A Framework for Thermal Comfort in Contemporary Buildings in Nigeria: Adapting Passive Design Strategies from Colonial and Tropical Architecture Movement, Rivers State, Nigeria

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Abstract

Passive design strategies have long been employed in traditional buildings as effective architectural responses to achieve thermal comfort, particularly in regions with challenging climatic conditions. These strategies, deeply rooted in indigenous knowledge and adapted to local environments, successfully mitigated the effects of high temperatures, humidity, and solar radiation. However, in contemporary architectural practice, especially in modern buildings, such approaches are often overlooked or underutilized. This study examines two significant architectural styles within the Nigerian context: the colonial era (1920s to 1950) and the tropical architecture movement era (1950s to 1980).

This study employs a quantitative approach comprising case studies as its primary strategy and survey of literature as its secondary strategy. Data was collected through direct observations using tools such as a thermo-hygrometer and the Building Envelope Fabric Inventory, as well as through structured questionnaires administered to building occupants. In addition, a literature survey was conducted to gather relevant secondary data to support the analysis. The sample size consisted of 42 buildings, evenly split between 21 colonial architecture buildings and 21 tropical architecture movement buildings. These case studies were drawn from five towns across five local government areas within the study region.

Forty-four (44) passive design features such as windows with jalousies, vents in roofs and ceilings, deep eaves, and hooded windows were identified across both architectural styles, with only six features found to be common to both. The analysis revealed notable differences in the thermal performance of the two styles. Based on these insights, the study developed a thermal comfort framework that can inform the retrofitting of existing buildings and guide the design of contemporary structures in similar climatic contexts.

Keywords: Thermal comfort, Passive design, Colonial architecture, Tropical architecture movement, Contemporary buildings

Introduction

Contemporary buildings in tropical climates frequently experience thermal discomfort due to poor adaptation to local environmental conditions. Modern architectural practices often prioritize aesthetics and cost efficiency over climatic responsiveness, leading to increased indoor temperatures, dependency on mechanical cooling systems, and elevated energy consumption. These problems are compounded by poor orientation, limited natural ventilation, and the use of heat-retaining materials such as concrete and glass.

Passive design strategies are architectural methods that harness natural environmental conditions to achieve thermal comfort and offer a sustainable alternative. These strategies reduce reliance on mechanical systems and promote energy efficiency through features such as natural ventilation, shading, thermal mass, and appropriate building orientation. According to Givoni (1994), passive systems typically require no energy input and are often low-cost or no-cost, making them ideal for resource-constrained contexts. Historically, passive design strategies have been effectively integrated into traditional architecture to enhance indoor comfort.

In Nigeria, buildings from the Colonial period and the Tropical Architecture Movement era demonstrate such strategies, incorporating high ceilings, jalousie windows, deep overhangs, and roof vents to moderate internal climate conditions (Uduku, 2006; Brisibe, 2020). However, contemporary architectural practices have largely abandoned these climate-responsive techniques in favour of modern materials and construction trends that are less suited to the tropical environment (Le Roux, 2003).

In this context, this study investigates the passive design strategies employed in traditional tropical buildings and colonial architecture in selected local government areas of Rivers State, Nigeria. In this context, the aim of the research is to explore and adapt passive design strategies from traditional and colonial-era buildings to enhance thermal comfort in contemporary architecture within tropical climates. Its objectives are:

i. To identify key passive design strategies from both architectural styles
ii. To develop a thermal comfort framework based on strategies from both styles and reviewed literature.
iii. To evaluate its applicability for both retrofitting and new constructions
iv. To ascertain the relevance and applicability of these techniques in improving thermal comfort in present-day building practices.

The Context 1: Colonial Architecture

Colonial architecture, particularly British colonial architecture, reflected a fusion of European stylistic traditions with environmental adaptations suited to tropical climates. According to Gomez (2015), colonial architecture refers to the transposition of architectural styles from colonizing nations into their overseas territories, often resulting in hybrid designs that merged foreign aesthetics with the local environmental needs. In colonies lacking established architectural traditions, the British introduced styles popular in Britain at the time but made functional modifications to suit the local climate (Georghiou, 2013). Passive design strategies such as elevated floors (1.2–2.4 metres), wide verandas, large operable windows, and high ceilings were employed to improve airflow, minimize heat gain, and mitigate disease risks like malaria, which was believed to be spread through miasmas (Wilkinson & Power, 1998). These design responses not only enhanced thermal comfort but also protected building materials from humidity and pests. Institutions such as the Liverpool and London Schools of Tropical Medicine emerged to support these efforts, underscoring the link between architectural adaptation and public health during the colonial period.

The Context 2: Tropical Architecture movement

The Tropical Architecture movement emerged in the 1950s, initially in British West Africa, including Ghana, Nigeria, Sierra Leone, and the Gambia, as a response to the need for modernist architecture suited to warm and humid climates (Le Roux, 2003). This architectural style, influenced by colonial design, adapted European modernism to the tropical environment, incorporating passive design strategies to improve thermal comfort. Key features of tropical architecture include the use of brise soleil for shading, adjustable mechanical elements, and double-skin facades (Le Roux, 2003). These designs also prioritized building orientation, exposed concrete finishes, breeze blocks, and strategic use of ventilation to enhance air circulation. Uduku (2006) emphasizes the role of these designs in responding to environmental conditions through functional and aesthetic elements like flat gable roofs, deep eaves (around 0.75 meters), and sandcrete block walls with cement plaster finishes. Internal spaces featured high ceilings (around 3 meters) and ample natural light from large doors and windows, such as double-swing glass panels or French doors, which facilitated the connection between indoors and outdoors. Moreover, floor finishes like cement screed or terrazzo, along with decorative vents and deep porches, contributed to both the functionality and visual appeal of the buildings, while screen walls and single-loaded corridors enhanced privacy and the airflow.

Theoretical Framework

The understanding of thermal comfort within the context of Nigerian architecture particularly in tropical climates requires a multidimensional theoretical lens that incorporates environmental psychology, climatic design principles, and culturally embedded architectural practices. Central to this is the concept of thermal comfort, which, according to ASHRAE (2017), is "the condition of mind that expresses satisfaction with the thermal environment." This subjectivity implies that both environmental and personal factors influence human comfort, including temperature, humidity, air movement, clothing insulation, and metabolic rate.

In tropical regions like Nigeria, where high humidity and temperatures are constant challenges, thermal comfort cannot be achieved solely through mechanical systems. Instead, effective comfort management depends on passive design strategies and design approaches that utilize natural environmental conditions to regulate indoor climate (Nicol et al., 2012; de Dear & Brager, 1998). According to Givoni (1992), these strategies are vital not only for reducing energy consumption but also for aligning buildings with the adaptive behaviors and expectations of the users.

The theoretical foundation of passive design is rooted in environmental determinism and adaptive architecture, both of which find early expressions in the works of scholars such as Amos Rapoport and Paul Oliver. Rapoport (1969) argues that vernacular architecture emerges as a direct response to climate, available materials, and socio-cultural needs, suggesting that environmental context is not peripheral but central to architectural expression. Similarly, Oliver (2003) emphasizes that traditional architectural forms evolve through generations of climatic adaptation and cultural knowledge, providing passive thermal solutions embedded in everyday practice. These theorists highlight that comfort is culturally mediated and inherently architectural supporting the idea that passive systems are not only effective but contextually appropriate.

The principle of traditional architecture understood here as locally developed architectural responses using climate-responsive techniques is therefore a critical lens. Denyer (1978) contributes further by suggesting that such architecture cannot be fully understood outside of its environmental and social systems. These foundational perspectives underpin the argument of this paper that adapting the passive design principles of historical Nigerian architecture can offer sustainable comfort solutions for contemporary buildings. In this framework, passive strategies such as orientation, natural ventilation, shading, thermal mass, and daylighting are not viewed merely as techniques but as theoretical constructs.

Orientation, for instance, is used to regulate solar exposure and air movement, thereby reducing reliance on mechanical systems (Altan et al., 2016; Akande, 2015). Natural ventilation including cross and stack ventilation supports airflow and indoor air quality, aligning with traditional practices observed in buildings generated by both Colonial Architecture and Tropical Architecture Movement (Osasona, 2007). Similarly, shading devices like verandas and roof overhangs reflect long-standing responses to sun exposure and precipitation in humid climates (Shokpeke, 2019).

Colonial architecture in Nigeria, although derived from British architectural traditions, have incorporated several passive design elements to adapt to the tropical climate. For example, building elevations typically 1.2 to 2.4 meters above ground are accepted to enhance air circulation and have prevented material degradation from damp conditions and insect infestation (Wilkinson & Power, 1998). Verandas, wide eaves, and the use of imported yet adaptable materials like corrugated iron sheets and cement have signaled a hybrid architectural model that merged European forms with the tropical needs (Ogunsote & Prucnal-Ogunsote, 2014; Osasona, 2018).

The Tropical Architecture Movement, emerging in the post-colonial period of the 1950s, represents a more deliberate application of modernist ideals to tropical contexts. Architects like Maxwell Fry, Jane Drew, and Otto Koenigsberger, working alongside Nigerian architects such as Adedokun Adeyemi, have introduced design principles that included brise soleil, breeze blocks, and double-skin facades to facilitate shading and natural airflow (Le Roux, 2003; Uduku, 2006). These innovations reflect a theory of "climatic modernism" a convergence of the international style with regional responsiveness, reinforcing the validity of passive systems in tropical contexts.

For assessing thermal comfort in this context, the Temperature-Humidity Index (THI) could be employed. Unlike PMV models that often rely on static lab-based assumptions, THI provides a more straightforward and locally applicable measure, particularly relevant in high-humidity environments (Fanger, 1970; Thom, 1959). This aligns with the advocacy for context-specific comfort indices in tropical design studies (Givoni,1992).

In summary, this theoretical framework is grounded in the interplay between climate, culture, and architectural form. It draws from seminal theories of vernacular architecture, climatic determinism, and environmental adaptation to justify the relevance of passive design strategies in contemporary Nigerian buildings. Rather than imposing external models, it builds upon historically tested approaches found in the buildings generated by both the Colonial and Tropical Architecture Movements to propose a contextually robust and sustainable pathway for achieving thermal comfort in the present-day architectural practices.

Review of Literature

Thermal comfort in residential and institutional buildings has long been a priority in the discourse on passive design strategies, particularly in tropical climates where high temperatures and humidity significantly influence indoor environmental quality. The effectiveness of passive design measures in promoting comfort, energy efficiency, and sustainable architecture is globally recognized, but their contextual application especially in sub-Saharan African regions like Rivers State, Nigeria requires a more grounded and locally sensitive approach.

Studies have shown that buildings designed using passive strategies perform significantly better in terms of indoor thermal regulation (Givoni, 1994; Altan et al., 2016). Givoni (1998) emphasizes that passive cooling methods such as ventilation, shading, and appropriate orientation are vital in tropical climates to avoid mechanical air conditioning and reduce energy consumption. Similar findings are echoed in Southeast Asia and North Africa, where courtyard housing and thermal mass design features are employed to optimize indoor climate (Jaouaf et al., 2024; Tatarestaghi et al., 2018). Indeed, these studies affirm the relevance of passive strategies in hot, humid environments, but their direct application to the Nigerian context demands adaptation to indigenous materials, cultural habits, and socioeconomic conditions.

In Nigeria, empirical investigations into the local relevance of passive design have increased in recent years. In this regard, Akande (2010, 2015) has conducted extensive research on residential buildings in the hot dry regions of Nigeria, advocating for natural ventilation, building orientation, and the use of shading devices to maintain indoor thermal comfort. While informative, these studies have not been not situated within the humid equatorial climate of the

Rivers State, where persistent rainfall, high relative humidity, and coastal breezes shape building performance differently. Alozie, Odim, and Alozie (2016) has taken a step toward addressing this gap by assessing thermal comfort in residential buildings in Umuahia, using the Effective Temperature Index (ETI). Their findings highlight that many houses are thermally uncomfortable for most of the year, largely due to the poor consideration of climate-responsive design in contemporary constructions.

However, the challenge is not solely about climatic variance but also about architectural lineage. In this regard, Rivers State presents a unique architectural tapestry, shaped by the Tropical Architecture Movement (TAM) and the colonial legacies that have introduced spatial arrangements and material uses not fully aligned with the local climate (Uduku, 2006; Brisibe, 2020). For example, Uduku (2006) traces the ideological underpinnings of modernist tropical architecture across West Africa, noting its emphasis on modular design, cross-ventilation, and raised floor system strategies originally deployed to combat heat and dampness. Similarly, Le Roux (2003) outlines how networks of tropical architecture were deployed as part of colonial planning to maintain thermal comfort in the administrative buildings. However, post-independence adaptation of these models in Nigeria has often been diluted by poor execution and material substitution, reducing their efficacy.

Within the Rivers State, recent climatic shifts have intensified the thermal performance challenges of buildings. In fact, Ayotamuno and Tech (2020) document significant climatic changes in the region, including increased flooding and rising temperatures. This underscores the urgent need for buildings that can dynamically respond to such shifts using climate-appropriate design. Ogele (2020) links these climatic changes to broader human security issues, indirectly underscoring the relevance of architectural solutions that mitigate climate stress through passive means.

Globally, the adaptive model of thermal comfort developed by De Dear and Brager (2013) and supported by Nicol, Humphreys, and Roaf (2012) has shifted the discourse from prescriptive to experiential comfort standards. This model suggests that occupants in naturally ventilated buildings can accept wider temperature ranges if they have control over their indoor environments. This is particularly pertinent to the low-income households in the Rivers State, where air conditioning is neither affordable nor sustainable (Akande, 2010). Yet, despite the theoretical applicability, very few studies have tested adaptive comfort models empirically in the Niger Delta, leaving a significant gap in knowledge and practice.

Moreover, contemporary Nigerian studies are increasingly focused on integrating local materials and traditional forms into passive design. For example, Ogunsote and Prucnal-Ogunsote (2014) explore roofing and external finishes in university buildings, finding that reflective and insulated materials contributed positively to comfort levels. Similarly, Brisibe (2020) has offered a compelling case study of the bungalow of the merchant-venturer in the Niger Delta, revealing a vernacular typology inherently aligned with the climatic conditions. They point out that features such as deep eaves, shaded verandas, and elevated floors have been effective in promoting airflow and reducing heat gain. These architectural forms, if reinterpreted in modern designs, could offer resilient solutions rooted in the local context.

Nevertheless, globally, there is growing evidence supporting the role of passive design in reducing energy consumption while improving comfort. For example, Hu et al. (2023) provide a comprehensive review showing that passive design measures in hot climates can reduce energy loads by up to 50%, with corresponding improvements in thermal comfort. Alwetaishi and Taki (2020) have also found that optimizing window-to-wall ratios significantly improved thermal performance in Saudi Arabian school buildings offering lessons for similar institutions in the humid zones of Nigeria. Yet, unlike these regions, Nigeria lacks updated simulation models or empirical datasets specific to its diverse climatic zones, particularly the Niger Delta.

The few existing local studies have largely remained descriptive. For example, Usman and Ayuba (2020) have evaluated passive design features in medical science buildings in Northern Nigeria but have not included performance metrics or user comfort assessments. Likewise, Bulus, Hamid, and Lim (2017) have discussed the use of courtyards as passive cooling strategies but have stopped short of contextual adaptation in different Nigerian climates. These further demonstrate the need for localized, performance-based frameworks.

A theoretical lens into thermal comfort also reveals divergence between international standards and local experiences. The widely used Predicted Mean Vote (PMV) model developed by Fanger (1970) and adapted by ASHRAE (2017) has been criticized for its limited applicability in naturally ventilated buildings in the Global South. The Discomfort Index proposed by Thom (1959) also fails to account for cultural and behavioral adaptation, which are significant in the African settings. Therefore, frameworks built on international standards alone are insufficient to inform policy or practice in the Rivers State.

The need for culturally and climatically specific design is further supported by Osasona (2007, 2015), who highlights how traditional Yoruba architecture, though not from the Niger Delta, reflects deep climate sensitivity through its use of courtyards, natural materials, and spatial organization. In fact, adapting such principles to the architecture of Rivers State possibly by referencing Kalabari and Ogoni traditional housing typologies could offer a pathway toward context-sensitive solutions.

Despite these insights, key gaps remain. First, there is insufficient data on building performance related to the humid climate of the Rivers State, particularly with regard to residential buildings. Second, little has been done to consolidate traditional architectural strategies and contemporary building practices into a replicable design framework. Third, few studies have empirically tested adaptive comfort models with occupants in the region, missing the human dimension of thermal comfort.

To this end, the literature reveals strong support for passive design strategies in improving thermal comfort in tropical climates, with theoretical frameworks and empirical studies from both the global and Nigerian contexts. However, the application of these strategies in Rivers State remains fragmented and under-researched. In this context, a locally grounded framework that integrates empirical performance data, traditional design knowledge, and user comfort perceptions is urgently needed. This study seeks to fill this gap by proposing a thermal comfort framework specifically tailored for contemporary buildings in Rivers State, Nigeria.

Research Methodology

This study adopts a quantitative methodology focused on the systematic collection and analysis of numerical data to evaluate passive design strategies and thermal comfort in colonial and tropical architecture movement buildings in Rivers State, Nigeria. Data was gathered using a structured survey instrument containing both closed and open-ended questions on demographics, building characteristics, and thermal conditions. Purposive sampling was used to select 51 buildings based on criteria related to their architectural styles and dating. The research is primarily quantitative although it does use qualitative data. It draws on both primary data from case studies and secondary data from existing studies that were reviewed to ensure depth and reliability.

Case study research is an in-depth investigation of a phenomenon within its real-life context, particularly valuable for exploring complex issues that cannot be fully understood through traditional quantitative approaches (Ellinger & Rochell, 2016). It allows for the examination of relationships by using theoretical frameworks and triangulating data from multiple sources to ensure validity. This study adopts the multiple and shallow case study approach, which involves analysing several cases across different contexts to identify patterns and variations. While this method may offer less depth per case, it enhances the generalisability and robustness of findings (Yin, 2017).

In this research, a number of buildings from different architectural eras were studied, focusing on their passive design features and thermal comfort performance. To ensure a comprehensive understanding, the study utilised document analysis, surveys, direct observation, and building envelope assessments. Interviews were excluded as they were not relevant to the study objectives. This approach enabled the researcher to compare colonial and tropical architecture movement buildings across Rivers State, Nigeria, and to build a framework grounded in real-world data and context.

Study Area and the Case Studies

The Study Area

Rivers State, one of Nigeria's 36 states, is in the South-South geopolitical zone within the Niger Delta region. Rivers State has 23 local government areas that spans 11,077 square kilometres and is in Nigeria's South-South geopolitical zone, specifically within the delta region. It shares boundaries with Anambra, Imo, and Abia States to the North; the Atlantic Ocean to the South; Bayelsa and Delta States to the West; and Akwa Ibom State to the East (Ogele, 2020).

Its capital, Port Harcourt, is situated in a region characterized by a tropical monsoon climate, which includes two distinct seasons: an extended rainy season and a short dry season. December and January are typically the only months classified as part of the dry season. The state experiences significant rainfall throughout the year, following a bimodal pattern, with heavy precipitation even during the dry months. This makes Rivers State unique in that the harmattan season, which affects much of West Africa, has a minimal impact here (Ayotamuno & Tech, 2020). The topography of the state consists of both upland and riverine areas, with the uplands covering about 61% of the landmass, including Port Harcourt, Isiokpo, and Elele, characterized by tropical rainforests and relatively higher elevations. The remaining 39% comprises riverine zones like Abonnema and Opobo, which are part of the intricate network of waterways and mangrove swamps of the Niger Delta. This division results in varied ecosystems and topographies across the state. The study area comprises of five towns across five local government areas in Rivers State, Nigeria. The towns are Opobo in the Opobo Nkoro Local Government Area, Abonnema in the Akuku Toru Local Government Area, Isiokpo and Elele in the Ikwerre Local Government Area, as well as Old Town and Orominike in the Port Harcourt Local Government Area. Moreover, Rumuola and Rumuadolu communities were examined within the Obio/Akpor Local Government Area. It is important to note that some areas in the Port Harcourt local government area and Obio/Akpor local government areas make up the Port Harcourt metropolitan area; therefore, Old Town, Orominike, Rumuola and Rumuola will henceforth be referred to collectively as Port Harcourt.

Rivers State experiences a tropical rainforest climate, characterized by high temperatures, high humidity, and significant rainfall throughout the year. This climatic context necessitates the adoption of passive design strategies to achieve thermal comfort in buildings, as mechanical systems for cooling and ventilation are often inefficient and costly in such an environment. In Rivers State, where air temperatures remain consistently high and can regularly exceed 30°C and humidity levels remain high thereby trapping heat indoors, achieving thermal comfort requires careful consideration of both environmental and architectural factors. The high humidity, in particular, makes it more difficult for the body to dissipate heat through evaporation, thus exacerbating discomfort. Temperatures in Rivers State remain relatively stable year-round, with monthly maximum averages ranging from 28°C to 33°C, and minimum monthly averages between 17°C and 24°C. The mean annual temperature is approximately 26°C, with the hottest months occurring from February to May. The temperature difference between the wet and dry seasons is minimal, averaging about 2°C. Relative humidity stays high throughout the year, with a slight decline during the dry season (Ayotamuno & Tech, 2020).

Data collection

In this study, data were collected using surveys, direct observations, and document analysis. These methods enabled the researcher to obtain both quantitative and qualitative data on building envelope features, thermal conditions, and architectural details across multiple case studies. Interviews were not used, as they were not applicable to the research focus. The research used the following instruments:

i. Building Composition Table (BCT)
ii. Building Envelope Features Inventory (BEFI)
iii. Thermo-hygrometer.
iv. Review of secondary data

Pilot study

A pilot study was carried out to test the feasibility of the research methods, identify potential issues, refine data collection tools, and improve overall study design before the main research begins giving the researcher access to the gate keepers and receptive historians. Towns with a proliferation of buildings constructed between 1920 to 1980 were therefore identified.

The Survey

Multiple buildings across the two architectural eras were examined by administering a mixed-format survey instrument directly to building occupants to obtain reliable, first-hand information. It served multiple purposes: confirming the chronological age and architectural classification of each building, verifying that respondents were adults capable of providing informed responses, and collecting detailed accounts of any renovations or alterations made to the structures. The inclusion of both closed and open-ended questions allowed for standardized data collection while capturing additional context essential to understanding the buildings' current states. Other survey instruments such Building Composition Table (BCT) and Building Envelope Features Inventory (BEFI) were used to record data through direct observation.

Direct Observation

The buildings were first tabulated in the Building Composition Table as an originality test. The aim was to assess the architectural integrity of each building. This is to evaluate the extent to which the 51 buildings retained their original architectural features. This assessment employed a survey instrument titled the Building Composition Table, which detailed building components and elements across key structural categories: roof, walls/columns, and floors/stairs. The table listed specific elements under each component, such as roofing materials, ceiling types, wall finishes, and floor finishes, along with other considerations like insulation and column materials. Each building element was assessed for its alignment with the original design. A binary scoring system was used, where "yes" = 1 indicated the feature was consistent with its original state, and "no" = 0 indicated deviation. The data collected from this survey allowed for the calculation of a total score and percentage for each building. Only buildings that scored 70% or above in originality were considered for further analysis. This threshold ensured that the selected buildings adequately represented their original architectural design, preserving the integrity of the study's focus on passive design strategies.

Table 1: Building Composition Table (BCT)
Source: Author

BUILDING COMPOSITIONS					
S/No	BUILDING COMPONENTS	BUILDING ELEMENTS			ADDRESS
1	ROOF	ONE FLOOR	MORE THAN ONE FLOOR	-	
2		covering	"	-	-
3		ceiling	"	-	-
4		woodwork	"	-	-
5		others such as insulation	"	-	-
6	WALL/ COLUMNS	wall material	"	-	-
7		internal finishing	"	-	-
8		external finishing	"	-	-
9		window opening	"	-	-
10		door opening	"	-	-
11		others such as insulation	"	-	-
12			internal column material	-	-

13			internal column finishing	-	-
14	FLOOR/ STAIRS	ground floor finish	"	-	-
15		others e.g insulation	"	-	-
16			elevated floor finishing	-	-
17			Stairs	-	-
18	TOTAL				-
19	PERCENTAGE				
20	where yes =1 and no =0				

Fifty-one (51) buildings were subjected to the Building Composition Test, of which 48 recorded a score of 70% or above. Among these, 23 were identified as colonial buildings, while 25 represented tropical architecture. To ensure balanced research and maintain parity across the two categories, the originality criteria threshold was raised to 75%. Consequently, the study selected a total of 42 buildings that scored above 75%, comprising 21 colonial buildings and 21 tropical architecture movement buildings to facilitate a comparative analysis with equal sample sizes

Table 2: Frequency and Percentage of Building Era Distribution
Source: Author

Building Era	Frequency	Percentage
Colonial	21	50%
Tropical	21	50%
Total	**42**	**100%**

These 42 buildings were then further subjected to another survey instrument 'Building Envelope Features Inventory' (BEFI) to comprehensively record data gotten through observation that identified passive design features that made up the architectural styles. Roslan and Said (2020) emphasize the importance of identifying and documenting key architectural elements when assessing heritage buildings, including their setting, shape, roof features, projections, and decorative trim. The setting encompasses the surrounding environment, while the building's shape and form define its visual character. Roof design, porches, bay windows, and decorative elements such as color, patterning, shutters, railings, and exterior wall panels further contribute to the overall aesthetic and functional identity of the structure. Beyond these visual characteristics, it is also essential to recognize how these elements along with materials, construction methods, and building components, play a role in shaping indoor thermal comfort. Similarly, Alozie, Odim, and Alozie (2016) also considers factors like building orientation, plot area coverage, landscaping, setbacks, fencing heights, material choices, and finishes. Additionally, elements such as the zoning of living spaces, room dimensions, ceiling heights, window types and sizes, and the placement of openings all significantly impact both the functionality and thermal performance of a building. Understanding these aspects holistically allows for a more comprehensive analysis of indoor comfort. This instrument is also used to record temperature and relative humidity readings obtained from a thermo-hygrometer. Thermo-hygrometer is a device that measures both temperature and relative humidity. It is essential for assessing indoor comfort, as these two factors directly influence how occupants feel within a space. High temperatures or humidity levels can lead to discomfort, while optimal ranges support thermal comfort, health, and productivity.

Fig. 1: Thermo-hygrometer RT817E by Thermoworks
Source: Author

Table 3: Inventory of the Building Envelope Features
Source: Author

BUILDING ENVELOPE FEATURES INVENTORY					
	Building Elements			**address**	**address**
S/No					
1	Roof	Covering	Concrete tiles/slates		
2			Shingles		
3			corrugated sheets		
4			asbestos sheets		
5		roof type	hip/dutch		
6			Gable		
7			shed/monopitch		
8			Others		
9		roof pitch	>45		
10			20-45		
11			5'-20'		
12			flat roof		
13			Others		
14		roof eaves	over 1200mm		
15			901-1200mm		
16			601-900mm		
17			301-600mm		
18			< 300mm		
19			no eaves		
20		ceiling	asbestos boards		
21			wooden batten		
22			particle board		
23			exposed beams		
24			Others		
25	Walls	internal	timber cladding		
26			cement plaster render		
27			corrugated steel cladding		
28			painted cement plaster render		
29		external	Brick		
30			ornamental concrete blocks		
31			timber cladding		

32			cement plaster over concrete blocks		
33			Brick covered with cement plaster		
34			corrugated sheets cladding		
35		height	over 4000mm		
36			3000-4000mm		
37			2400-3000mm		
38			less than 2400mm		
39		door type	wooden (carved)		
40			wooden (panel)		
41			wooden (panel and with jalousies)		
42			wooden panel and without jalousies		
43			Glass casement		
44			Louvers		
45			glass panel		
46	wall cont'd	entrance door movement	double swing		
47			single swing		
48			slide shutter		
49			dual purpose door and window		
50		door size	>2.4x1.2		
51			2.4x1.2		
52			2.1x1.5		
53			2.1x1.2		
54			<2.1x0.92.1x1.5		
55		window style	glass casement		
56			glass louvers		
57			wooden shutter with slatted jalosie		
58			wooden shutter with panel		
59			steel shutters		
60			sliding windows		
61		window glass type	Opaque		
62			transparent		
63			translucent		
64			stained glass		
65			coloured glass		
66			steel mesh		
67		window size	>2.4x1.2m		
68			1.8x1.2 to 2.1x1.2m		
69			1.2x1.2 to 1.2x1.5m		
70			0.6x1.2 to 0.9x1.2		
71			0.9x1.5m		
72			Others		
73		ventilation	cross ventilation		
74			single ventilation		
75			mechanical ventilation		
76			open walls		
77			Others		
78	Floors	finishes	Terrazzo		
79			wooden floor boards		
80			cement screed floor		
81			concrete floor		
82			plastic tiles		
83			ceramic tiles		

84	Other considerations	unique features	Hoods		
85			roof/ceiling vents		
86			high level window/ jalousies		
87			porch/ porticos		
88			Balcony		
89			Others		
90	TH readings	temperature in degree celcius and relative humidity in percentage	Morning temperature (°C)		
91			Morning relative humidity (%)		
92			Afternoon temperature (°C)		
93			Afternoon relative humidity (%)		
94			Evening temperature (°C)		
95			Evening relative humidity (%)		

Review of Secondary Data

This study also relied on secondary data to generate a wholistic approach to proposing a framework for thermal comfort. Certain design considerations such as single-loaded and double-loaded corridors which significantly influence the thermal performance of a building, especially in hot climates needed to be incorporated. Single-loaded corridors, with rooms on one side and open spaces on the other, encourage cross-ventilation, reducing indoor heat buildup (Bulus et al., 2017). In contrast, double-loaded corridors, which have rooms on both sides, often restrict airflow, leading to higher temperatures and increased reliance on mechanical cooling systems (Tatarestaghi et al., 2018). Other considerations necessary to mitigate heat gain include shading elements like overhangs, louvers, and greenery which help to block direct solar radiation while maintaining the natural airflow (Hu et al., 2023). These elements are particularly effective in tropical climates, where high temperatures and humidity make passive cooling strategies essential (Alwetaishi & Taki, 2020).

Consequently, courtyards have long been considered a vital feature in passive cooling strategies, promoting air circulation and creating shaded cool microclimates within the buildings. Research highlights their role in regulating indoor temperatures by reducing heat accumulation and enhancing evaporative cooling, especially when combined with vegetation and water features (Callejas et al., 2020). Open courtyards in tropical and colonial architecture generate pressure differentials that drive airflow through indoor spaces, improving ventilation (Hu et al., 2023). Meanwhile, closed courtyards, when designed with adequate openings, provide shaded, thermally stable environments that buffer against extreme heat fluctuations (Bulus et al., 2017). These strategies align with climate-responsive design principles, ensuring energy efficiency while enhancing occupant comfort (Olgyay & Olgyay, 2015).

The use of breathing walls (perforated or air-permeable materials) further enhances ventilation, preventing excessive heat buildup inside the walls (Shalaby et al., 2020). Similarly, raised dwarf walls, a common feature in colonial-era buildings, minimize direct heat transfer from the ground while allowing air circulation beneath the floors (Hu et al., 2023). These techniques help optimize indoor comfort and reduce the need for mechanical cooling in tropical climates. Window design and landscaping also contribute to thermal comfort. Studies suggest that maintaining a window-to-wall ratio (WWR) between 30% and 40% ensures ample daylight while limiting heat gain (Olgyay & Olgyay, 2015).

In fact, Alwetaishi and Taki (2020) has found that in hot climates, WWR should not exceed 35%, 25%, and 20% for Northwest, Southeast, and Southwest facades, respectively, to maintain energy efficiency. Larger openings, paired with external shadings like deep eaves or jalousies, enhance ventilation while reducing the solar exposure. (Rahman et al., 2020). Incorporating greenery and water features in courtyards further mitigates urban heat island effects, reinforcing the effectiveness of passive design strategies (Givoni, 1998).

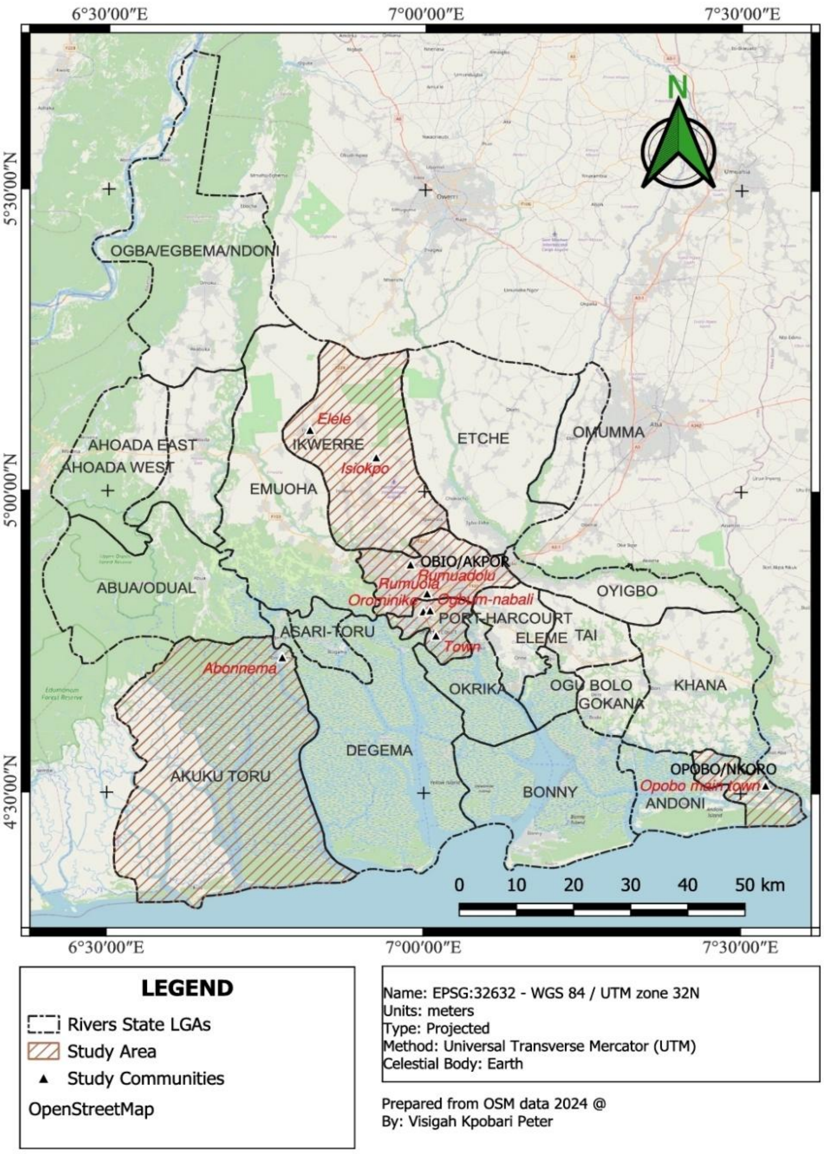

Fig. 2: A map of the towns in the study area, Rivers state**.**
Source: Author

The study is conducted in five towns within Rivers State, Nigeria as follows.

- Port Harcourt,
- Isiokpo, Elele,
- Abonnema, and
- Opobo.

Rivers State consists of approximately 61% upland areas, Port Harcourt, Isiokpo, and Elele, and 39% riverine areas, including Abonnema and Opobo. These towns are selected due to their abundance of colonial and post-colonial buildings, a result of early European contact, particularly with the Portuguese traders and the British colonial administration. Their historical roles as administrative and commercial centres lead to the presence of numerous colonial and Tropical Architecture Movement buildings, ensuring a sufficient and diverse sample size. Thw location of Rivers State in the tropical climate zone also makes it suitable for studying passive design strategies for thermal comfort. Figure 2 presents a geographical map of the study area.

Table 4: Building Envelope Features Inventory
Source: Author

Town	Colonial	Tropical	Total	Percentage
Elele (Upland)	3	3	6	14.3
Isiokpo (Upland)	2	2	4	9.5
Opobo (Riverine)	5	4	9	21.4
Abonnema (Riverine)	6	6	12	28.6
Port Harcourt (Upland)	5	6	11	26.2
Total	**21**	**21**	**42**	**100**

Identifying key passive design strategies from both architectural styles

Using the Building Envelope Features Inventory (BEFI), the predominant features of both colonial and tropical architecture movement buildings were documented in the table below.

Table 5: Key Passive Design Strategies from Both Architectural Styles
Source: Author

Feature	Colonial Architecture	Tropical Architecture Movement
Roof Type	Predominantly hip/Dutch roofs; some feature sun-ray design, leading to a mix of gable and hip roofs.	Flat gable roof.
Roof Pitch	>20 degrees	Flat roof.
Roof Eaves	Typically above 900mm, made of wooden battens in strips of 100-150mm width, offering significant shading.	0.75m or less, providing a streamlined appearance while still offering some protection.
Roof Coverage	Corrugated sheets.	Corrugated sheets.
Ceiling	Made of asbestos (1.2m x 1.2m squares) or wooden strips (100-150mm wide, held by joinery). Equipped with roof and ceiling vents for ventilation.	Made of particle board or asbestos.
External Wall	Primarily brick, either exposed or finished with plain or decorative cement plaster render for durability and aesthetics.	Sandcrete blocks, finished with plain cement plaster render for a clean and modern look.
Internal Wall	Finished with plain cement plaster render, either painted or unpainted. Some feature wood panelling for warmth.	Painted plain cement plaster render for a bright and inviting atmosphere.
Building Height	3000-4000mm, allowing for spacious interiors and improved air circulation.	2400-3000mm.
Door Type	Wooden panel doors, often with slatted jalousies for ventilation. Entrance doors are double swing, starting at 1.2m width, often featuring a fixed high-level window for additional daylight.	Double swing glass panel doors, 1.2m-1.5m width, allowing natural light and indoor-outdoor connection. Can be sliding French doors in some cases.
Window Style & Size	Casement windows that are either fully wood or wood and glass. Wooden windows are sometimes combined with slatted jalousies for improved airflow. High-level windows (often fully operable) range from 0.3x0.9m to 0.3x1.8m. Individual window awnings present in single-storey buildings.	Multiple bay casement windows (1.5m to 2.4m), may also feature louvres for improved ventilation.
Floor Slab & Elevation	Typically elevated from 0.9 meters upwards to prevent moisture ingress and allow air circulation beneath floors.	Features less than 0.6m elevation.

Finishes	Cement screed floor or wooden floorboards.	Ceramic tiles, terrazzo, or cement screed.
Ventilation	Cross ventilation and through ventilation. Integrated vents in walls, ceilings, and roofs to enhance airflow.	Cross ventilation and through ventilation. Walls often incorporate decorative block vents for airflow.
Unique Features	Deep porches (often 1.8m or more), high-level windows, decorative wood panelling, ventilated ceilings. Roof/Ceiling vents are integral for airflow. Brick or ornamental concrete plastered walls. Elevated floor slabs.	Porches, balconies, deep verandas, hoods above windows and doors (at least 0.3m), single-loaded corridors with screen or breathing walls to enhance airflow and privacy.
Porches & Balconies	Present, often deep (≥1.8m) for shading and ventilation.	Present, typically above 1.5m to enhance outdoor living spaces.

Findings and the Discussion

This study examined the thermal comfort performance of Colonial and Tropical Architecture Movement (TAM) buildings in Rivers State using Thermal Heat Index (THI) as an evaluative measure. While both building categories recorded THI values exceeding the ASHRAE standard comfort benchmark, this does not automatically denote thermal inadequacy when viewed within the environmental context of Rivers State. Given that daily temperatures in this region regularly surpass 30°C and relative humidity often remains high occasionally reaching even extreme levels, such conditions pose unique challenges to achieving universally defined thermal comfort standards.

Within this climatic reality, both colonial and TAM buildings demonstrate commendable levels of thermal performance, albeit with room for improvement. The data indicates that colonial-era buildings performed slightly better, with marginally lower then the THI values. This performance advantage can be attributed to the strategic use of ventilation systems such as roof vents, ceiling vents, operable windows, and wall openings. These features collectively support cross-ventilation and heat dissipation, making colonial buildings more adept at passively regulating indoor thermal conditions. The architectural logic embedded in these structures reflects an intentional adaptation to environmental challenges through design although not necessarily through technological intervention, but through thoughtful spatial planning and material deployment.

TAM buildings, though theoretically grounded in bioclimatic principles, often fall short in practical execution. Factors such as increased building compactness, reduced ventilation surface area, and evolving construction practices may have inadvertently reduced their passive performance capacity. This reinforces observations by scholars such as Akande (2010) and Uduku (2006), who noted that while modern tropical architecture in Nigeria aims for climate responsiveness, it sometimes lacks the integration of effective passive design details at the building envelope level.

Nevertheless, the performance of both building typologies underlines the enduring relevance of passive strategies in contemporary architectural discourse. Neither typology failed to provide habitable environments; rather, they highlight the need for improved adaptation strategies within the tropical context. More importantly, they offer valuable insights into how traditional and transitional architectural knowledge can inform sustainable design in present-day Nigeria.

That is why the proposed passive design framework developed in this study offers a contextually responsive model. It synthesizes building envelope features, environmental performance data, and socio-cultural factors to guide the design of thermally comfortable residential buildings in Nigeria. By drawing from the thermal performance strengths of colonial structures and the theoretical intentions of the TAM period and pairing them with other features identified through empirical and literature-based data the framework contributes to the development of adaptive, resilient, and sustainable architectural practices suitable for Rivers State and similar tropical environments.

A Thermal Comfort Framework Based on Identified Strategies and Reviewed Secondary Data

This study integrates both primary data from case studies and secondary data from existing studies to develop a comprehensive framework for thermal comfort in buildings located in tropical climates. Evaluating primary and secondary data reveals both alignment and notable disparities in passive design strategies for thermal comfort. The review of existing studies emphasizes specific design features that promote thermal regulation in tropical climates, such as single-loaded corridors for enhanced cross-ventilation (Bulus et al., 2017), open and closed courtyards, breathing walls, raised dwarf walls, roof and ceiling vents, external shading devices like overhangs and louvers, and green elements such as vegetation and water features (Hu et al., 2023; Apolonio Callejas et al., 2020).

It also stresses optimal window-to-wall ratios (WWR), specific window orientations, and perforated wall systems (Shalaby et al., 2020). In contrast, the primary data derived from case studies of colonial and tropical architecture movement buildings in Rivers State, Nigeria, revealed a different set of features that were rooted in locally available materials and historically evolved practices. Features like roof type and pitch, extended roof eaves (≥900mm) in colonial buildings, and deep porches (≥1.8m) align with shading and ventilation strategies discussed in literature. However, breathing walls, courtyards, and green integration—widely cited in literature—were absent or minimally featured in the buildings studied. Instead, elevated floor slabs, wooden or asbestos ceilings with roof vents, decorative block vents, and slatted jalousie doors/windows were the dominant strategies enhancing ventilation and thermal comfort. Notably, the presence of ceiling and roof vents across both building typologies reflects a local adaptation to improve air exchange, though this was more structurally embedded than landscaped.

While secondary data underscores environmental features like greenery and orientation-based shading ratios, the case study buildings leaned more on architectural form, material choices, and construction detailing like the use of casement windows, deep verandas, and screen walls to respond to climatic demands. This disparity therefore informed the development of a holistic framework that combines both research-driven strategies and context-specific architectural responses, ensuring a more integrated, climate-responsive approach to enhancing thermal comfort in contemporary Nigerian buildings.

Drawing from the combined data, forty-four (44) design features were identified from the combination of all the design strategies employed. They were identified under four (4) broad groups: building envelope, orientation, layout and materials. The main group served as the identifier group where a feature originated from. This is closely followed by several sub-groups up until the last number that identifies a particular feature.

For the purposes of identification, each feature has a unique identification code which was generated from its main and sub-group or sub-groups as some main groups have more than one sub-group. Building envelope is represented by BE, orientation O, layout L and materials M. This is closely followed with a hyphen then the initials representing the sub-group or sub-groups and a numerical identifier. For example, BE-WW1 represents Glass casement window from the main group Building Envelope (BE), the first sub-group Wall (W) and the second sub-group Window (W) and the numeric identifier 1. It is also the first feature in the window subgroup giving it its unique identification code. It can also be referred to as passive design feature (PDF) 10 as it is the 10th feature out of the total 44 features. Below is a list of all 44 passive design feature (PDF).

Table 6: Passive Design Features
Source: Author

S/No	Group identification	Passive design feature (PDF)	PDF No
1	BE-RCv1	Corrugated roofing sheet	1
2	BE-RCv2	Roof tiles	2
3	BE-RCg1	Asbestos	3
4	BE-RCg2	Polished timber boards	4
5	BE-RE1	Eaves ≥ 900mm	5
6	BE-RE2	Eaves ≤ 600 mm	6
7	BE-RV1	Roof vents	7
8	BE-RV2	Ceiling vents	8
9	BE-RV3	Wall vents	9
10	BE-WW1	Glass casement windows	10
11	BE-WW2	Wood casement with jalousies	11
12	BE-WW3	Wood casement without jalousies	12
13	BE-WW4	Louvers	13
14	BE-WW5	Operable clearstory windows	14
15	BE-WW6	30 to 40% window to wall ratio	15
16	BE-WWt1	Dwarf walls	16
17	BE-WWt2	Breathing walls	17
18	BE-WWt3	Solid walls	18
19	BE-WD1	Wood panel doors with jalousies	19
20	BE-WD2	Wood panel door without jalousies	20
21	BE-WD3	Glass casement doors	21
22	BE-WD4	French doors (window-door)	22
23	BE-S1	Elevated ground floor slab	23
24	BE-S2	Flat foor slab material	24
25	O-H	Hoods ≥ 450mm	25
26	O-CTV	Cross/Through ventilation	26
27	L-Co1	Double loaded corridor	27
28	L-Co2	Single loaded corridor	28
29	L-HSS1	Porches	29
30	L-HSS2	Balconies	30
31	L-HSD1	Enclosed public areas	31
32	L-HSD2	Enclosed private areas	32
33	L-CY1	Open courtyard	33
34	L-CY2	Closed courtyard	34
35	L-AS1	Out houses	35
36	L-AS2	Connected spaces	36
37	L-EW	Landscaping	37
38	M-B1	Exposed brick	38
39	M-B2	Rendered brick	39
40	M-T1	Timber cladding	40
41	M-T2	Laminate timber floorboards	41
42	M-C1	Exposed cement plaster render	42
43	M-C2	Painted cement plaster render	43
44	M-C	Concrete blocks	44

These 44 features come together to form the Thermal Comfort Framework for residential buildings in the tropics. This framework illustrates how these features can work synergistically to enhance thermal comfort and energy efficiency, serving as a guide for integrating passive design principles into contemporary architectural practices.

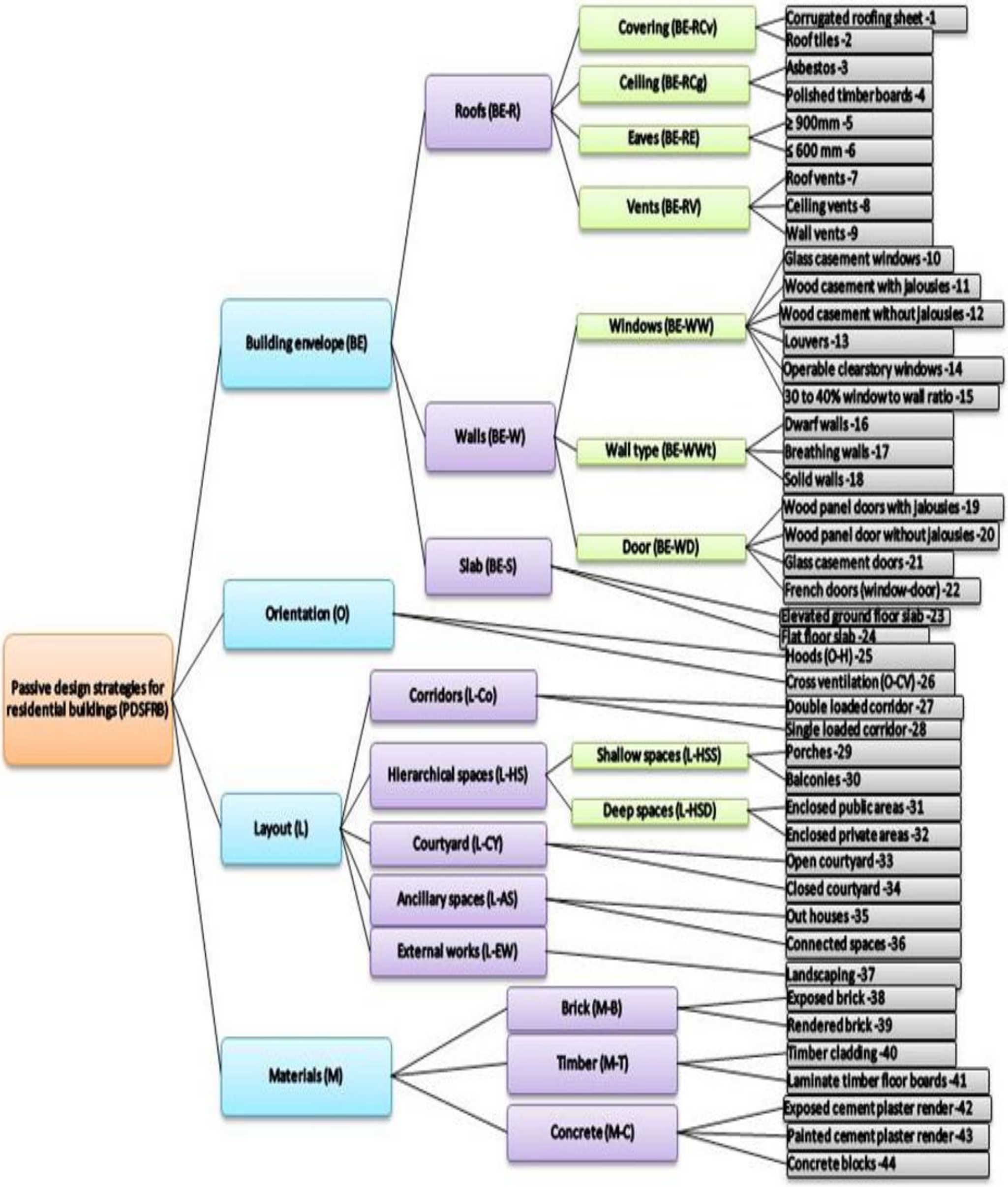

Fig. 3: Thermal Comfort Framework
Source: Author

Thermal Comfort Performance of the Colonial vs. Tropical Architecture

While recording data in BEFI, temperature and relative humidity readings were taken for all the 42 sample buildings to determine the thermal comfort performance using Thermal Heat Index (THI). The table shows the comparison of Thermal Heat Index (THI) values between colonial and TAM era buildings highlights slight differences in indoor thermal comfort. Colonial era buildings exhibit a mean temperature of 33.82°C and a mean humidity of 57.0%, resulting in a THI value of 84.50. In contrast, TAM era buildings have a higher mean temperature of 34.8°C and a mean humidity of 62.4%, yielding a THI value of 86.97. These THI values for both colonial and tropical buildings exceed the standard comfort value of 74.16, derived from a mean temperature of 26°C and humidity of 60%.

This suggests that both building eras provide environments warmer than the optimal comfort level, with tropical buildings being less thermally comfortable than colonial buildings due to their higher THI. Despite advancements in building design during the tropical era, the increase in temperature and humidity suggests that Colonial buildings offer better indoor comfort relative to their Tropical Architecture Movement counterparts with Tropical Architecture Movement buildings approaching the severe stress threshold.

Table 7: Thermal Comfort Performance of Colonial vs. Tropical Architecture Movement
Source: Author

Category	Mean Temperature (°C)	Mean Humidity (%)	THI Value
Colonial	33.8	57.0	84.50
Tropical	34.8	62.4	86.97
ASHRAE Standard Value	**26**	**60**	**74.16**

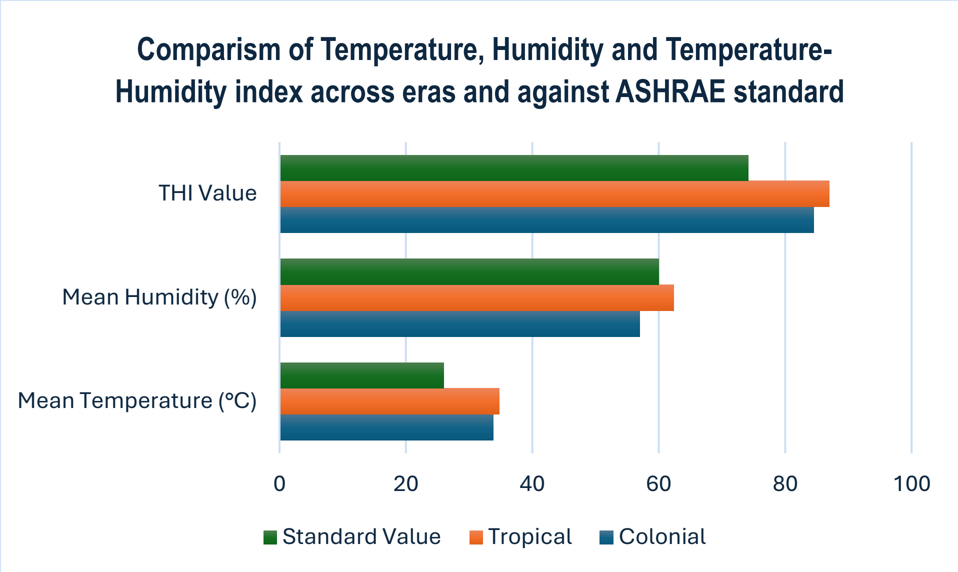

Fig. 4: Comparision of Temperature, Humidity and Temperature-Humidity Index across eras and against AHRAE standard
Source: Author

Applicability for Both Retrofitting and New Constructions

Building upon this framework, a thermal comfort checklist is proposed for use by the professionals in the built environment, as well as government officials and policymakers. These parameters are designed to inform decisions regarding optimal indoor environments, ensuring that new developments prioritize occupant comfort, and existing structures can be remodelled to minimise energy consumption.

Maximum Thermal Comfort Checklist

Buildings that rely solely on natural cooling and ventilation, maximum thermal comfort model should be used. Maximum thermal comfort specifies specific features from each sub group which should be incorporated in the design. Special attention should be given to the materials used in this case, brick and timber, making sure to incorporate porches, balconies, all types of vents, window design and wall types. The building should be able to breathe.

Table 8: Maximum Thermal Comfort Checklist
Source: Author

S/No	Group identification	Passive design feature (PDF)	PDF No	Points per group
1	BE-RCv	Roof tiles	2	1
2	BE-RCg	Polished timber boards	4	1
3	BE-RE	Eaves ≥ 900mm	5	1
4	BE-RV	Vents	7, 8 and 9	3
5	BE-WW	Windows	10 or 11, 14 and 15	3
6	BE-WWt	Walls	16 or 17 and 18	2
7	BE-WD	Wood panel doors with jalousies	19 or 20 or 21 or 22	1
8	BE-S	Elevated ground floor slab	23	1
9	O-H	Hoods ≥ 450mm	25	1
10	O-CV	Cross ventilation	26	1
11	L-Co	Single loaded corridor	28	1
12	L-HSS	Porches and balconies	29 and 30	2
13	L-HSD	Enclosed private areas	32	1
14	L-CY	Open courtyard	33	1
15	L-AS	Connected spaces	36	1
16	L-EW	Landscaping	37	1
17	M-B	Exposed brick	38 or 39	1
18	M-T	Timber cladding	40 and 41	2
19	M-C	Painted cement plaster render	43	1
20	**TOTAL**			**26**

Average Thermal Comfort Checklist

For buildings where there may be some form of dependence on mechanical cooling systems either at certain times of the day or where their available power supply, the average thermal comfort model can be deployed.

Table 9: Average Thermal Comfort Checklist
Source: Author

S/No	Group identification	Passive design feature (PDF)	PDF No	Points per group
1	BE-RCv	Corrugated roofing sheets	1	1
2	BE-RCg	Aesbestos	3	1
3	BE-RE	Eaves ≥ 900mm	5	1
4	BE-RV	Vents	7 and 8 or 9	2
5	BE-WW	Windows	10 or 11 or 13, 14 and 15	3
6	BE-WWt	Walls	18	1
7	BE-WD	Wood panel doors with jalousies	19 or 21 or 22	1
8	BE-S	Flat floor slab	24	1
9	O-H	Hoods ≥ 450mm	25	1
10	O-CV	Cross ventilation	26	1
11	L-Co	Corridors	27 or 28	1
12	L-HSS	Shallow spaces	29 or 30	1
13	L-HSD	Enclosed areas	31 or 32	1
14	L-CY	Courtyard	33 or 34	1
15	L-AS	Ancillary spaces	35 or 36	1
16	L-EW	Landscaping	37	1
17	M-B	Brick	Nil	
18	M-T	Timber cladding	40 or 41	1
19	M-C	Painted cement plaster render	43	1
20	**TOTAL**			**21**

Minimum Thermal Comfort Checklist

For buildings where there's almost total dependence on mechanical cooling systems, the average thermal comfort model can be used as a fall back in the event of power failure.

Table 10: Minimum Thermal Comfort Checklist
Source: Author

S/No	Group identification	Passive design feature (PDF)	PDF No	Points per group
1	BE-RCv	Corrugated roofing sheets	1	1
2	BE-RCg	Aesbestos	3	1
3	BE-RE	Eaves ≥ 900mm	6	1
4	BE-RV	Vents	7 and 8 or 9	1
5	BE-WW	Windows	10 or 11 or 12 or 13	1
6	BE-WWt	Walls	18	1
7	BE-WD	Wood panel doors with jalousies	19 or 21 or 22	1
8	BE-S	Flat floor slab	24	1
9	O-H	Hoods ≥ 450mm	Nil	
10	O-CTV	Cross/ through ventilation	26	1
11	L-Co	Corridors	27 or 28	1
12	L-HSS	Shallow spaces	29 or 30	1
13	L-HSD	Enclosed areas	31 or 32	1
14	L-CY	Courtyard	Nil	1
15	L-AS	Ancillary spaces	35 or 36	1
16	L-EW	Landscaping	Nil	
17	M-B	Brick	Nil	
18	M-T	Timber finishings	40 or 41	1
19	M-C	Painted cement plaster render	42 or 43 and 44	2
20	**TOTAL**			**17**

Conclusion

This study has examined the thermal performance of Colonial and Tropical Architecture Movement (TAM) buildings in Rivers State, Nigeria, using Thermal Heat Index (THI) data derived from measured temperature and relative humidity levels. Both architectural typologies recorded THI values exceeding the standard comfort threshold of 74.16, which reflects the broader climatic reality of Rivers State a region where outdoor temperatures frequently surpass 30°C and humidity levels can be significantly high. In this context, the thermal performance of these buildings cannot be dismissed as inadequate but rather viewed as suboptimal relative to contemporary expectations for indoor comfort.

The slightly better thermal performance of the colonial buildings can be attributed to their extensive use of passive ventilation strategies. These include a greater number and diversity of vents in roofs, ceilings, walls, and windows, which facilitate improved air circulation and thermal regulation. While the TAM era introduced new building ideals, its implementation often did not achieve the same degree of indoor thermal moderation as seen in the colonial prototypes. Nonetheless, both typologies offer valuable insights into regionally responsive design, with each presenting strategies that remain relevant to current thermal comfort needs in hot-humid climates.

The findings underscore the necessity for a more context-specific approach to passive design in Nigeria. That's why the proposed passive design framework developed in this study offers a contextually responsive model. It synthesizes building envelope features, environmental performance data, and socio-cultural factors to guide the design of thermally comfortable residential buildings in Nigeria. By drawing from the thermal performance strengths of colonial structures and the theoretical intentions of the TAM period and pairing these with empirically reviewed features this framework contributes to the development of adaptive, resilient, and sustainable architectural practices suitable for Rivers State and similar tropical environments.

Although this study offers a robust and contextually grounded framework for improving thermal comfort, it is not without limitations. Its strengths lie in its empirical comparison of two architectural typologies and the integration of environmental data with architectural analysis. The study also contributes original insights by highlighting the importance of aligning building performance with local climatic and cultural conditions. However, limitations include the absence of long-term environmental monitoring and a geographic focus restricted to one Nigerian state, which may affect generalizability. Furthermore, while the framework is comprehensive, its application has not yet been tested in live architectural projects. These limitations highlight directions for further research, particularly in piloting and validating the framework across different tropical settings.

Recommendations

The findings of this research underscore the critical role of passive design in enhancing thermal comfort in buildings located in hot-humid regions like Rivers State, Nigeria. The Thermal Comfort Framework developed in this study offers a practical, context-specific tool that draws on the strengths of colonial and Tropical Architecture Movement (TAM) design strategies. The following recommendations are proposed to support the implementation and expansion of this framework.

i. **For Architects and Urban Planners**:

Professionals are encouraged to adopt the Thermal Comfort Framework as a design guide for both new constructions and retrofits. By incorporating features such as strategic building orientation, operable vents, deep overhangs, and thermally responsive materials, architects can enhance indoor comfort and reduce dependence on active cooling systems. The framework helps translate theoretical principles into design decisions suited to the Nigerian tropical context.

ii. **For Government Agencies and Policymakers**:

There is a pressing need to integrate passive design standards into building codes and development guidelines. This includes establishing minimum requirements for natural ventilation, shading, and thermal insulation. Incentives such as tax reliefs, fast-tracked approvals, or green building certifications could further encourage the adoption of climate-responsive architecture. These policy shifts are vital for promoting long-term energy efficiency and occupant well-being.

iii. For Property Developers, Builders, and Homeowners:

One of the major strengths of this study is the development of a Thermal Comfort Checklist that is simple and accessible enough to be used by non-professionals. This tool allows homeowners, builders, and even local artisans to evaluate and improve thermal comfort in both existing and new buildings, without requiring extensive technical knowledge. Encouraging the use of this checklist can lead to widespread adoption of passive strategies at the grassroots level, fostering incremental improvements in housing quality across the region.

iv. For Academic Researchers and Industry Innovators:

Future research should aim to expand and refine the Thermal Comfort Framework for application in other tropical regions. Studies should explore how emerging technologies, such as smart ventilation systems or dynamic shading, can be integrated into passive design without compromising affordability. Longitudinal assessments of buildings constructed or retrofitted using the framework will also help validate its effectiveness and guide future iterations. Moreover, cross-disciplinary collaborations could enhance the social and technical dimensions of the framework, increasing its real-world impact.

Finally, the Thermal Comfort Framework and accompanying Checklist provide a robust foundation for designing climate-responsive residential buildings in Nigeria. Their adaptability, empirical grounding, and accessibility even to non-professionals make them powerful tools for promoting thermally comfortable, sustainable, and culturally relevant architecture in tropical environments.

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