© JUL 2025 | IRE Journals | Volume 9 Issue 1 | ISSN: 2456-8880

Climatic Considerations and implementation of Bioclimatic Design Strategies for Student Affairs Buildings in a Hot-Humid Environment

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Abstract- ***In hot-humid climates such as that of Ilorin, Kwara State, Nigeria, achieving indoor thermal comfort in institutional buildings presents persistent challenges due to high temperatures, intense humidity, and seasonal rainfall. This study examines climatic considerations and the implementation of bioclimatic design strategies in Student Affairs Buildings, with a focus on improving indoor environmental quality while reducing reliance on mechanical cooling systems. Using a mixed-method approach, data were collected through structured questionnaires, site observations, and climate data analysis. A total of 126 staff members from student affairs offices across selected universities participated in the survey, while Mahoney tables and thermal diagnosis tools were employed to analyze local climatic parameters. Findings reveal that Ilorin's climate is characterized by high diurnal temperature ranges in the dry season, extreme humidity during the wet months, and seasonal wind direction shifts. These conditions necessitate design interventions such as proper building orientation (preferably along the east–west axis), cross and stack ventilation, shaded courtyards, thermal mass materials, wide roof overhangs, and rain protection features. Thermal analysis indicates consistent daytime heat stress, emphasizing the need for passive cooling strategies and ventilated building envelopes. Among the bioclimatic strategies evaluated, courtyards and open spaces emerged as the most effective (Relative Importance Index [RII] = 0.85), followed by proper building orientation (RII = 0.81) and natural ventilation methods (RII = 0.79). Buffer zones (e.g., verandas and shaded lobbies) and solar control devices were also widely adopted, while solar panels, though least directly impactful on thermal comfort, supported energy sustainability. These findings demonstrate a growing awareness and integration of climate-responsive design elements in institutional settings. The study concludes that bioclimatic design in hot-humid environments should prioritize passive cooling techniques that align with local climate dynamics and occupant behavior. Implementing design features such as operable windows, vegetative shading, and outdoor communal spaces can enhance comfort, reduce energy use, and create culturally appropriate student environments. The recommendations offer practical guidance for architects, planners, and educational institutions aiming to promote sustainability and resilience in tropical climates.***

Indexed Terms- Bioclimatic Design, Thermal Comfort, Hot-Humid Climate, Passive Cooling

I. INTRODUCTION

Achieving indoor thermal comfort in buildings is pivotal for enhancing occupant satisfaction, productivity, and overall well-being, while simultaneously addressing the environmental and economic challenges associated with high energy consumption (Peter, 2016). The relationship between indoor environmental quality and occupant health is well-established, with thermal comfort playing a significant role in occupant experience. Discomfort from extreme indoor temperatures often leads to stress, fatigue, and reduced productivity among building users (Nicol & Humphreys, 2002; Hedge, 2004). In hot-humid environments, such as the North Central region of Nigeria, prolonged exposure to high indoor temperatures can further contribute to health risks, exacerbating existing medical conditions and posing challenges to energy-efficient building operation (WHO, 2007).

Kwara State, located in Nigeria's hot-humid climatic zone, experiences consistently high temperatures, intense solar radiation, and high humidity levels for most of the year (Malgwi & Sagada, 2014; Aashi ., et al.2020). These environmental conditions create substantial challenges for achieving indoor comfort and energy efficiency in buildings. Institutional and office buildings, often occupied for long hours by a large number of people, are particularly vulnerable to the adverse effects of poor thermal design. Historically, many of these buildings in Nigeria have relied heavily on mechanical cooling systems to maintain indoor comfort, resulting in increased energy consumption, operational costs, and environmental impact (Christian, Oduneka, & Imoh, 2022). As awareness of sustainable design practices grows, there is a pressing need to explore climate-responsive architectural solutions tailored to local climatic contexts.

Bioclimatic design has emerged as one of the most effective strategies for addressing thermal comfort challenges in hot-humid climates. This approach promotes the integration of climate-responsive architectural features, including building orientation, shading devices, natural ventilation, and passive cooling techniques (Givoni, 1998; Adamovský & Kny, 2019). These strategies aim to optimise indoor environmental quality while reducing reliance on mechanical cooling systems. Evidence from international and regional studies has demonstrated that bioclimatic design can improve indoor thermal comfort and energy efficiency in various building types (Manzano-Agugliaro, 2015; Rahbarianyazd & Raswol, 2019). However, there is a need to investigate the specific climatic parameters influencing building performance in Kwara State and to identify the bioclimatic design strategies already in use within institutional facilities such as Student Affairs Buildings, which play a central role in campus life.

This study focuses on assessing the climate of Kwara State in relation to bioclimatic performance requirements and identifying the specific bioclimatic design strategies commonly integrated into Student Affairs Buildings within the region. By analysing the climatic characteristics of Kwara and evaluating how existing Student Affairs Buildings respond to these conditions through bioclimatic features, the study seeks to provide evidence-based insights for improving indoor environmental quality in institutional settings. These findings will not only contribute to the body of knowledge on sustainable architectural practices in hot-humid climates but will also inform the future design of climate-responsive academic support facilities in Kwara State and beyond.

II. STUDY AREA

Ilorin, the capital city of Kwara State in Nigeria, is situated at approximately 8.4936N latitude and 4.5353E longitude. Located in the central part of the country within the North Central geopolitical zone, Ilorin is positioned at an elevation of about 300 meters (984 feet) above sea level, which influences its tropical savanna climate with distinct wet and dry seasons. The city combines historical significance with modern development, featuring a mix of residential, commercial, and institutional areas. As a growing urban center, Ilorin has diverse infrastructure including roads, educational institutions such as the University of Ilorin and Kwara State University, and healthcare facilities. However, it faces challenges related to rapid urbanization, including pressure on infrastructure, housing, and transportation, necessitating improved urban planning and sustainable development.

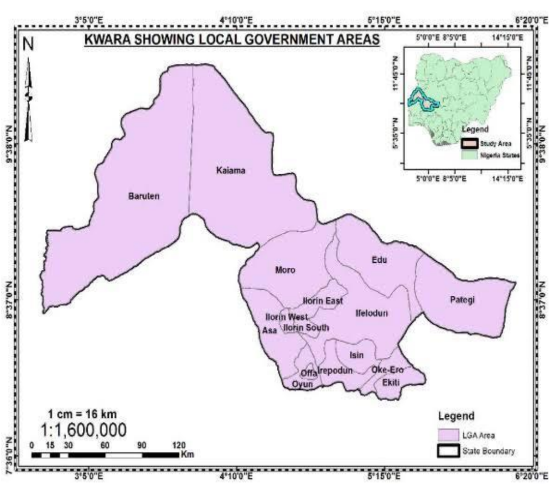

Figure 1: Map of Kwara state and its Local Government in Nigeria
Source: United Nations cartograhic section (2021)

III. LITERATURE REVIEW

Bioclimatic design refers to an environmentally responsive architectural approach that harmonizes building design with the local climate to enhance indoor thermal comfort and reduce dependence on mechanical energy systems. The term was introduced by the Olgyay brothers in the 1960s, proposing a methodology that integrates passive solar technologies, natural ventilation, and strategic material use to optimize a building's performance within its climatic context (Olgyay, 1963). According to Manzano-Agugliaro et al. (2015), the core principle of bioclimatic design is to achieve energy efficiency by reducing cooling and heating loads through building orientation, shading, ventilation strategies, and thermal insulation. In recent decades, the relevance of bioclimatic architecture has gained renewed significance as a response to global concerns about rising energy demands and environmental degradation, especially in rapidly urbanizing regions of the Global South (Adamovský & Kny, 2019). In Nigeria, where cities like Ilorin and Offa in Kwara State experience persistently high temperatures and solar radiation levels throughout the year, the need for climate-sensitive design solutions in institutional and office buildings is increasingly urgent (Adunola, 2016; Malgwi & Sagada, 2014). Traditional Nigerian architecture historically incorporated passive design features such as thick mud walls, inner courtyards, and shaded verandas to mitigate climatic extremes, providing valuable precedents for contemporary bioclimatic applications (Ashwani et al., 2018).

In hot-humid climates like Kwara State, maintaining indoor thermal comfort while minimizing energy consumption poses significant design challenges due to high ambient temperatures, intense solar radiation, and limited wind movement during certain periods (Al-Sallal, 2016). To address these challenges, researchers and practitioners have identified a range of bioclimatic strategies tailored to such climates, emphasizing techniques that prevent excessive heat gain, enhance natural ventilation, and utilize thermal mass for cooling (Givoni, 1998; Aashi et al., 2020). Common strategies include orienting buildings along the east-west axis to reduce solar exposure on longer facades, integrating shading devices such as overhangs, louvers, and brise-soleils, and employing natural ventilation techniques like cross and stack ventilation to promote airflow and remove indoor heat (Tartarini et al., 2018). The strategic use of high thermal mass materials like stone and concrete can absorb heat during the day and release it at night, stabilizing indoor temperatures (Benhammou et al., 2015). Green roofs, vegetative walls, and shaded courtyards are also increasingly recognized for their ability to lower building surface temperatures and improve indoor environmental quality (Susanne et al., 2014). According to Nematchoua et.al (2020) these strategies not only enhance thermal comfort but also contribute to occupant well-being, reduce operational costs, and mitigate the environmental footprint of buildings in tropical settings.

While global research on bioclimatic design continues to expand, most existing studies in Nigeria have concentrated on residential buildings, with limited emphasis on institutional facilities such as government offices and university Student Affairs buildings (Christian, Oduneka, & Imoh, 2022). This gap restricts the broader application of proven bioclimatic solutions within public-sector and educational contexts, where long hours of occupancy, high internal heat gains, and operational sustainability are critical concerns. Furthermore, although precedents like Ken Yeang's bioclimatic skyscrapers and Michael Reynolds' Earthship concepts demonstrate the viability of climate-responsive design at scale (Yeang, 1999; Reynolds, 1998), their adaptation to the socio-economic and climatic realities of regions like Kwara State remains underexplored. A context-specific understanding of Kwara's climatic data including temperature trends, humidity patterns, prevailing wind directions, and solar angles is essential for determining appropriate bioclimatic performance requirements for institutional buildings (Adunola, 2016). Identifying the specific bioclimatic strategies already integrated into similar buildings in the region would further inform evidence-based, sustainable designs for new projects such as the proposed Student Affairs Building at Summit University, Offa. Such research is critical for bridging the existing knowledge gap and advancing sustainable campus infrastructure development in hot-humid climates.

IV. METHODOLOGY

The study adopted a mixed-method research approach, integrating both quantitative and qualitative methods to effectively investigate the application and performance of bioclimatic design strategies in student affairs buildings within Kwara State, Nigeria. Primary data were obtained through structured, close-ended questionnaires administered directly to administrative staff working within student affairs buildings across selected universities. A total of 126 questionnaires were distributed using a census sampling technique, ensuring that every eligible staff member participated, thereby capturing a complete and representative understanding of user perceptions and experiences. The administration of questionnaires was carried out physically during official working hours, between 8:00 a.m. and 4:00 p.m., from Monday to Friday, deliberately excluding weekends and public holidays to coincide with standard office operations. In addition to questionnaires, primary data were supplemented through direct physical observations, site visits, and reconnaissance surveys to assess existing bioclimatic design features in the buildings. Secondary data were sourced from relevant published and unpublished materials, including academic journals, climate records, architectural reports, previous studies, and online resources. Quantitative data from the questionnaires were systematically collated, coded, and analyzed using descriptive statistical tools such as frequency tables, percentages, relative importance indices (RII), and mean weight values to evaluate staff awareness, perceptions, and satisfaction with bioclimatic design strategies. Qualitative data derived from site observations and architectural assessments were thematically analyzed to identify the specific bioclimatic strategies employed and assess their effectiveness in regulating thermal comfort, improving indoor environmental quality, and enhancing energy efficiency within the student affairs buildings.

V. RESULTS AND DISCUSSIONS

5.1Bioclimatic Performance of Ilorin Climate

The climatic analysis of Kwara State, reveals a distinct hot-humid tropical savannah climate (Aw), under Köppen classification, characterized by a pronounced dry season and a rainy season The state experiences high temperatures throughout the year, with monthly maximum temperatures ranging from 32.0°C in August to a peak of 38.9°C in March. The hottest period occurs between February and April, just before the onset of the rainy season, where daytime temperatures frequently approach or exceed 38°C. Conversely, monthly minimum temperatures vary from 14.9°C in January to 20.5°C in March, producing a relatively wide diurnal temperature range during the dry season (November–March). This wide range, particularly evident during the Harmattan period (December–February), results in hot daytime conditions and notably cooler nights, creating fluctuating thermal comfort challenges for building occupants.

Table 1: MAHONEY TABLE APPROACH TO CLIMATIC ANALYSIS

Location	kwara
Longitude	4.5421 E
Latitude	8.4966 N
Altitude	340 M

Table 2: Temperature of Kwara State

Month	Temp (max)	Temp (min)	Temp mean monthly	RH(AM)%	RH(PM)%	Rainfall (mm)	Windspeed (m/s)
January	36.9	14.9	22	65	21	6.2	4.0
February	38.5	17.6	20.9	64	19	15.5	4.0
March	38.9	20.5	18.4	74	38	64.6	6.0
April	37.6	18.8	18.8	81	47	144.8	6.0
May	35.7	20.0	15.7	85	61	271.2	6.0

June	33.6	19.3	14.3	91	69	289.1	5.0
July	32.2	19.8	12.4	92	73	188.2	5.0
August	32.0	19.3	12.7	93	73	236.3	5.0
September	32.3	18.9	13.4	92	72	397.4	4.0
October	34.0	19.8	14.2	88	62	227.9	4.0
November	36.0	17.7	18.3	76	38	34.0	4.0
December	36.3	15.3	21	70	24	4.6	4.0
Average	35.3	18.5	16.8	81	50		4.8

Table 3: Table of Air Temperature (oC)

	Jan	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Highest	AMT
Monthly mean max.	36.9	38.5	38.9	37.6	35.7	33.6	32.2	32.0	32.3	34.0	36.0	36.3	38.9	26.9
Monthly mean min.	14.9	17.6	20.5	18.8	20.0	19.3	19.8	19.3	18.9	19.8	17.7	15.3	14.9	24
Monthly mean range	22	20.9	18.4	18.8	15.7	14.3	12.4	12.7	13.4	14.2	18.3	21	Lowest	AMR

The relative humidity in Kwara state also exhibits distinct seasonal variation. During the dry season (November–March), morning relative humidity values range between 64% and 74%, while afternoon values drop sharply to between 19% and 38%, contributing to hot, dry, and dusty conditions. In contrast, the wet season (April–October) brings significantly higher humidity levels, with morning relative humidity peaking between 91% and 93%, and afternoon values rising to 69–73%. These elevated humidity levels, when combined with high temperatures, can lead to extremely uncomfortable indoor conditions, emphasizing the need for effective bioclimatic design solutions in building projects within the region.

Rainfall patterns in Kwara state are highly seasonal, with an annual total of approximately 1,879.8 mm. The rainy season extends from April to October, with peak precipitation recorded in September (397.4 mm). Heavy rains during this period increase moisture levels, reduce wind speeds, and elevate the demand for natural ventilation and moisture-resistant building materials. The dry season, particularly from November to February, experiences minimal rainfall, with monthly averages below 15 mm.

Wind direction analysis reveals a seasonal shift between the dry and wet seasons. North-Easterly winds (Harmattan winds) prevail during the dry months (November–March), bringing dry, dusty, and cooler air, while South-Westerly winds dominate during the wet season (April–October), accompanying monsoon rains. Wind speeds remain moderate year-round, ranging from 4.0 m/s to 6.0 m/s, with slightly higher values typically observed during the transition periods of March and April.

VI. DESIGN IMPLICATIONS

The climatic analysis of Kwara state highlights high daytime temperatures, significant diurnal temperature differences during the dry season, high humidity in the wet season, and seasonal wind shifts. To address these conditions, buildings should incorporate thermal mass materials such as thick masonry or concrete walls to absorb excess heat during the day and release it at night, helping to stabilize indoor temperatures. Effective solar shading devices like deep verandas, wide roof overhangs, vertical fins, and pergolas are essential to minimize heat gain, particularly on East and West façades. Careful building orientation along the East–West axis will reduce exposure to low-angled solar radiation, while maximizing shading opportunities on the North and South façades.

To enhance comfort during humid conditions and encourage passive cooling, natural ventilation strategies must be prioritized. This includes designing for cross-ventilation with openings on opposing walls, complemented by stack ventilation using high-level vents or clerestory windows to expel hot air. Open-plan layouts will improve airflow, while outdoor areas should feature shaded courtyards, covered walkways, water features, and dense vegetation to lower surrounding temperatures and improve microclimate conditions. Landscaping should also act as windbreaks during the Harmattan season. Collectively, these bioclimatic strategies will improve occupant comfort, reduce dependence on mechanical cooling systems, and ensure sustainable, climate-responsive student affairs facilities in Ilorin's hot-humid environment.

Table 4: Table of Humidity, Rain and Wind.

Rel. Humidity (%)		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Monthly mean Max. (a.m)		65	64	74	81	85	91	92	93	92	88	76	70	
Monthly mean Min. (p.m)		21	19	38	47	61	69	73	73	72	62	38	24	
Average		43	41.5	56	64	73	80	82.5	83	82	75	57	47	
Humidity Group (HG)		2	2	3	3	4	4	4	4	4	4	3	2	
Rainfall (mm)		6.2	15.5	64.6	144.8	271.2	289.1	188.2	236.3	397.4	227.9	34.0	4.6	1879.8
Wind	Prevailing		NE	NE	NE	SW	SW	SW	SW	SW	SW	NE	NE	
	Secondary		S	S	S	NE	NE	NE	E	E	NE	SW	SW	

Design Implications for Table 4

The climatic patterns in Table 4 highlight consistently high humidity during the wet season (June–September) with relative humidity peaking at 93% in August and heavy rainfall concentrated between April and October, reaching its highest in September (397.4 mm). To respond to this, buildings should incorporate wide roof overhangs, deep verandas, and rain screens to protect façades, windows, and doors from wind-driven rain. The predominance of South-West prevailing winds during the wet season should be harnessed by placing large operable windows and ventilation openings on the South-West and North-East façades to enhance natural cooling and cross-ventilation during humid months. Additionally, outdoor spaces such as covered courtyards, shaded walkways, and arcades should be integrated to allow for functional open areas even during heavy rainfall.

In the dry Harmattan season (November–March), North-East winds bring dry, dust-laden air which can affect indoor air quality and thermal comfort. To mitigate this, designs should incorporate screen planting, perforated or louvered walls, and filtered ventilation openings to control dust while maintaining airflow. The high humidity in the wet months also necessitates moisture-resistant construction materials and techniques, such as raised floors to prevent ground moisture ingress, breathable wall finishes, and ventilated roof spaces to minimize condensation and reduce internal heat build-up. This dual-seasonal response ensures buildings remain comfortable, functional, and durable throughout the year's changing conditions.

Table 5: Thermal Diagnosis of Kwara state Climate

		Jan	Feb	Mar	Apr	May	Jun.	Jul	Aug	Sep	Oct	Nov .	Dec
Humidity group		2	2	3	3	4	4	4	4	4	4	3	2
Temperature (oC)													
Monthly mean Max.		36.9	38.5	38.9	37.6	35.7	33.6	32.2	32.0	32.3	34.0	36.0	36.3
Day Comfort	Max	31	31	29	29	27	27	27	27	27	27	29	31
	Min	25	25	23	23	22	22	22	22	22	22	23	25
Monthly mean Min.		14.9	17.6	20.5	18.8	20.0	19.3	19.8	19.3	18.9	19.8	17.7	15.3
Night Comfort	Max	24	24	23	23	21	21	21	21	21	21	23	24
	Min	17	17	17	17	17	17	17	17	17	17	17	17
Thermal Stress													
Day		H	H	H	H	H	H	H	H	H	H	H	H
Night		O	O	H	H	-	o	-	H	H	H	O	O

The persistent daytime thermal stress (H) throughout the year as revealed in Table 5 with daytime temperatures regularly exceeding comfort limits (27–31°C), particularly in February, March, and April. To address this, buildings should prioritize passive cooling strategies such as cross-ventilation through well-placed openings on opposing walls, shaded courtyards, and evaporative cooling features like water bodies and plant-covered spaces. The use of light-coloured, reflective external finishes will help minimize heat gain. Incorporating thermal mass materials (e.g. concrete, brick) can moderate indoor temperatures by absorbing excess heat during the day, but must be paired with night-purging ventilation systems to release accumulated heat once outdoor temperatures drop.

Nighttime comfort varies, being acceptable in cooler months (January, February, June, November, December) and uncomfortable during hotter periods (March–May and September–October). To enhance nighttime cooling, design solutions should include large operable windows with high window-to-wall ratios on shaded façades, ventilated roof designs with ridge vents or clerestory openings, and provisions for outdoor sleeping spaces like screened verandas and terraces. Such features are especially valuable during the hot, still nights of the dry season. Overall, these measures will improve thermal comfort for building occupants while reducing dependence on mechanical cooling systems.

Table 6: Bioclimatic Design Indicators Summary

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Humid													
H1 Air movement (essential)	V	V	V	V	V	V	V	V	V	V	V	V	12
H2 Air movement (desirable)													
H3 Rain protection					V	V			V				03

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Arid													
A1 Thermal storage	V	V	V						V		V	V	06
A2 Outdoor sleeping	V	V											02
A3 cold-season problem													

The predominance of air movement as highlighted in Table 6 is an essential requirement (H1) throughout all twelve months, affirming the need for architectural layouts that enable continuous, unrestricted airflow. This justifies the use of single-banked room layouts, open courtyards, and strategically placed large, operable windows (40–80% of wall areas) on the North and South facades. Shading elements such as deep verandas, overhangs, and covered walkways should also be prioritized, especially to address the three months (May, June, September) requiring rain protection (H3). These features help maintain thermal comfort during heavy rainfall while allowing ventilation.

The table further shows a moderate need for thermal storage (A1) in six months — mostly during the dry season — suggesting the integration of heavy external and internal walls or well-insulated lightweight structures to moderate daytime heat and release it at night. The indication for outdoor sleeping (A2) in January and February implies the importance of culturally appropriate design features like screened terraces, shaded patios, or rooftop sleeping platforms, offering relief from high nighttime temperatures during the hottest months. Collectively, these indicators provide clear guidance for a climate-responsive building envelope and spatial arrangement.

Table 7: Mahoney-Based Sketch Design Recommendations

Indicator total from table 4						Recommendations
Humid			Arid			
H1	H2	H3	A1	A2	A3	
12	0	3	06	02	0	
						Layout
			0-10			35. Buildings orientated on east-west axis to reduce exposure to sun
					5-12	
			11-12		0-4	
						36. Compact courtyard planning
						Spacing
11 or 12						37. Open spacing for breeze penetration
2 – 10						38. As A3, but protect from cold hot wind
0 or 1						39. Compact planning
						Air movement
3 – 12			0-5			40. Rooms single banked. Permanent provision for air movement
1 or 2			6 - 12			
0	2 - 12					41. Double- banked rooms with temporary provision for air movement.
	0 or 1					42. No air movement requirement.
						Openings
			0 to 1		0	43. Large openings, 40-80% of N and S walls

			11 or 12		0 or 1	44. Very small openings, 10-20%
Any other conditions						45. Medium openings, 20 -40 %
						Walls
			0 – 2			46. Light walls; short time lag
			3 - 12			47. Heavy external and internal walls
						Roofs
			0 – 5			48. Light insulated roofs
			6 - 12			49. Heavy roofs; over 8 hours' time lag
						Outdoor sleeping
				2 - 12		50. Space for outdoor sleeping required
						Rain penetration
		3 – 12				51. Protection from heavy rain needed

Table 7 translates the climatic indicators into direct design recommendations. It emphasizes the East–West orientation of buildings to minimize solar heat gain on longer façades, a critical measure in hot-humid regions. Open site planning and generous building spacing are recommended to maximize natural airflow, supporting passive cooling strategies identified in Table 6. The guidance for single-banked rooms with continuous air movement provision ensures that interior spaces are well-ventilated, reducing reliance on mechanical cooling. Additionally, large operable openings (40–80%) on the North and South façades, shaded by louvers or canopies, are essential for effective cross-ventilation and solar control.

For thermal performance, the table recommends heavy external and internal walls and roofs with a time lag exceeding eight hours to moderate extreme daytime heat and maintain comfortable indoor temperatures at night, particularly significant during dry seasons with large diurnal ranges. The need for outdoor sleeping areas in hotter months highlights the value of shaded terraces, verandas, or screened patios. Lastly, the emphasis on rain protection measures like wide eaves, covered entrances, and verandas safeguards occupants and building elements from heavy rains, especially between May and September. Together, these strategies promote a sustainable, climate-appropriate, and culturally attuned design for institutional buildings in Kwara's tropical savannah climate.

4.2 Identify the specific bioclimatic design strategies commonly integrated into Student affairs buildings in hot-humid climates like Kwara State

To identify the most specific bioclimatic strategies employed in the Student Union Affairs Building, Kwara, a structured questionnaire survey was conducted. Respondents comprising staffs and student representatives rated six bioclimatic strategies based on their perceived contribution to indoor environmental comfort, energy efficiency, and thermal regulation in the building.

Table 8: Analysis of the specific bioclimatic design strategies commonly integrated into Student affairs buildings Student Union Building Design

S/N	Bioclimatic Strategy	ΣW (Total Weighted Score)	A × N (Maximum Possible Score)	RII Value	Rank	% Importance	Cumulative %
1	Courtyards and Open Spaces	109	126	0.85	1st	18.9%	18.9%
2	Proper Building Orientation	97	126	0.81	2nd	18.0%	36.9%
3	Natural Ventilation Methods	88	126	0.79	3rd	17.5%	54.4%
4	Buffer Zones	78	126	0.74	4th	16.5%	70.9%
5	Shading Devices and Solar Control	64	126	0.70	5th	15.5%	86.4%
6	Solar Panels	51	126	0.65	6th	13.6%	100.0%

4.2.1 Courtyards and Open Spaces (RII = 0.85, Rank 1st)

Courtyards and open spaces emerged as the most impactful bioclimatic strategy. Respondents noted their multifunctional benefits acting both as thermal buffers and social interaction hubs. In Ilorin's hot-humid climate, central shaded courtyards, perimeter gardens, and semi-open atriums play a crucial role in passive cooling. By creating open-to-sky areas surrounded by mass walls, these spaces enable cross and stack ventilation, lowering ambient temperatures through evaporative cooling and enhancing air quality. Moreover, their psychological and social benefits offering shaded, serene areas for congregation and recreation make them indispensable in student-centered buildings. Courtyards also assist in pressure equalization, reducing the risk of stagnant heat zones, and act as visual relief points, reinforcing biophilic design principles.

4.2.2 Proper Building Orientation (RII = 0.81, Rank 2nd)

Proper orientation was ranked second, reflecting its strategic role in passive thermal regulation. Positioning buildings along an east-west axis minimizes exposure to the intense low-angle morning and afternoon sun, while maximizing the building's interaction with prevailing southwesterly winds in Ilorin. Respondents emphasized the importance of aligning principal openings (such as operable windows and louvered panels) with dominant wind directions to enable efficient cross-ventilation. Additionally, strategic management of window-to-wall ratios, especially by limiting glazed surfaces on east and west facades, was recognized as vital in controlling unwanted solar heat gain. This approach reduces reliance on mechanical cooling systems, thereby lowering operational costs and enhancing indoor comfort passively.

4.2.3 Natural Ventilation Methods (RII = 0.79, Rank 3rd)

Natural ventilation techniques were highly rated for their direct impact on thermal comfort without additional energy expenditure. In hot-humid settings like Ilorin, cross ventilation, stack ventilation, and the use of adjustable louvers and ventilated courtyards collectively support effective air circulation and indoor air quality. Cross ventilation via strategically positioned openings promotes continuous air movement through congregational and office spaces, while stack ventilation using clerestory windows and roof ventilators exploits the natural buoyancy of warm air to facilitate upward air movement and expulsion. Respondents also appreciated the flexibility offered by adjustable louvers and vent blocks, which enable occupants to modulate airflow and daylight, improving user control over thermal conditions.

4.2.4 Buffer Zones (RII = 0.74, Rank 4th)

Buffer zones, such as colonnades, verandas, semi-open lobbies, and shaded pergolas, were identified as effective intermediary spaces that reduce the impact of external heat on interior environments.

By creating shaded, ventilated transitional areas around the building's perimeter, these features reduce direct heat transmission into air-conditioned or enclosed spaces. Respondents noted that shaded lobbies and walkways not only enhance thermal performance but also improve user comfort by providing cooler, shaded waiting and resting areas. These zones moderate microclimatic conditions around the building envelope, reducing overall cooling loads.

4.2.5 Shading Devices and Solar Control (RII = 0.70, Rank 5th)

Though recognized as essential, shading devices ranked fifth. The study identified strategies such as horizontal overhangs, vertical louvers, brise-soleils, and vegetative trellises as effective means of controlling solar radiation and glare. Respondents acknowledged that while these devices prevent direct solar gain and reduce indoor overheating, their influence is somewhat limited in comparison to courtyards and ventilation strategies in Ilorin's consistently humid climate.

However, shading solutions remain valuable for enhancing visual comfort, reducing glare in reading areas, and lowering solar load on façades.

4.2.6 Solar Panels (RII = 0.65, Rank 6th)

Solar panels received the lowest ranking, not due to ineffectiveness, but because their contribution is primarily energy generation, rather than direct passive thermal regulation. Respondents noted that while photovoltaic systems reduce dependency on grid electricity and support sustainable operations, their immediate impact on indoor environmental comfort is indirect.

This study confirms that in hot-humid climates like Ilorin, bioclimatic design should prioritize shaded courtyards and open spaces to enhance passive cooling, promote air movement, and offer comfortable social areas for occupants. Buildings should be oriented along prevailing wind paths while limiting east and west sun exposure to reduce heat gain and improve natural ventilation. Cross and stack ventilation, adjustable louvers, and ventilated courtyards must be integrated to maintain indoor comfort without heavy reliance on mechanical systems. Buffer zones such as colonnades, verandas, and shaded walkways should be used to minimize heat transfer into indoor spaces and improve surrounding microclimates. Shading devices remain essential for controlling glare and solar gain, while renewable systems like solar panels should be paired with ventilated shading structures to deliver both energy and environmental benefits, ensuring future student facilities remain climate-responsive, efficient, and culturally relevant.

CONCLUSION AND RECOMMENDATIONS

This study has established that passive bioclimatic design strategies remain the most effective and contextually appropriate solutions for enhancing thermal comfort, energy efficiency, and user satisfaction in student affairs buildings within hot-humid climates like Kwara State, with combined insights from Mahoney Table assessments and occupant feedback confirming that courtyards, open spaces, natural ventilation, and proper building orientation offer the greatest environmental and social benefits, while modern technologies like solar panels support energy sustainability but serve best as supplementary measures to a fundamentally passive, climate-responsive architectural approach, ultimately affirming that prioritizing natural cooling and ventilation methods reduces operational energy demands and enhances the well-being of building users. In light of these findings, it is recommended that future institutional building designs in tropical savannah regions integrate courtyards and shaded open spaces as central organizing features, consistently orient buildings along the east–west axis, optimize cross and stack ventilation through operable openings, introduce buffer zones like verandas and shaded lobbies to moderate indoor-outdoor temperature transitions, and while incorporating shading devices and renewable energy systems remains important, these should complement rather than replace core passive strategies, with policymakers and campus administrators encouraged to enforce climate-responsive design guidelines for new developments, ensuring that sustainability, thermal comfort, and cultural suitability remain central to architectural decision-making in educational environments.

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