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ANALYSIS OF EXISTING DAYLIGHTING CONDITIONS IN SELECTED LIBRARY SPACES IN KADUNA, NIGERIA

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ABSTRACT

Purpose: *This study investigates the existing daylighting conditions in selected library spaces in Kaduna State, Nigeria, recognising that abundant natural light in the tropical wet-dry climate is underutilised. It aims to assess the visual comfort, light distribution, and energy efficiency challenges associated with traditional daylighting design approaches.*

Design/methodology/approach: *The study analysed three library case studies using climate-based daylight modelling and field measurements. Tools such as Velux Daylight Visualizer and Revit® were employed to evaluate illuminance levels and glare conditions. User surveys were also conducted to understand seating preferences regarding lighting comfort.*

Findings: *Results revealed uneven daylight distribution, excessive glare near windows, and insufficient illumination at core reading areas (often <300 lux). Average illuminance near windows reached 662.91 lux, but dropped significantly deeper into spaces. This shortfall leads to reliance on artificial lighting, contributing 20–30% to building energy loads. Survey feedback showed that 74% of users preferred well-lit seating areas.*

Research limitations/Implications*: The study is limited to selected libraries within Kaduna State and focuses primarily on side-lighting design, which may not reflect design variations across Nigeria. Simulation accuracy, although validated, may not capture all real-time conditions. Future research should explore the long-term performance of enhanced daylighting strategies and broader user behaviour.*

Practical implications: *Findings highlight the need to improve daylighting performance to enhance visual comfort, reduce operational costs, and mitigate reliance on artificial lighting in regions with unstable electricity. Introducing top-lighting strategies, including light pipes, is recommended to extend daylight penetration and improve energy efficiency.*

Originality/value *– This research provides a foundational re-analysis of daylighting in library spaces within the tropical Nigerian context. It offers evidence-based guidance for redesigning educational*

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buildings to improve sustainability, wellbeing, and learning environments, addressing a critical gap in regional architectural practice

Keywords: Daylighting; Energy efficiency; Illuminance; Libraries; Tropical climate

1.0 INTRODUCTION

Daylighting, the controlled use of natural light to illuminate interior spaces, is a critical resource in architectural design, particularly in regions with abundant sunlight like Nigeria's tropical wet-dry climate (Gregg, 2016). In public libraries, where visual tasks demand high acuity, effective daylighting enhances user comfort, productivity, and energy efficiency by reducing reliance on artificial lighting, which accounts for 20–30% of building energy loads (Omar et al., 2018). However, traditional designs in Nigeria's libraries often underutilise daylighting due to a focus on side-lighting via windows, leading to glare, uneven distribution, and insufficient illumination in deep-plan areas (Buhari & Alibaba, 2019). This study addresses the problem of suboptimal daylighting in public libraries, exemplified by case studies from Kaduna State University Library, Kashim Ibrahim Library and National Library Kaduna. These facilities face challenges such as low daylight quality from slanted louvre shading and reliance on artificial lighting. The aim is to analyse existing daylighting conditions to inform sustainable redesigns. Objectives include evaluating illuminance, distribution, and comfort, while research questions explore whether current conditions impact user experience and energy efficiency.
Literature such as Wu et al., (2024); Monteoliva et al., (2018) highlight daylight's psychological benefits but notes limitations in traditional strategies, setting the stage for this analysis.

2.0 LITERATURE REVIEW

A notable study by Monteoliva et al. (2018) in Argentina's subtropical climate explored daylighting in public libraries, using dynamic cubic illuminance metrics. It found that side-lighting with adjustable shading reduced glare by 40% but limited penetration to 2 meters, necessitating artificial lighting in core areas. Similarly, Omar et al. (2018) in Beirut's Mediterranean-tropical climate demonstrated that integrating top-lighting (e.g., skylights) with side-lighting cut energy use by 25%, improving user satisfaction. These findings highlight the need for balanced daylight strategies in tropical settings. The significance of these studies lies in their potential to address the pressing challenges of inefficient daylighting in public libraries within Kaduna State, Nigeria, where traditional sidelighting and shading designs lead to uneven light distribution, glare, and low illuminance (<300 lux) in core areas, contributing to 20–30% energy loads amid unreliable power supply. By analysing Kaduna State University Library, Kashim Ibrahim Library, and National Library Kaduna, the research provides a critical baseline for sustainable redesign, reducing reliance on artificial lighting, lowering operational costs, and enhancing user comfort, as evidenced by 74% preferring well-lit seating. This supports educational environments by improving visual performance and well-being. The study aims to evaluate existing daylighting conditions, with objectives to assess illuminance, distribution, and comfort, and to propose innovative top-lighting solutions. Its implications include informing architectural practices, guiding policy for sustainable infrastructure, and offering a scalable model for tropical climates.

3.0 METHODOLOGY

The study employed a mixed-method approach, focusing on four public libraries in Kaduna State. Data collection involved field measurements of illuminance (lux) using light meters. Case studies included Kaduna State University Library, Kashim Ibrahim Library, and National Library Kaduna, selected for their representation of regional architectural practices. Measurements assessed natural light distribution, focusing on reading areas, book stacks, and circulation zones, under varying sky conditions (clear, overcast) typical of Kafanchan's climate (6.0–9.8 hours daily solar exposure, 1000–1500 mm rainfall). Limitations include the geographical focus on Kaduna's climate and reliance on available tools, which may not fully capture real-world variability. User feedback on seating preferences (Othman & Mazli, 2015) supplemented quantitative data.

The study employed light meters to assess daylighting conditions in four public libraries in Kaduna State: Kaduna State University Library, Kashim Ibrahim Library and National Library Kaduna. Light meters were strategically placed at multiple sensors points across reading areas, book stacks, and circulation zones, with positions selected to capture illuminance variations near windows and in core areas. Data collection occurred during a field survey in 2025, conducted on clear and overcast days to reflect Kaduna's 6.0–9.8 hours daily solar exposure, with measurements taken at peak sunlight hours (typically 10:00 AM to 2:00 PM) for consistency. Data was recorded manually from light meters, averaged at 662.91 lux near windows, and stored in digital spreadsheets. Analysis compared these values against the recommended 300 lux standard for reading spaces by Sherif et al., 2016), revealing inadequate illumination in core areas, indicating a need for improved daylighting strategies.

4.0 PRESENTATIONAND DISCUSSION OF RESULTS 4.1. Case Study I: Kaduna State University Library

The Kaduna State University Library, located on the Kaduna campus in Kaduna State, Nigeria, serves as an academic resource centre for students and faculty in a region characterized by high solar exposure and unreliable power supply. Established as part of Kaduna State University (founded in 2004), it supports educational programs in architecture and other fields, but faces challenges from traditional design elements in a tropical wet-dry climate.



Plate I: Exterior view of KASU Library
Source: Field survey (2025).

The library relies heavily on side-lighting through windows and shading devices, resulting in uneven daylight distribution, with illuminance levels averaging below 300 lux in core areas and excessive glare near facades. Measurements in table 2 below showed average illuminance of 662.91 lux, but deep-plan spaces suffered from low light penetration, leading to increased artificial lighting use (20– 30% of energy load) and reduced user comfort

4.2. Case Study II: Kashim Ibrahim Library

Kashim Ibrahim Library is the main library of Ahmadu Bello University in Zaria, Kaduna State, Nigeria. Named after a prominent Nigerian politician, it was established in the 1960s as part of one of Nigeria's oldest universities, serving a large student population with resources for research and learning in a hot, semi-arid to wet-dry climate zone.



Plate II: Approach view of Kashim Ibrahim Library (KIL)
Source: Field survey (2025).

Similar to other analysed libraries, it depends on side-lighting strategies, leading to suboptimal daylighting with uneven distribution and glare issues. The study identified reliance on artificial lighting during daylight hours due to shading devices blocking natural light, contributing to high energy consumption and visual discomfort. From table 3 below, core areas showed insufficient illuminance, impacting user productivity and aligning with broader findings of underutilized sunlight in tropical settings, emphasizing the potential for light-pipe integration to enhance spatial daylight autonomy (sDA) and reduce operational costs.

4.3. Case Study III: National Library Kaduna

The National Library Kaduna is a branch of Nigeria's National Library, established in the 1970s to promote literacy and preserve cultural heritage in Kaduna State. It functions as a public resource hub in an urban setting with high solar potential but faces infrastructure challenges like power instability in the tropical wet-dry climate.



Plate XXVII: Main entrance of National Library Kaduna
Source: Field survey (2025).

Analysis revealed traditional side-lighting limitations, including low illuminance in interior zones (often below recommended 300 lux) and glare near windows, exacerbated by shading devices. These results in uneven light distribution, increased energy use for artificial lighting, and reduced user satisfaction. The study highlights these as common issues in Nigerian public libraries, suggesting lightpipe technology could improve daylight penetration and achieve up to 45% energy savings, making it a scalable model for similar facilities.

Table 1a: Case study summary

Case study Variables	Case I (K.A.S.U.L)	Case II (K.I.L ABU)	Case III (N.L.K)	Remarks

Building Materials and Reflectance	a. White finishes were used throughout the structure b. Single glazed windows primarily with white and plastered with cement/sand mortar. c. White painted ceiling board	a. For maximum light reflection in the reading areas, the internal wall finishes were used throughout the structure. b. Single glazed windows c. Celotex The ceiling makes use of only	White finishes for the walls and ceilings were used throughout the structure. Single glazed windows	The materials' coatings aid in increasing the amount of illumination needed for visual tasks.
Nature of Shading device	The use of vertical shading	The use of horizontal shading devices	The structure makes the most of both vertical and horizontal shading devices	Due to design considerations, the shading devices have an impact on the daylighting areas.
Orientation of Building	The longer axis was oriented primarily in a north-south direction	The building's longer axis was partly aligned East-West	The building's longer axis was oriented.	The right direction is taken into account in order to catch

Use of Daylighting strategy	direction. The side-lighting technique	with the North-South direction. The side-lighting technique	The side-lighting technique	more daylighting. The sole tactic used was side-light. Light pipes and other top lights can be used to improve this.

Source: Field work (2025)

Table 1b: Case study summary

Case study variables	**Case I (K.A.S.U.L)**	**Case II (K.I.L ABU)**	**Case III (N.L.K)**	**Remarks**

Geometry of Ceiling	Flat ceiling	Irregular ceiling	Flat ceiling	The areas have not been able to achieve a significant amount of daylight for the best work performance because of the ceiling.
Depth and size of spaces	Has a headroom of 3.5m	The library has a headroom of 3.15m with much depth	Has a headroom of 3.5m with not much deep depth	The average headroom from the cases reviewed is roughly 3.25 meters, and the spaces are meticulously organized.
The amount of daylight and illumination in the reading regions	There is not consistent daylight on the work plane where done; the lux	There is not consistent daylight on the work plane where reading is	There is not consistent daylight on the work plane where reading is	On the other hand, the typical reading work plane is 0.80 meters. More light is

	done; the lux level is higher near windows but falls away	level is higher done; the lux near windows but falls away	present near from them. level is higher when one moves away from them.
			less near from them.

Source: Field Survey (2025).

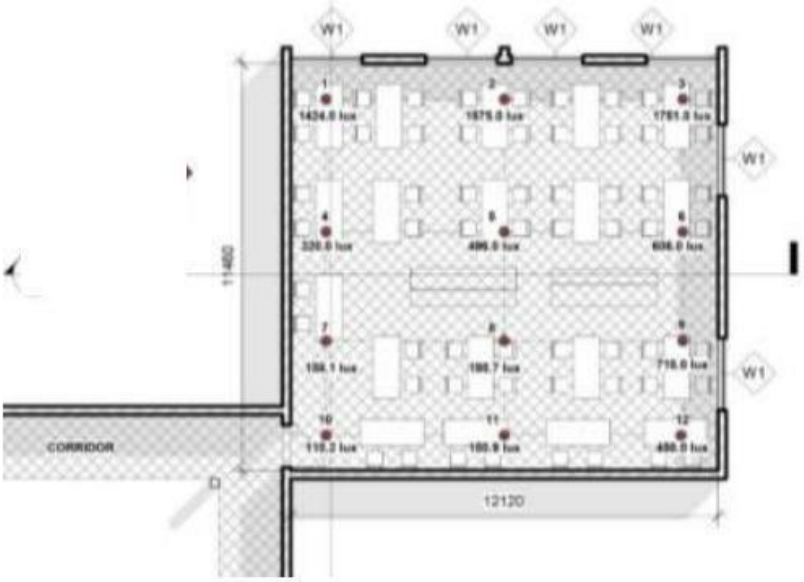


Figure 1: Kaduna State University's conventional reading area's measured illuminations in Kaduna.

Source: Field study (2025)

Table 2: Illuminances in the Kaduna State University Library's convention reading area were measured and replicated.

Sensor's points	**Measured (Lux)**
1	1424.00
2	1575.00
3	1751.00
4	320.00
5	496.00
6	606.00
7	158.10
8	195.70
9	718.00
10	110.20
11	150.90
12	450.00
Average	662.91

Source: Field Study (2025).

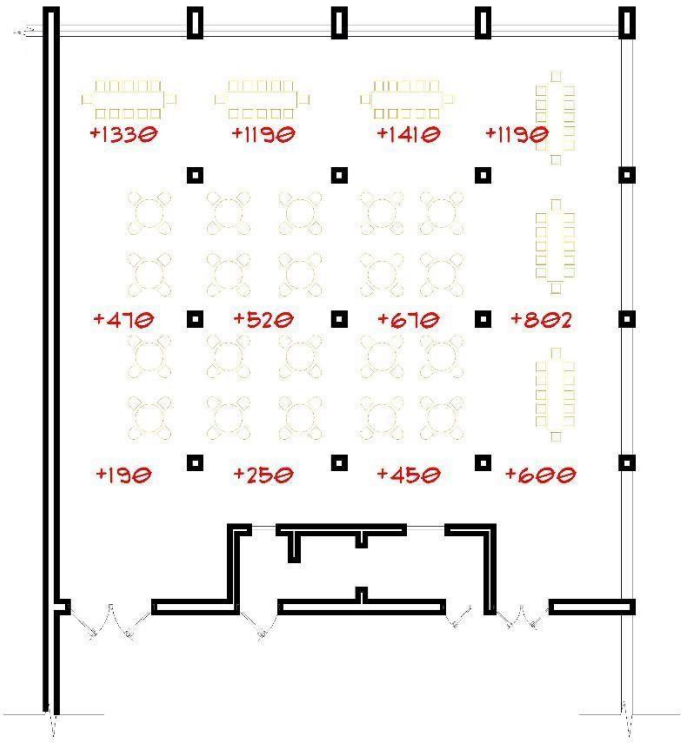


Figure 2: Kashim Ibrahim Library reading area's measured illuminations.
Source: Field study (2025)

Table 3: Illuminance in the Kashim Ibrahim Library reading area's measured

Sensor's points	Measured (Lux)
1	1330
2	1190
3	1410
4	1190
5	470
6	520
7	670
8	802
9	190
10	250
11	450
12	600
Average	756

Source: Field Study (2025).

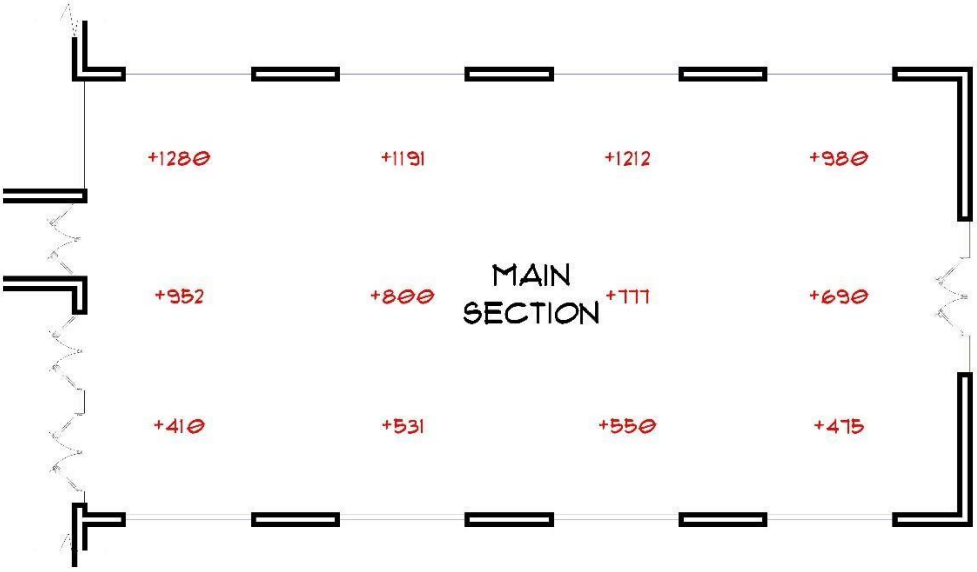


Figure 3: National Library Kaduna reading area's measured illuminations.
Source: Field study (2025)

Table 4: Illuminance in the National Library Kaduna reading area's measured

Sensor's points	Measured (Lux)
1	1280
2	1181
3	1212
4	980
5	952
6	800
7	777
8	690
9	410
10	531
11	550
12	475
Average	820

Source: Field Study (2025).

Analysis revealed suboptimal daylighting conditions across all case study libraries. Kaduna State University Library and Kashim Ibrahim Library exhibited uneven light distribution, with glare near windows and less than 300 lux in core areas, necessitating continuous artificial lighting. The National Library in Kaduna showed similar trends, with heat gain issues.

Shading devices, such as louvres, reduced solar gain but also daylight intensity, aligning with Buhari and Alibaba (2019), who noted their impact on quality. Side-lighting penetration was limited to 1.5–2.5 times window height, creating "hotspots". Sky conditions significantly influenced performance, illustrating variability (Suk & Kensek, 2015). User surveys indicated 74% preferred well-lit seating, reflecting visual comfort impacts (Othman & Mazli, 2015). Energy inefficiency was evident, with 20–

30% of loads from lighting, a concern in Kaduna's context. These findings highlight a gap in traditional designs, suggesting top-lighting as a potential solution, though further validation is needed.

5.0 CONCLUSION AND RECOMMENDATIONS

The analysis confirms that existing daylighting in selected case study libraries is inadequate, characterised by uneven distribution, glare, and low illuminance in core areas, driving energy inefficiency and user discomfort. Traditional side-lighting and shading fail to optimise sunlight, a critical resource in this tropical climate. Recommendations include adopting top-lighting strategies, such as light pipes, and engaging the government for implementation. Training for local architects and policy incentives for sustainable technologies are also suggested. Future research should assess longterm performance and user behaviour.

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