity. Each month was assigned a categorical thermal stress rating: very cold (−−), cold (−), comfortable (0), hot (+), or very hot (++), according to the criteria in Table 2.

Table 1: Comfort limits proposed by Evans (1974) as adapted for Nigeria (Ogunsote et al., 2003; Ayinla et al., 2021)

Relative Humidity (%)	Day Comfort Limit (°C)	Night Comfort Limit (°C)
0–30	29.5–32.5	27.5–29.5
30–50	28.5–30.5	26.5–29.0
50–70	27.5–29.5	26.0–28.5
70–100	26.0–29.0	25.5–28.0

Table 2: Evans thermal stress categories and their definitions (Ogunsote et al., 2003; Ayinla et al., 2021*)*

Stress Category	Condition Description	Symbol
Very Cold	Temperature ≥ 5°C below the lower comfort limit	−−
Cold	Temperature below lower comfort limit, but < 5°C below it	−
Comfortable	Temperature within comfort limits	0
Hot	Temperature above upper comfort limit, but < 5°C above it	+
Very Hot	Temperature ≥ 5°C above the upper comfort limit	++

Mahoney Tables Analysis

The Mahoney Tables were applied sequentially through four analytical stages, following the standard protocol of Koenigsberger et al. (1974) as adapted for Nigerian conditions by Ayinla et al. (2021). First, mean monthly relative humidity was computed and each month assigned to one of four humidity groups (Group 1: below 30%; Group 2: 30–50%; Group 3: 50–70%; Group 4: above 70%). Second, monthly thermal stress ratings from the Evans Scale analysis were translated into Mahoney's hot-neutral-cold classification ('+' and '++' = hot; '0' = neutral; '−' and '−−' = cold). Third, six climatic indicators were scored: H1 (air movement essential), H2 (air movement desirable), H3 (rain protection needed), A1 (thermal storage required), A2 (outdoor sleeping desirable), and A3 (cold-season problem). Finally, annual indicator totals were referenced against the Mahoney recommendation thresholds to derive design prescriptions for each of the eight architectural domains.

YetOke Model Integration Framework

The YetOke Bioclimatic Comfort Model synthesises the outputs of the Evans and Mahoney analyses through a five-component sequential framework, as detailed in Table 7 (Section 6). The integration is justified on three grounds: (i) complementarity- the Evans Scale's diagnostic granularity compensates for the Mahoney Tables' limited three-tier stress classification; (ii) methodological precedent- integration of the two tools was recommended by Nadimia and Yaghoubzadeh (2014) and has been validated empirically across Nigerian cities including Lagos, Ibadan, and Enugu (Ayinla et al., 2021); and (iii) policy relevance- the combined output provides the evidence base required by the N-BEEC for the formulation of region-specific passive design guidelines (Alegbe et al., 2025; Geissler et al., 2018).

Results and Analysis

Thermal Stress Analysis: Ibadan

Table 3 presents the Evans Comfort Scale analysis for Ibadan. Daytime thermal stress peaks at 'very hot' (++) during January–April- coinciding with the Harmattan dry season with maximum temperatures reaching 36°C in February against minimum relative humidity values of only 38–42%. Conditions transition to 'hot' (+) in May and June, then to 'comfortable' (0) during the core wet season months of July–September, when temperatures decline to 29°C and humidity increases substantially. The final quarter (October–December) sees a resurgence of heat stress, with November and December reverting to 'hot' (+) and 'very hot' (++), respectively, as the dry season re-establishes itself. Night-time conditions are predominantly 'cold' (−) through most of the year, with the exception of February (comfortable) and November–December, which exhibit 'hot' (+) ratings owing to elevated minimum temperatures during the transitional dry period. This bimodal diurnal stress pattern- very hot days and cold nights during the dry season, comfortable days and cold nights during the wet season- is consistent with patterns documented by Eludoyin et al. (2013) and Ayinla et al. (2021) for similar warm-humid inland cities.

Table 3: Evans Comfort Scale thermal stress analysis for Ibadan, Oyo State (2016–2023) (NIMET, 2025; Authors' Analysis, 2026)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Temp. (°C)	35.0	36.0	35.0	34.0	32.0	31.0	29.0	29.0	29.0	31.0	33.0	35.0
Min. RH (%)	38	42	48	58	67	72	75	75	71	68	56	49
Day Stress	++	++	++	++	+	+	0	0	0	+	+	++
Min. Temp. (°C)	24.1	25.5	25.0	24.9	24.4	23.5	23.1	22.7	23.0	23.4	28.85	29.5
Max. RH (%)	74	77	74	78	83	83	88	88	85	85	82	68
Night Stress	−	0	−	−	−	−	−	−	−	−	+	+

Thermal Stress Analysis: Abeokuta

Table 4 presents the Evans analysis for Abeokuta. The city experiences the most severe daytime thermal stress profile of the three study locations: 'very hot' (++) conditions persist from January through April and again in November and December, while 'hot' (+) conditions prevail from May through October- never reaching comfortable classification during daylight hours. This is attributable to Abeokuta's higher maximum temperatures (37.2°C in February) and its wider diurnal temperature range (up to 13.6°C in January), which are associated with its slightly more inland position and reduced maritime tempering relative to Lagos. Night-time conditions present a uniformly 'cold' (−) thermal stress rating throughout all twelve months- a

finding with important implications for building design, as it suggests the need for nocturnal ventilation management to prevent cold stress in sedentary occupants while avoiding daytime heat accumulation. This persistent nocturnal cold stress pattern has been noted as a distinctive feature of inland warm-humid locations in West Africa (Ayinla et al., 2021; Adebisi et al., 2018).

Table 4: Evans Comfort Scale thermal stress analysis for Abeokuta, Ogun State (2016–2023) (NIMET, 2025; Authors' Analysis, 2026)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Temp. (°C)	36.4	37.2	36.4	34.9	33.5	31.7	30.5	30.2	30.6	32.4	34.4	35.1
Min. RH (%)	43	43	51	61	68	73	78	77	75	70	55	48
Day Stress	++	++	++	++	+	+	+	+	+	+	++	++
Min. Temp. (°C)	22.8	24.7	24.7	24.4	23.4	22.6	22.3	22.3	22.7	22.7	23.4	22.4
Max. RH (%)	74	74	79	82	83	85	88	88	87	86	84	75
Night Stress	–	–	–	–	–	–	–	–	–	–	–	–

Thermal Stress Analysis: Lagos

Table 5 presents the Evans analysis for Lagos. As a coastal city, Lagos demonstrates a more moderated thermal stress profile: 'very hot' (++) daytime conditions are confined to January–March, while 'hot' (+) conditions dominate April–July and September–December. August alone achieves 'comfortable' (0) daytime classification, driven by peak oceanic humidity and rainfall (71.1 mm) which effectively suppress maximum temperatures. Night-time conditions alternate between 'cold' (−) and 'comfortable' (0) in March and April, with predominantly cold stress prevailing through the remaining months. The narrow diurnal range in Lagos (6.0°C in August) reflects the coastal oceanic influence and argues for a design emphasis on sustained ventilation rather than thermal mass, given the limited overnight temperature recovery available for passive cooling.

Table 5: Evans Comfort Scale thermal stress analysis for Lagos, Lagos State (2016–2023) (NIMET, 2025; Authors' Analysis, 2026)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Temp. (°C)	34.3	34.5	34.1	33.7	32.5	30.7	29.5	29.4	29.9	31.0	32.9	33.7
Min. RH (%)	50	58	62	66	72	79	79	76	77	76	71	61
Day Stress	++	++	++	+	+	+	+	0	+	+	+	+

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min. Temp. (°C)	23.3	25.0	25.4	25.0	24.4	23.4	23.4	23.4	23.4	23.5	23.5	22.7
Max. RH (%)	72	77	78	77	83	84	85	83	82	80	79	81
Night Stress	–	–	0	0	–	–	–	–	–	–	–	–

Mahoney Tables Analysis and Indicator Scoring

The Mahoney Tables analysis generated humidity group classifications and indicator scores for each city. Across all three cities, humidity groups ranged primarily between Group 3 (50–70%) and Group 4 (above 70%), confirming the warm-humid classification. The indicator totals reflect important inter-city differences. For Ibadan, H1 (air movement essential) scored 7, H2 (air movement desirable) scored 3, H3 (rain protection) scored 5, and A1 (thermal storage) scored 2- a profile indicating a predominantly humid climate with moderate dry-season thermal storage needs. For Abeokuta, H1 scored 7, H2 scored 0, H3 scored 1, and A1 scored 5 reflecting the city's wider diurnal range and the consequent greater need for thermal storage even in a humid climate. For Lagos, H1 scored the highest at 10, H2 scored 1, H3 scored 4, and A1 scored 1, reflecting the coastal city's near-constant humidity and strong need for air movement but minimal thermal storage requirements.

These indicator profiles translate directly into differentiated design prescriptions, as detailed in Table 6 and discussed in Section 6. The divergence in wall construction recommendations light walls for Ibadan and Lagos versus heavy walls for Abeokuta is a particularly significant finding, given that these three cities are conventionally treated as climatically homogeneous. The YetOke Model's location-specific granularity thus represents a substantive methodological advance over generalised regional guidelines.

The YetOke Bioclimatic Comfort Model (YBCM)

Model Architecture and Components

The YetOke Bioclimatic Comfort Model (YBCM) is structured as a five-component sequential analytical framework (Table 6). The model name originally coined from a late Yoruba traditional architecture scholar’s name (Late Dr. Yetunde Okeyinka) is drawn from the Yoruba words 'YETunde' (meaning “mother has returned” and contextually linked to mother of “measurement” or 'calibrator') and 'OKE' (meaning 'height' or 'peak condition') reflects its purpose of calibrating thermal stress towards optimal comfort conditions.

Table 6: The YetOke Bioclimatic Comfort Model (YBCM): Five-component framework architecture

Model Component	Tool / Source	Output
Thermal Stress Diagnosis	Evans Comfort Scale	Monthly comfort/stress ratings (−−, −, 0, +, ++)

Model Component	Tool / Source	Output
Climatic Classification	Mahoney Humidity Groups	Humidity group designation (1–4)
Indicator Scoring	Mahoney Indicator Table	H1, H2, H3, A1, A2, A3 totals
Design Prescription	Mahoney Recommendation Table	8 passive design strategies
Validation Layer	Cross-comparison across three cities	Location-specific calibrated design guidelines

Component 1: Thermal Stress Diagnosis applies the Evans Comfort Scale to generate monthly daytime and night-time stress ratings using the protocol established in Section 4.2. This component provides the fine-grained, five-tier classification that the Mahoney Tables' built-in stress assessment cannot supply.

Component 2: Climatic Classification assigns monthly humidity groups (1–4) based on mean relative humidity, following the Mahoney Tables protocol. This classification determines which indicator criteria apply to each month and ensures that the subsequent indicator scoring accounts for seasonal humidity variation.

Component 3: Indicator Scoring integrates the Evans stress ratings (translated into Mahoney's hot/neutral/cold categories) with humidity groups and rainfall data to score the six Mahoney indicators: H1 (air movement essential), H2 (air movement desirable), H3 (rain protection needed), A1 (thermal storage required), A2 (outdoor sleeping desirable), and A3 (cold-season problem). This component represents the analytical bridge between the Evans and Mahoney frameworks.

Component 4: Design Prescription translates annual indicator totals into actionable design recommendations across eight architectural domains: building layout and orientation, spacing, air movement provision, opening sizes, wall construction type, roof construction type, outdoor sleeping provision, and rain protection. These prescriptions form the direct output of the Mahoney Tables recommendation thresholds.

Component 5: Cross-Location Comparative Analysis- the model was applied to a minimum of three climatically representative cities within the target region to identify convergent and divergent design recommendations. Convergence indicates regionally robust strategies (e.g., east-west orientation is universal across all three study cities); divergence reveals location-specific adaptations that generalised regional codes would miss (e.g., heavy vs. light wall construction).

Application for BioClimatic Design Recommendations

Tables 7,8,9; 10,11,12 and 13,14,15 presents the Bioclimatic design recommendations for all three study cities with the application of the YetOke Bioclimatic Model.

Ibadan

Table 7: Air temperature, Relative humidity and Indicator for Ibadan

Ibadan 2016-2023	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max Temperature (^{0}c)	35.0	36.0	35.0	34.0	32.0	31.0	29.0	29.0	29.0	31.0	33.0	35.0
Monthly Mean Min Temperature (^{0}c)	24.1	25.5	25.0	24.9	24.4	23.5	23.1	22.7	23.0	23.4	28.85	29.5
Monthly mean temperature range	10.9	10.5	10	9.1	7.6	7.5	5.9	6.3	6	7.6	4.15	5.5
Monthly Mean Max. Relative Humidity (%)	74	77	74	78	83	83	88	88	85	85	82	68
Monthly Mean Min. Relative Humidity (%)	38	42	48	58	67	72	75	75	71	68	56	49
Monthly Mean Relative Humidity average (%)	56	59.5	61	68	75	77.5	81.5	81.5	78	76.5	69	58.5
Humidity group	3	4	3	3	4	4	4	4	4	4	3	3
Rainfall (mm)	5.1	9.4	151.8	111.3	201	297	205.4	187.4	341.8	270	54.2	17.3
Day Thermal Stress	++	++	++	++	+	+	**0**	**0**	**0**	+	+	++
Night Thermal Stress	-	**0**	-	-	-	-	-	-	-	-	+	+

AMT = (Highest Max. Temp + Lowest min. Temp)/2 = 29.35

Note: *Day and Night thermal stress are adopted from the previous Evans comfort scale analysis; + and ++ are within the Mahoney Hot discomfort range, 0 =Neutral, and - and - - are within the Mahoney's Cold discomfort range.*

Source: Authors' Analysis, 2026

Humidity group	If average RH :
1.	below 30%
2.	30-50%
3.	50-70%
4.	Above 70%

Table 8: Indicator Table for Ibadan

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Humid													
H1 Air movement (essential)	--	√	--	√	√	√	--	--	--	√	√	√	07
H2 Air movement (desirable)	--	--	--	--	--	--	√	√	√	--	--	--	03
H3 Rain protection	--	--	--	--	√	√	√	--	√	√	--	--	05
Arid													
A1 Thermal storage	√	--	√	--	--	--	--	--	--	--	--	--	02
A2 Outdoor sleeping	--	--	--	--	--	--	--	--	--	--	--	--	00
A3 cold-season problem	--	--	--	--	--	--	--	--	--	--	--	--	00

Applicable when	Indicator	Thermal stress		Rainfall	Humidity group	Monthly mean range
		Day	Night			
Air Movement essential	H1	H			4	
		H			2,3	Less than 10
Air Movement desirable	H2	O			4	
Rain protection necessary	H3	Over 200 mm				
Thermal capacity necessary	A1				1,2,3	More than 10
Outdoor sleeping desirable	A2		H		1,2	
		H	O		1,2	More than 10
Protection from cold	A3	C				

Table 9: Sketch Design Recommendations for Ibadan

Indicator total from table 4						*Recommendations*	
Humid			*Arid*				
H1	*H2*	*H3*	*A1*	*A2*	*A3*		
07	*03*	*05*	*02*	*00*	*00*		
						Layout	
			0 - 10			*1. Buildings orientated on east-west axis to reduce exposure to sun*	✓
					5 - 12		
			11- 12		*0 - 4*	*2. Compact courtyard planning*	
						Spacing	
11 or 12						*3. Open spacing for breeze penetration*	
2 - 10						*4. Open spacing for breeze penetration, but protect from hot and cold winds*	✓
0 or 1						*5. Compact planning*	
						Air movement	
3 - 12						*6. Rooms single banked. Permanent provision for air movement*	✓
			0 - 5				
1 or 2			*6 - 12*			*7. Double- banked rooms with temporary provision for air movement.*	
	2 - 12						
0	*0 or 1*					*8. No air movement requirement.*	
						Openings	
			0 to 1		*0*	*9. Large openings, 40 - 80 % of N and S walls*	
			11 or 12		*0 - 3*	*10. Very small openings, 10 - 20 %*	
			Any other conditions			*11. Medium openings, 20 -40 %*	✓
						Walls	
			0 - 2			*12. Light walls; short time lag*	✓
			3 - 12			*13. Heavy external and internal walls*	
						Roofs	
			0 - 5			*14. Light and well insulated roofs*	✓
			6 - 12			*15. Heavy roofs; over 8 hours' time lag*	
						Outdoor sleeping	

Indicator total from table 4	*Recommendations*	
0	*16. No provision for Outdoor sleeping required*	✓
2 - 12	*17. Space for outdoor sleeping required*	
	Rain penetration	
3 - 12	*18. Protection from heavy rain needed And provide adequate rain water drainage*	✓
1-2	*19. Provide adequate rain water drainage*	
0	*20. No protection from heavy rain required*	

Source: Author's analysis, 2026

After analysing the Climatic data of Ibadan in the Tables A1, A2 and A3 above, the following design procedures are recommended

1. **Layout:** Buildings should be orientated on east-west axis to reduce exposure to sun
2. **Spacing:** Open spacing should be provided for breeze penetration, but openings should be protected from hot and cold wind
3. **Air Movements:** Rooms should be single banked. Permanent provision for air movement is required
4. **Openings:** Medium openings, 20 -40 % of wall area
5. **Walls:** Light walls; short time lag
6. **Roofs:** Light and well insulated roofs
7. **Outdoor sleeping:** No provision for Outdoor sleeping required
8. **Rain protection:** Protection from heavy rain needed and provision for adequate rain water drainage required

Abeokuta

Table 10: Air temperature, Relative humidity and Indicator for Abeokuta

Abeokuta 2016-2023	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Monthly Mean Max Temperature (^{0}c)	36.4	37.2	36.4	34.9	33.5	31.7	30.5	30.2	30.6	32.4	34.4	35.1
Monthly Mean Min Temperature (^{0}c)	22.8	24.7	24.7	24.4	23.4	22.6	22.3	22.3	22.7	22.7	23.4	22.4
Monthly mean temperature range (^{0}c)	13.6	12.5	11.7	10.5	10.1	9.1	8.2	7.9	7.9	9.7	11	12.7
Monthly Mean Max. Relative Humidity (%)	74	74	79	82	83	85	88	88	87	86	84	75
Monthly Mean Min. Relative Humidity (%)	43	43	51	61	68	73	78	77	75	70	55	48
Monthly Mean Relative Humidity average (%)	58.5	58.5	65	71.5	75.5	79	83	82.5	81	78	69.5	61.5
Humidity group	3	3	3	4	4	4	4	4	4	4	3	3
Rainfall (mm)	11.7	16.6	93.6	98.6	184	157.5	190.4	86.3	211.5	164.5	43.5	1.4
Day Thermal Stress	++	++	++	++	+	+	+	+	+	+	++	++
Night Thermal Stress	-	-	-	-	-	-	-	-	-	-	-	-

AMT = 29.75

Note: *Day and Night thermal stress are adopted from the previous Evans comfort scale analysis; + and ++ are within the Mahoney Hot discomfort range, 0 =Neutral, and - and - - are within the Mahoney's Cold discomfort range.*
Source: Authors' Analysis, 2026

Table 11: Indicator Table for Abeokuta

	Jan.	***Feb.***	***Mar.***	***Apr.***	***May***	***Jun.***	***Jul.***	***Aug.***	***Sep.***	***Oct.***	***Nov.***	***Dec.***	***Total***
Humid													
H1 Air movement (essential)	--	--	--	√	√	√	√	√	√	√		--	*07*
H2 Air movement (desirable)	--	--	--	--	--	--	--	--	--	--	--	--	*00*
H3 Rain protection	--	--	--	--	--	--	--	--	√	--	--	--	*01*
Arid													
A1 Thermal storage	√	√	√	--	--	--	--	--	--	--	√	√	*05*
A2 Outdoor sleeping	--	--	--	--	--	--	--	--	--	--	--	--	*00*
A3 cold-season problem	--	--	--	--	--	--	--	--	--	--	--	--	*00*

Table 12: Sketch Design Recommendations for Abeokuta

Indicator total from table 4						***Recommendations***	
Humid			*Arid*				
H1	*H2*	*H3*	*A1*	*A2*	*A3*		
07	*00*	*01*	*05*	*00*	*00*		
						Layout	
			0 - 10			*1Buildings orientated on east-west axis to reduce exposure to sun*	✓
					5 - 12		
			11- 12		*0 - 4*	*2. Compact courtyard planning*	
						Spacing	
11 or 12						*3. Open spacing for breeze penetration*	
2 - 10						*4. Open spacing for breeze penetration, but protect from hot and cold winds*	✓
0 or 1						*5. Compact planning*	
						Air movement	
3 - 12						*6. Rooms single banked. Permanent provision for air movement*	✓
			0 - 5				
1 or 2			*6 - 12*			*7. Double- banked rooms with temporary provision for air movement.*	
	2 - 12						
0	*0 or 1*					*8. No air movement requirement.*	
						Openings	
			0 to 1		*0*	*9. Large openings, 40 - 80 % of N and S walls*	
			11 or 12		*0 - 3*	*10. Very small openings, 10 - 20 %*	
			Any other conditions			*11. Medium openings, 20 -40 %*	✓

Indicator total from table 4	*Recommendations*	
	Walls	
0 - 2	*12. Light walls; short time lag*	
3 - 12	*13. Heavy external and internal walls*	✓
	Roofs	
0 - 5	*14. Light and well insulated roofs*	
6 - 12	*15. Heavy roofs; over 8 hours' time lag*	✓
	Outdoor sleeping	
0	*16. No provision for Outdoor sleeping required*	✓
2 - 12	*17. Space for outdoor sleeping required*	
	Rain penetration	
3 - 12	*18. Protection from heavy rain needed And provide adequate rain water drainage*	
1-2	*19. Provide adequate rain water drainage*	✓
0	*20. No protection from heavy rain required*	

Source: Author's analysis, 2026

After analysing the Climatic data of Abeokuta in the Tables B1,B2 and B3 above, the following Bioclimatic design procedures were recommended

1. **Layout:** Buildings should be orientated on east-west axis to reduce exposure to sun
2. **Spacing:** Open spacing should be provided for breeze penetration, but openings should be protected from hot and cold wind
3. **Air Movements:** Rooms should be single banked. Permanent provision for air movement is required
4. **Openings:** Medium openings, 20 -40 % of wall area
5. **Walls:** Heavy external and internal walls
6. **Roofs:** Heavy roofs; over 8 hours' time lag
7. **Outdoor sleeping:** No provision for Outdoor sleeping required
8. **Rain protection:** Protection from heavy rain not required but make provisions for adequate rain water drainage.

Lagos

Table 13: Air temperature, Relative humidity and Indicator for Lagos

Lagos 2016-2023	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Monthly Mean Max Temperature (^{0}c)	34.3	34.5	34.1	33.7	32.5	30.7	29.5	29.4	29.9	31	32.9	33.7
Monthly Mean Min Temperature (^{0}c)	23.3	25	25.4	25	24.4	23.4	23.4	23.4	23.4	23.5	23.5	22.7
Monthly mean temperature range (^{0}c)	11	9.5	8.7	8.7	8.1	7.3	6.1	6	6.5	7.5	9.4	11

Lagos 2016-2023	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Mean Max. Relative Humidity (%)	72	77	78	77	83	84	85	83	82	80	79	81
Monthly Mean Min. Relative Humidity (%)	50	58	62	66	72	79	79	76	77	76	71	61
Monthly Mean Relative Humidity average (%)	61	67.5	70	71.5	77.5	81.5	82	79.5	79.5	78	75	71
Humidity group	3	3	4	4	4	4	4	4	4	4	4	4
Rainfall (mm)	26.8	47.5	73.3	122.5	206.8	294.9	182.1	71.1	267.8	216.8	86.4	29.4
Day Thermal Stress	++	++	++	+	+	+	+	**0**	+	+	+	+
Night Thermal Stress	-	-	**0**	**0**	-	-	-	-	-	-	-	-

AMT = 28.6

Note: *Day and Night thermal stress are adopted from the previous Evans comfort scale analysis; + and ++ are within the Mahoney Hot discomfort range, 0 =Neutral, and - and - - are within the Mahoney's Cold discomfort range.*

Source: Authors' Analysis, 2026

Table 14: Indicator Table

	Jan.	***Feb.***	***Mar.***	***Apr.***	***May***	***Jun.***	***Jul.***	***Aug.***	***Sep.***	***Oct.***	***Nov.***	***Dec.***	***Total***
Humid													
H1 Air movement (essential)	--	√	√	√	√	√	√	--	√	√	√	√	*10*
H2 Air movement (desirable)	--	--	--	--	--	--	--	√	--	--	--	--	*01*
H3 Rain protection	--	--	--	--	√	√	--	--	√	√	--	--	*04*
Arid													
A1 Thermal storage	√	--	--	--	--	--	--	--	--	--	--	--	*01*
A2 Outdoor sleeping	--	--	--	--	--	--	--	--	--	--	--	--	*00*
A3 cold-season problem	--	--	--	--	--	--	--	--	--	--	--	--	*00*

Table 15: Sketch Design Recommendations for Lagos

Indicator total from table 4						***Recommendations***	
Humid			*Arid*				
H1	*H2*	*H3*	*A1*	*A2*	*A3*		
10	*01*	*04*	*01*	*00*	*00*		
						Layout	
			0 - 10			*1Buildings orientated on east-west axis to reduce exposure to sun*	✓
					5 - 12		
			11- 12		*0 - 4*	*2. Compact courtyard planning*	
						Spacing	
11 or 12						*3. Open spacing for breeze penetration*	
2 - 10						*4. Open spacing for breeze penetration, but protect from hot and cold winds*	✓
0 or 1						*5. Compact planning*	
						Air movement	

Indicator total from table 4				*Recommendations*	
3 - 12				*6. Rooms single banked. Permanent provision for air movement*	✓
		0 - 5			
1 or 2		*6 - 12*		*7. Double- banked rooms with temporary provision for air movement.*	
	2 - 12				
0	*0 or 1*			*8. No air movement requirement.*	
				Openings	
		0 to 1	*0*	*9. Large openings, 40 - 80 % of N and S walls*	✓
		11 or 12	*0 - 3*	*10. Very small openings, 10 - 20 %*	
		Any other conditions		*11. Medium openings, 20 -40 %*	
				Walls	
		0 - 2		*12. Light walls; short time lag*	✓
		3 - 12		*13. Heavy external and internal walls*	
				Roofs	
		0 - 5		*14. Light and well insulated roofs*	✓
		6 - 12		*15. Heavy roofs; over 8 hours' time lag*	
				Outdoor sleeping	
			0	*16. No provision for Outdoor sleeping required*	✓
			2 - 12	*17. Space for outdoor sleeping required*	
				Rain penetration	
	3 - 12			*18. Protection from heavy rain needed And provide adequate rain water drainage*	✓
	1-2			*19. Provide adequate rain water drainage*	
	0			*20. No protection from heavy rain required*	

Source: Author's analysis, 2026

After analysing the Climatic data of Abeokuta in the Tables C_1, C_2, C_3 above, the following Bioclimatic design procedures were recommended

1. **Layout:** Buildings should be orientated on east-west axis to reduce exposure to sun
2. **Spacing:** Open spacing should be provided for breeze penetration, but openings should be protected from hot and cold wind
3. **Air Movements:** Rooms should be single banked. Permanent provision for air movement is required
4. **Openings:** Large openings, 40 - 80 % of N and S walls
5. **Walls:** Light walls; short time lag
6. **Roofs:** Light and well insulated roofs
7. **Outdoor sleeping:** No provision for Outdoor sleeping required
8. **Rain protection:** Protection from heavy rain needed and make adequate rain water drainage provision

Comparative Design Recommendations

Table 16 presents the synthesised design recommendations for all three study cities as generated by the YetOke Model.

Table 16: YetOke Model comparative passive design recommendations for Ibadan, Abeokuta, and Lagos (Authors' Analysis, 2025)

Design Element	Ibadan	Abeokuta	Lagos
Building Orientation	East–West axis	East–West axis	East–West axis
Spacing	Open, protected from hot/cold winds	Open, protected from hot/cold winds	Open, protected from hot/cold winds
Air Movement	Single-banked; permanent provision	Single-banked; permanent provision	Single-banked; permanent provision
Openings	Medium (20–40% N & S walls)	Medium (20–40% N & S walls)	Large (40–80% N & S walls)
Walls	Light walls; short time lag	Heavy internal & external walls	Light walls; short time lag
Roofs	Light and well insulated	Heavy; >8 hrs time lag	Light and well insulated
Rain Protection	Heavy rain protection + drainage	Adequate drainage only	Heavy rain protection + drainage
Outdoor Sleeping	Not required	Not required	Not required

The YetOke Model identifies five universally applicable passive design strategies for warm-humid Southwest Nigeria: (i) east-west building orientation to minimise solar exposure through the long building elevations; (ii) open building spacing with protection from prevailing hot and cold winds; (iii) single-banked room configurations with permanent provisions for cross-ventilation; (iv) protection from heavy seasonal rainfall with adequate drainage systems; and (v) no requirement for outdoor sleeping provision, given the uniformly non-arid character of all three cities.

Three design domains exhibit significant inter-city variation. Wall construction diverges most markedly: Abeokuta's wide diurnal range (up to 13.6°C) warrants heavy thermal mass walls with long time lags to buffer the day-night temperature differential, while the narrower diurnal ranges in Ibadan and Lagos (6.0–10.9°C) make light wall construction with short time lags more appropriate. Roof construction follows the same logic: Abeokuta requires heavy roofs with time lags exceeding eight hours, while Ibadan and Lagos benefit from light, well-insulated roof assemblies that minimise heat gain without excessive thermal mass. Opening ratios also differ: Lagos- with its persistently high H1 scores and oceanic humidity warrants large openings of 40–80% of the north and south wall area, while medium openings of 20–40% are appropriate for both Ibadan and Abeokuta, where seasonal variations in humidity and temperature necessitate a balance between ventilation and heat moderation.

Seasonal Design Strategies Implied by the YetOke Model

An important emergent feature of the YetOke Model is its inherent seasonality: because the Evans–Mahoney integration operates on a monthly basis; the model reveals shifting design priorities across the year rather than producing a single annual prescription. During the dry season (November–March), when daytime 'very hot' (++) conditions and night-time 'cold' (−) ratings co-occur across all three cities, building design must simultaneously address aggressive

heat protection through shading, reflective surfaces, and ventilation and nocturnal cold moderation through thermal mass or operable insulation. During the transitional months of April–June and October, 'hot' (+) daytime conditions coincide with 'cold' (−) nights, indicating that cross-ventilation should be maximised during the day while windows are partially closed at night. During the wet season (July–September), when Ibadan achieves 'comfortable' (0) daytime ratings and humidity climbs to 85–88%, the design priority shifts from heat protection to moisture management: building envelopes must facilitate continuous airflow while protecting interiors from driving rain and preventing condensation on cool surfaces.

This seasonally adaptive design logic is consistent with the adaptive thermal comfort model advocated by ASHRAE Standard 55 and with the findings of Lapisa et al. (2018) and Patel & Ghuge, 2024), who demonstrated that occupant comfort temperature in naturally ventilated tropical buildings is best predicted by running mean outdoor temperature rather than fixed thresholds. The YetOke Model thus provides the localised empirical basis for implementing adaptive comfort principles in Southwest Nigerian institutional buildings.

Discussion

Methodological Contributions of the YetOke Model

The primary methodological contribution of the YetOke Bioclimatic Comfort Model lies in its formalisation and systematisation of the Evans–Mahoney integration into a replicable, five-component analytical framework. Previous applications of these tools in Nigeria have employed them in parallel but without a unifying structural model that establishes explicit analytical linkages between Evans outputs and Mahoney inputs, or that mandates cross-location validation as a quality-assurance step. By codifying these linkages, the YBCM ensures that thermal stress diagnosis and design prescription are analytically co-produced rather than sequentially appended, reducing the risk of interpretive inconsistencies at the Evans-to-Mahoney translation stage.

A further methodological contribution is the model's explicit resolution of the Evans–Mahoney classification gap. The Evans Scale's five-tier output ('very cold', 'cold', 'comfortable', 'hot', 'very hot') must be translated into the Mahoney Tables' three-tier input ('cold', 'comfortable', 'hot') at the indicator scoring stage. The YBCM formalises this translation mapping both '+' and '++' to Mahoney's 'hot' and both '−' and '−−' to Mahoney's 'cold'. This translation directly alters the resulting numerical indicator totals relative to the standard Mahoney derivation method, as the expanded five-tier inputs are structurally collapsed to fit the standard three-tier scoring framework. Simultaneously, the model preserves the Evans Scale's granular stress severity data in the diagnostic output layer. This dual-layer approach provides architects and planners with both the design prescription (Mahoney output) and the thermal stress context (Evans output) simultaneously, enabling more nuanced design decision-making than either tool alone would allow.

The YetOke Model also addresses a significant gap in bioclimatic assessment literature by demonstrating that ostensibly similar cities within the same climatic zone- Ibadan, Abeokuta,

and Lagos require meaningfully different wall construction, roof construction, and opening size specifications. This finding challenges the common practice of applying single-set regional design guidelines across Southwest Nigeria and provides empirical support for the Nigerian Building Energy Efficiency Code's call for region-specific guidelines (N-BEEC, 2017, as referenced in Geissler et al., 2018).

Comparison with Existing Models and Studies

The YetOke Model's prescriptions converge with those of several recent empirical studies in analogous contexts. Sorgho et al. (2022) identified single-banked room configurations with cross-ventilation as the single most effective passive strategy for warm-humid office buildings in Burkina Faso, reducing discomfort hours by 40% is consistent with the YBCM's universal prescription of single-banked rooms with permanent air movement for all three Nigerian cities. The model's recommendation of light, well-insulated roofs for Ibadan and Lagos aligns with simulation findings by Abdullahi et al. (2025) and Ibrahim et al. (2025) for analogous Nigerian institutional building typologies, where roof insulation was shown to deliver the greatest reductions in solar heat gain. The recommendation of heavy thermal mass walls for Abeokuta corresponds with the findings of Ghada (2021) for climates characterised by diurnal temperature ranges exceeding 10°C, where thermal mass has been shown to reduce peak indoor temperatures by up to 4°C.

The YetOke Model's performance may also be contextualised against the ASHRAE 55 adaptive model, which defines the comfortable indoor operative temperature range as a function of the prevailing mean outdoor temperature. For Southwest Nigeria's dry-season months (mean outdoor temperatures of 28.5–30.5°C), the ASHRAE 55 adaptive model predicts comfortable indoor temperatures of approximately 27–30°C for 90% acceptability in naturally ventilated buildings- values that the YetOke Model's prescriptions are specifically designed to achieve passively (Lapisa et al., 2018). During wet-season months (mean outdoor temperatures of 25.5–27°C), the corresponding adaptive comfort range narrows to approximately 24–28°C, suggesting that the wet season's naturally comfortable daytime conditions are achievable through ventilation alone, without thermal mass thereby reinforcing the model's recommendation against heavy wall construction in Ibadan and Lagos.

Policy Implications and the N-BEEC Alignment

The YetOke Model's outputs directly inform the regulatory gap identified in Nigeria's building energy policy landscape. The N-BEEC, launched in 2017, emphasised climate-adaptive design as the primary lever for reducing cooling energy consumption in Nigerian buildings but acknowledged the absence of location-specific design guidelines as a critical implementation barrier (Geissler et al., 2018). The YBCM, by generating city-specific passive design prescriptions from publicly available meteorological data, provides precisely the kind of evidence base that the N-BEEC's implementation framework requires.

More broadly, the model's application to public university buildings positions it within Nigeria's higher education infrastructure development agenda. Nigerian universities facing extreme energy poverty, with electricity supply interruptions averaging 8–12 hours per day stand to benefit enormously from building envelopes designed to maintain thermal comfort passively. The YBCM's prescriptions, if incorporated into institutional building specifications, could materially reduce the dependence on diesel generator-powered air conditioning that currently constitutes one of the largest operational expenses for Nigerian universities (Alegbe et al., 2025).

The model is further relevant to the emerging discourse on climate resilience in Nigerian urban development (SPP, 2024). As climate change intensifies heat stress events across Southwest Nigeria, a trend documented by Nasara et al. (2026) over the 1950–2023 period, the building stock's adaptive capacity will depend increasingly on the quality of passive design embedded at the construction stage. The YetOke Model provides a practical and accessible tool for architects, engineers, and building regulators to embed this adaptive capacity systematically.

Limitations and Future Research Directions

The YetOke Model, as presented here, carries several important limitations. First, the model operates on secondary, station-based meteorological data and does not account for intra-urban microclimate variation particularly the urban heat island effect, which can elevate temperatures in dense urban cores by 1–3°C relative to station records (Al-Hajri et al., 2025). Future iterations of the YBCM should incorporate high-resolution microclimate data, potentially sourced from distributed sensor networks or satellite-derived land surface temperature products. Second, the model does not yet incorporate dynamic building energy simulation to quantify the energy performance benefits of the prescribed strategies in specific building typologies. Coupling the YBCM with EnergyPlus or IES-VE simulation would permit quantification of cooling energy savings, which would significantly strengthen its policy uptake. Third, the model's current validation is limited to three cities within a single climatic zone. Extension to Nigeria's other climatic zones- the warm-dry zone, the hot-dry savanna, and the montane zone and to comparable warm-humid zones in other West African countries, would test the model's generalisability and enable calibration of its component thresholds for diverse contexts. Fourth, the Evans Scale's comfort limits, originally developed in the 1970s, have not been systematically re-validated against modern physiological and psychological comfort data in Nigeria, where acclimatisation patterns may have shifted due to climate change and increased air-conditioning use (Patle & Ghuge, 2024). Updating these limits through a new field-based validation study in Southwest Nigeria represents a critical priority for future work.

Conclusion

This study has presented the YetOke Bioclimatic Comfort Model (YBCM), a novel hybrid analytical framework that integrates the Evans Comfort Scale and the Mahoney Tables into a

five-component sequential model for thermal stress diagnosis and passive architectural design prescription in warm-humid climates. Applied to eight years of meteorological data (2016–2023) for three cities in Southwest Nigeria viz, Ibadan, Abeokuta, and Lagos, the model generated detailed monthly thermal stress profiles and location-specific passive design strategies with a granularity and analytical rigour not previously achieved through application of either tool in isolation.

The Evans Scale analysis revealed that all three cities experience bimodal dry-season thermal stress, with 'very hot' daytime conditions from January to April and a resurgence in November–December, interspersed with cooler wet-season conditions from July to September. Night-time conditions are predominantly 'cold' throughout the year, underscoring the importance of thermally adaptive ventilation management. The Mahoney Tables analysis generated consistent prescriptions for east-west orientation, single-banked room configurations, open spacing, and heavy rain protection, while differentiating significantly in wall construction (light for Ibadan and Lagos; heavy for Abeokuta), roof construction (light for Ibadan and Lagos; heavy for Abeokuta), and opening ratios (large for Lagos; medium for Ibadan and Abeokuta).

The YetOke Model's five-component architecture- thermal stress diagnosis, climatic classification, indicator scoring, design prescription, and cross-location validation provides a replicable, accessible, and empirically grounded framework for generating location-specific bioclimatic design guidelines from publicly available meteorological data. Its application to institutional university buildings in Southwest Nigeria directly addresses the implementation gap in Nigeria's Building Energy Efficiency Code and contributes a practical decision-support tool for architects, planners, and policymakers working to advance climate-responsive, energy-efficient design across tropical West Africa.

Future research should extend the model to other Nigerian climatic zones, couple it with dynamic energy simulation tools, integrate microclimate data, and undertake a systematic re-validation of the Evans Scale comfort limits for contemporary Nigerian populations. These developments would establish the YetOke Bioclimatic Comfort Model as a comprehensive, climate-adaptive standard tool for building design in the Global South.

Declarations

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AKA- Review and editing, visualisation. All authors have read and agreed to the published version of the manuscript.

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