Available online www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 221 (2026) 70-114 EISSN 2392-2192

The Community Library as Civic Infrastructure in Semi-Rural Nigeria: A Design Science Research Inquiry into the Obudu Learning Centre

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https://doi.org/10.65770/NBXO3059

ABSTRACT

This paper presents a design science research (DSR) inquiry into the architectural and infrastructural vacuum surrounding public learning spaces in semi-rural Nigeria, using Obudu, Cross River State, as a critical case. While international library discourse has shifted toward hybrid, socially embedded, and technology-augmented civic spaces, Nigerian public library provision remains bifurcated: relatively resourced university libraries on one hand, and absent or decaying public infrastructure on the other. This bifurcation is not merely a service gap but a spatial expression of uneven development. The study asks: what architectural and programmatic strategies can produce a library that is climatically responsive, socially inclusive, and economically viable in a semi-rural, tourism-adjacent, low-infrastructure context? The research adopts a design science research methodology structured around the three-cycle view of relevance, rigor, and design, integrating literature review, comparative case-study analysis (Caritas University Library, Nigeria; Helsinki Central Library Oodi, Finland), and site-specific climatic analysis. The design artifact (a community library and learning centre) is developed through iterative design cycles and evaluated against requirements derived from the relevance cycle using descriptive requirement-matrix assessment, an accepted approach for early-stage unbuilt schematic DSR outputs.

(Received 15 September 2026; Accepted 10 October 2026; Date of Publication 19 November 2026)

The proposal integrates passive climatic strategies suited to the Obudu Plateau, an activity-based zoning logic that mediates between quiet study and collaborative production, and a program that embeds digital literacy, vocational information services, and community assembly within the library envelope. The paper argues that in the absence of state-led public library provision, architectural design operates as a form of infrastructural advocacy, making visible and spatializing the demand for equitable learning environments. This study employs descriptive conceptual evaluation for the unbuilt schematic design artefact; empirical performance simulation and local stakeholder validation are designated subsequent research activities. The findings offer a transferable DSR framework for community library design across comparable semi-rural African contexts.

Keywords: design science research, community library, civic infrastructure, semi-rural Nigeria, climate-responsive architecture, library architecture, Obudu.

1. INTRODUCTION

1.1. The Library as Contested Terrain

The library has never been a neutral building type. From the archival enclosures of Nineveh and Alexandria, where knowledge was hoarded on behalf of ruling elites to the Carnegie-funded public libraries of the nineteenth century, which spatialized a liberal faith in self-improvement, the library has always materialized particular assumptions about who knowledge is for, how it should be accessed, and what kind of citizen it produces [1]. In the contemporary moment, that question has acquired renewed urgency. Digital ubiquity has destabilized the library's traditional monopoly on information storage, forcing a reconsideration of its purpose. Some have predicted obsolescence; others have argued that the library's future lies precisely in its physicality as a site of equitable access, social infrastructure, and civic assembly [2], [3].

This debate, however, has been conducted almost entirely within the epistemic and infrastructural assumptions of the Global North. In Nigeria, and across much of sub-Saharan Africa, the terms of the debate are different. The question is not whether physical libraries can survive digital disruption, but whether they can be brought into existence at all. Nigeria's public library infrastructure is severely underdeveloped, particularly outside major urban centres. Where libraries exist, they are frequently underfunded, poorly maintained, and architecturally undistinguished. University libraries constitute a partial exception, but their access is stratified by enrollment and institutional affiliation [4].

This paper takes the absence of public library infrastructure in semi-rural Nigeria as its point of departure not as a problem to be lamented, but as a condition to be theorized and addressed through design. It asks what it means to design a library in a context where the library as a civic institution has never been consolidated. And it proposes that architectural design, in such contexts, operates as a form of infrastructural advocacy: making visible, spatializing, and rendering actionable a demand for equitable learning environments that the state has failed to meet.

1.2. Obudu as Critical Site

Obudu, a town in the northern senatorial district of Cross River State, sits at the foot of the Obudu Plateau. It is nationally known as a tourism destination, “home to the Obudu Mountain Resort,” but has no public library. Students in Obudu and surrounding communities (Bebi, Utugwang, Bendeghe) rely on under-resourced school libraries or fee-charging private study spaces.

During examination periods, demand for quiet study space exceeds supply, and students converge on churches and empty classrooms. Researchers and professionals lack access to reference materials or digital databases. Children have no structured space for early literacy development outside the classroom [5].

Obudu is therefore not simply a site lacking a library. It is a site where the absence of the library as a civic institution is compounded by three specific conditions:

- A semi-rural economic base with limited public infrastructure;
- A tourism-driven identity that creates demand for civic and architectural quality but has not yet produced it; and
- A cooler, elevated climate that presents both constraints and opportunities for passive design. These conditions make Obudu a critical case for examining how architectural design can intervene in contexts of infrastructural absence without reproducing imported typologies.

1.3. Research Aim and Questions

This paper aims to develop and evaluate an architectural proposal for a community library and learning centre in Obudu through a design science research methodology. The research is guided by three questions framed within the relevance, rigor, and design cycles of DSR:

Relevance (Theoretical): What requirements does a semi-rural Nigerian context impose on the design of a community library, and how can the library be reconceptualized as civic infrastructure in a context where it has no institutional precedent?

Rigor (Methodological): What design strategies "spatial, climatic, programmatic" can be derived from existing knowledge bases (literature, standards, comparative case studies), and how can they be adapted to the Obudu context?

Design (Propositional): What architectural and programmatic configuration can simultaneously serve students, researchers, artisans, children, and the wider community while remaining climatically responsive and economically viable?

1.4. Contribution and Structure

The paper contributes to three fields: architectural design research, library and information science, and African urban/regional studies. Its contribution is threefold:

- It applies design science research methodology to architectural design in a semi-rural African context, demonstrating the relevance cycle in practice;
- It develops a set of evaluated design requirements and principles for community library provision in low-infrastructure contexts; and
- It offers a transferable design framework for comparable semi-rural African communities.

The paper proceeds as follows. Section 2 reviews literature on library architecture, civic infrastructure, and climate-responsive design, identifying a gap in semi-rural African contexts. Section 3 outlines the design science research methodology, including the three-cycle framework, requirements derivation, and evaluation strategy. Section 4 presents the case study analysis through the rigor cycle. Section 5 presents the site and climatic analysis. Section 6 develops the design proposal through the design cycle. Section 7 evaluates the design against requirements, discusses implications, limitations, and concludes.

2. LITERATURE REVIEW: FROM LIBRARY TO CIVIC INFRASTRUCTURE

2.1. The Library as Social Infrastructure

Contemporary library scholarship has increasingly framed the library not as a book repository but as social infrastructure, a space that supports civic life, social cohesion, and equitable access to resources [6], [2], [7]. This reframing has architectural consequences. If the library is social infrastructure, its design must prioritize flexibility, accessibility, and the accommodation of diverse uses, not merely the efficient storage of materials. The Finnish library system, exemplified by Helsinki's Oodi, represents the most ambitious realization of this model: a library that functions as a living room for the city, incorporating maker spaces, recording studios, meeting rooms, and public gathering areas alongside traditional collections [8], [9].

Recent empirical work has begun to test this framing. Kim [3] demonstrates that public libraries function as connective infrastructure that links individuals to community resources, social networks, and civic participation “particularly for marginalized populations.” Enneking et al. [2] Extend this analysis, showing that the strength of the library-community connection depends on spatial accessibility, programmatic responsiveness, and the library's capacity to adapt to local needs. Peterson [7], however, offers a critical counterpoint: examining children's place in Aotearoa New Zealand's transforming public libraries, the study finds that despite rhetoric of inclusivity, children's needs are often marginalized in library redesigns that prioritize adult-oriented social infrastructure. This tension between the library as universal civic space and the library as a site of competing claims is directly relevant to Obudu in Nigeria, where the facility must serve students, researchers, artisans, children, and the wider community without privileging one group over another.

But this model assumes a level of state investment, institutional capacity, and digital infrastructure that is absent in most Nigerian contexts. The question, then, is not how to replicate Oodi, but how to translate its underlying principles, flexibility, hybridity, and civic orientation into a context of infrastructural scarcity. This requires what Watson [10] calls "situated" design thinking: an approach that begins from the specific conditions of a place rather than from universalizing typological models.

2.2. Climate-Responsive Design in Tropical Uplands

Obudu's elevated terrain produces a climate that differs markedly from the lowland Nigerian norm. At approximately 6°40′N, 9°10′E, the town experiences cooler temperatures, higher humidity, and substantial seasonal rainfall (1,770–1,800 mm annually, with a peak in September). This climatic profile creates both constraints (high rainfall, potential for dampness) and opportunities (reduced cooling loads, potential for natural ventilation).

Climate-responsive design literature emphasizes passive strategies: orientation to minimize solar gain, cross-ventilation, shading devices, and thermal mass [11], [12]. Recent Nigerian research has advanced this agenda. Ndubueze and Munonye [13] demonstrate that passive design strategies, including building orientation, shading devices, and natural ventilation, can significantly reduce cooling loads in tropical Nigerian housing, though their effectiveness depends on careful integration of site-specific climatic data. Oluwafemi et al. [14] extend this analysis to a broader sustainability framework, arguing that climate-responsive architecture in Nigeria must balance thermal performance with economic viability and long-term maintenance considerations. Yusuf et al. [15] develop a multi-dimensional optimization framework for passive cooling in hot semi-arid residential buildings, demonstrating that trade-offs between thermal comfort, energy use, and cost must be explicitly managed in design.

For libraries specifically, thermal comfort and indoor environmental quality are critical determinants of user satisfaction and learning efficacy. Liu et al. [16] evaluated thermal comfort and indoor air quality in a library building through measurement and simulation, finding that passive design strategies "when properly implemented" can maintain acceptable comfort conditions while reducing energy consumption. The study employed CFD simulation validated by field measurements, including air velocity, temperature, and CO2 concentration at multiple locations [16]. Zhou et al. [17] examined atrium-structured libraries, demonstrating that stack ventilation and daylighting can be optimized through integrated design, using TRNSYS-CONTAM co-simulation validated by field measurements across four seasons and a questionnaire with 2,220 responses [17]. Zhang et al. [18] applied termite-inspired principles to window-to-wall ratio design for office buildings in Nigeria's temperate dry region, showing that biomimetic approaches can inform climate-responsive envelope design.

These studies collectively suggest that Obudu's climate makes passive design not merely desirable but viable, provided it is integrated with a spatial logic that supports natural airflow and daylight distribution. However, as Oluwafemi et al. [14] caution, passive strategies must be evaluated within a broader sustainability framework that includes economic and maintenance considerations, particularly in contexts of limited institutional capacity.

2.3. Learning Spaces and Environmental Stimuli

A growing body of research examines how physical environments affect learning outcomes in library and educational settings. Wu et al. [19] investigated mechanisms of environmental stimuli on learning efficacy in university library spaces, finding that thermal comfort, lighting quality, and acoustic conditions significantly predict user concentration and satisfaction. Wang et al. [20] conducted comprehensive field measurements of light, noise, thermal, and air quality in library informal learning spaces, demonstrating that IEQ factors interact in complex ways "for example", high noise levels can reduce tolerance for thermal discomfort. Thneibat et al. [21] applied structural equation modeling to assess post-COVID interactions between IEQ and occupants in educational buildings, finding that perceived control over environmental conditions mediates the relationship between IEQ and satisfaction.

Nigerian-specific research on library indoor environmental quality has identified significant challenges. A pilot study of Nigerian university libraries found that all fourteen studied spaces presented background noise levels greater than 45 dB, with the highest value (72 dB) reached in the afternoon [34]. This excessive noise was attributed to HVAC systems, standing fans, traffic, and user behavior, demonstrating that noise control is a critical design consideration in Nigerian library contexts [34].

Another study monitored di(2-ethylhexyl) phthalate (DEHP) in indoor aerosols across nine Nigerian universities, finding that library spaces showed lower ILCR values, possibly due to better ventilation and reduced occupancy compared to offices and laboratories [26].

These findings have direct implications for library design in Obudu. They suggest that environmental quality is not merely a comfort issue but a learning issue, and that passive design strategies, which often give users greater control over their immediate environment (operable windows, adjustable shading), may have pedagogical as well as energy benefits.

2.4. Post-Occupancy Evaluation as Design Feedback

Post-Occupancy Evaluation (POE) provides a systematic methodology for assessing building performance after occupation, offering critical feedback for design improvement [30]. POE is defined as "a systematic and meticulous process used to assess buildings after they have been constructed and occupied for a certain period," centered on building occupants and their requirements [15]. The methodology offers insights into the outcomes of past design decisions and lays a foundation for superior future buildings [30].

POE has been applied extensively to library buildings. A study evaluating school library enhancements through POE found that group learning spaces received lower satisfaction scores due to teacher-centric book placements and furniture designs that limited seating flexibility, while varied reading spaces achieved high satisfaction ratings exceeding 4 out of 5 [1]. Research on campus library POE has confirmed the changing role of libraries as study spaces and identified interventions to introduce postural variation and physical activity [29]. The Fayetteville Public Library POE conducted over several weeks included staff interviews, public input sessions, and rigorous analysis of performance data, revealing the impact of higher than expected use patterns and rapidly changing content-delivery systems [8].

For the present study, POE principles inform the evaluation strategy for the proposed design, even though the building is not yet constructed. The requirements derived from case study analysis and literature review function as evaluation criteria, and the design is assessed against these criteria in Section 7. This approach aligns with DSR evaluation guidance, which specifies that "the utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods" [35].

2.5. Critical Regionalism and the Politics of Typology

Frampton's [22] concept of critical regionalism offers a useful lens for approaching library design in Obudu. Critical regionalism resists both the placelessness of global modernism and the nostalgia of vernacular revivalism. It seeks instead to mediate between universal techniques and local conditions to produce buildings that are modern but rooted, contemporary but context-specific.

Recent scholarship has revisited critical regionalism in contemporary contexts. An [23] argues that critical regionalism remains relevant in the twenty-first century, particularly in contexts where global architectural flows threaten to erode local specificity. The study emphasizes that critical regionalism is not about formal quotation of vernacular elements but about a design attitude an openness to local conditions, materials, and practices that informs every design decision.

Applied to the library, critical regionalism suggests that the building should not simply import the Oodi model (which is responsive to Finnish climatic, social, and institutional conditions) nor retreat into a romanticized "African" vernacular. Rather, it should synthesize: drawing on international best practices in library planning while responding to Obudu's climate, materials, cultural practices, and socio-economic realities. This synthesis is not merely technical but political, it asserts that semi-rural Nigerian communities deserve architecture of the same ambition and quality as urban centres.

2.6. Multifunctional Library Design

Contemporary library design increasingly emphasizes multifunctionality, the integration of diverse programs within a single facility. Park [9] examined the spatial composition of university libraries transitioning into multifunctional cultural complexes, identifying key design strategies: flexible floor plates, movable partitions, and the clustering of related functions. Az-Zahidah [24] applied adaptive architecture principles to library and learning centre design in Surabaya, demonstrating that spatial adaptability is essential for accommodating changing user needs and technological developments.

For Obudu, multifunctionality is not merely a design preference but a necessity. A community library serving a dispersed, semi-rural population must accommodate multiple user groups with different needs, students requiring quiet study, artisans seeking vocational information, children developing literacy skills, and community groups needing assembly space. The design challenge is to accommodate this diversity without diluting the library's core identity as a space for reading and learning.

2.7. The Gap: Semi-Rural African Library Architecture

The literature on library architecture is dominated by studies of urban libraries in the Global North. African library architecture is understudied, and what exists focuses predominantly on university libraries or national libraries in major cities [25]. There is, to date, no substantial body of research on community library design in semi-rural African contexts, contexts characterized by limited infrastructure, low institutional capacity, and communities with no prior experience of public library provision. This paper addresses that gap. It does not simply apply existing models but interrogates what the library can and should be in a context where it has no institutional precedent.

3. METHODOLOGY: DESIGN SCIENCE RESEARCH

3.1. Design Science Research Framework

This study employs a design science research (DSR) methodology, which is particularly suited to research that seeks to create and evaluate artifacts, constructs, models, methods, or “instantiations” to address identified problems [35]. Unlike natural science research, which focuses on understanding why things work the way they do, DSR focuses on creation: "how things ought to be in order to attain goals, and to function" [35]. The purpose of design science is "to change existing situations into preferred ones" [36].

DSR is organized around three cycles: the relevance cycle, the rigor cycle, and the design cycle [5]. The relevance cycle bridges the research environment (application context) with the design science activities, ensuring that the research addresses a real-world problem. The rigor cycle connects design science activities with the knowledge base of scientific foundations, experience, and expertise, ensuring that the research draws on and contributes to existing knowledge.

The design cycle iterates between the construction of the artifact and its evaluation, refining the design until it satisfies the derived requirements from the relevance and rigor cycles [5].

This study operationalizes the DSR framework as follows:

Relevance Cycle: Identifying the problem of library infrastructure absence in Obudu, deriving requirements from site analysis, climatic data, and community needs inference (Sections 1.2, 5).

Rigor Cycle: Drawing on literature, standards, and comparative case study analysis to establish design knowledge (Sections 2, 4).

Design Cycle: Developing the architectural proposal (Section 6), evaluating it against requirements (Section 7), and articulating design principles as knowledge contributions.

3.2. Requirements Derivation

In DSR, the articulation of a clear set of requirements is critical because it provides the researcher with evaluation metrics [36]: the design artifact can be evaluated in terms of whether it meets these requirements and refined accordingly during iterative design cycles [5]. The lack of such evaluation metrics, as March and Smith (1995) warn, makes it impossible to effectively judge the research effort [5].

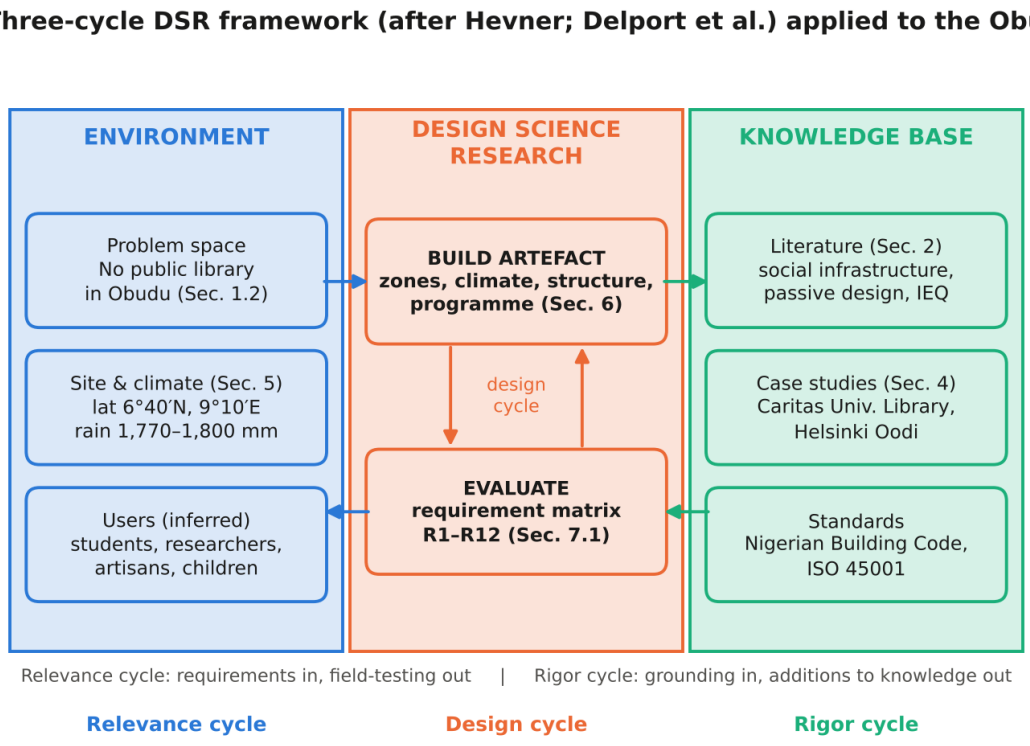


Figure 1. Three-Cycle Design Science Research Framework.

Maps the article's relevance, rigor, and design cycles onto the Obudu study: environment (problem, site, users), knowledge base (literature, case studies, standards), and the build-evaluate loop in the centre.

For this study, requirements were derived from three sources:

- Literature and standards: Nigerian Building Code [31], ISO 45001 [28], IFLA guidance, and climate-responsive design research [13], [14], [15].
- Case study analysis: Transferable principles identified from Caritas University Library and Helsinki Central Library Oodi (Section 4.3).
- Site and climatic analysis: Obudu's specific climatic, topographic, and contextual conditions (Section 5).

The resulting requirements are presented in Section 4.4.

3.3. Case Study Strategy

Selecting two cases that represent distinct positions on the spectrum of library provision:

Caritas University Library, Enugu, Nigeria: a representative example of Nigerian academic library provision, offering insight into local planning norms, spatial organization, and operational challenges [27].

Helsinki Central Library Oodi, Finland: an internationally recognized exemplar of the contemporary community library, offering insight into flexible programming, civic orientation, and climate-responsive design in a different climatic context [8].

The cases were selected not for their similarities but for their differences. Caritas represents the Nigerian status quo, functional but constrained; Oodi represents the aspirational model, hybrid, civic, and generously resourced. The analytical value lies in the tension between them: what can be learned from Oodi that is transferable to Obudu, and what must be rejected as contextually inappropriate?

3.4. Data Sources and Analysis

Data were drawn from three sources:

- Documentary analysis: Published literature, standards, and technical guidelines on library planning, climate-responsive design, and Nigerian building regulations [31], [28].
- Site analysis: Reconnaissance of the proposed site in Obudu, including topographic, climatic, and land-use analysis, supported by meteorological data [29].
- Case study analysis: Site visits and photographic documentation (Caritas); documentary and published sources (Oodi).

Analysis proceeded through a process of thematic coding: identifying recurrent design principles, spatial strategies, and operational patterns across the cases, and evaluating their transferability to the Obudu context.

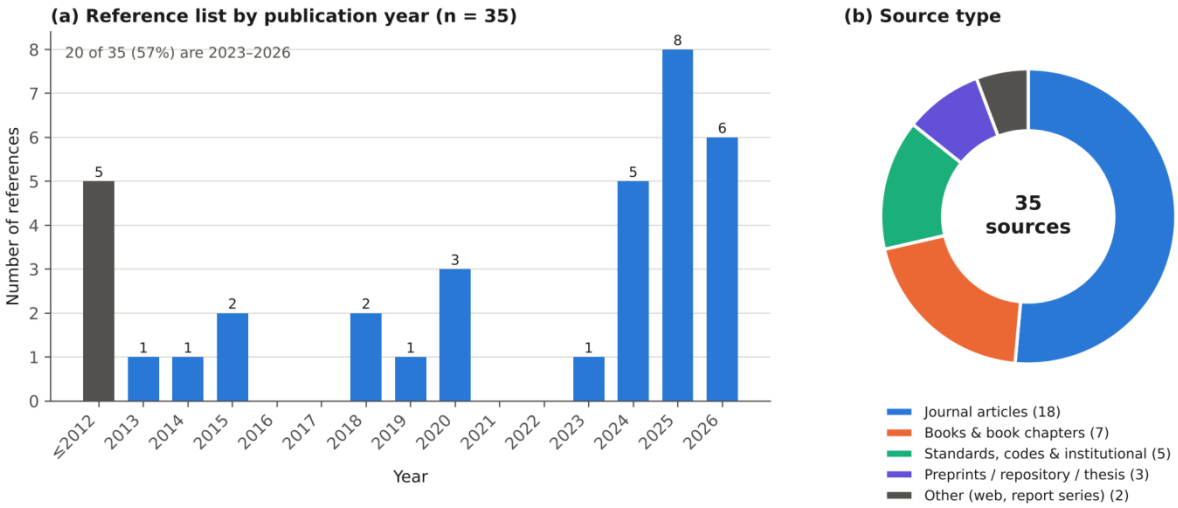


Figure 2. Literature Base: Publication Years and Source Types.

Histogram of the 35 references by publication year, with older items pooled as ≤ 2012, and a donut of source types. It shows how current the rigor-cycle knowledge base is.

Key result: 20 of 35 references (57%) date from 2023–2026; 18 are journal articles.

Equations

(2.1) Histogram count

$$n_k = \sum_{i=1}^{N} \mathbf{1}\,[y_i = k], \qquad N = 35$$

y_i is the publication year of reference i.

(2.2) Recency share

$$\rho_{\text{recent}} = \frac{\sum_{k \geq 2023} n_k}{N} = \frac{20}{35} = 0.57$$

(2.3) Source-type share

$$p_j = \frac{m_j}{N}, \qquad \sum_j m_j = 35$$

Journals 18, books/chapters 7, standards/institutional 5, preprint/thesis 3, other 2.

Table 1. Parameters

Symbol / item	Value	Source
N	35	Article reference list
Year bins	≤2012, then 2013–2026	Chosen for display

3.5. Evaluation Strategy

DSR requires rigorous evaluation of the design artifact. Hevner et al. [35] specify that "the utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods." This study employs a “descriptive requirement-matrix evaluation approach,” which is an established evaluative mode for early-stage schematic design-science research where the artefact remains unbuilt and physical post-occupancy evaluation (POE) is not yet possible [35].

This evaluation method assesses the conceptual architectural proposal against pre-defined requirements derived from the relevance-cycle and rigor-cycle activities. It validates internal logical consistency between contextual needs, scholarly knowledge, and design output, rather than measuring real-world in-use performance. This distinction is critical: descriptive evaluation cannot substitute for empirical building-performance testing or stakeholder lived-experience assessment after construction.

In this study, evaluation proceeds by cross-referencing each design decision against the requirements matrix (Section 4.4). Compliance, partial compliance, and unaddressed requirements are explicitly documented. Recognising the limits of conceptual-only assessment, the study frames quantitative thermal, daylight, and airflow simulation, as well as eventual POE post-construction, as mandatory subsequent research steps.

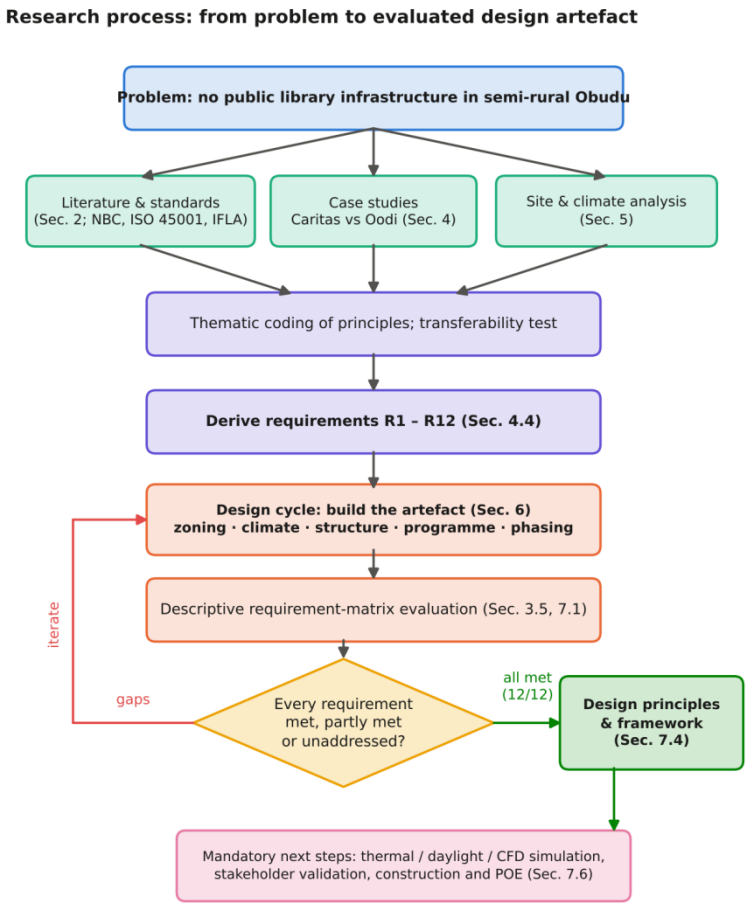


Figure 3. Research Process and Evaluation Decision Loop.

Follows the study from problem statement, through three evidence sources, thematic coding and requirement derivation (R1–R12), to the design cycle and the requirement-matrix decision. The article reports all 12 requirements met, so the loop exits to design principles; simulation and post-occupancy evaluation (POE) remain mandatory next steps.

Key result: Compliance index CI = 12/12 = 1.00 (descriptive, not empirical).

Equations

(3.1) Requirement status score

$$s_i \in \{1,\ 0.5,\ 0\} \quad \text{(Met, Partial, Unaddressed)}$$

Section 3.5 states that compliance, partial compliance and unaddressed requirements are documented; the scores are an arithmetic coding of those three states.

(3.2) Compliance index

$$CI_k = \frac{1}{12}\sum_{i=1}^{12} s_i^{(k)}$$

k is the design iteration.

(3.3) Loop stop rule

$$\text{iterate while} \min_i s_i^{(k)} < 1 \ \Rightarrow\ \text{stop when} CI_k = 1$$

In the Section 7.1 evaluation table every s_i = 1, so CI = 1.

Design Proposal

This section presents the design proposal for the Obudu Learning Centre at schematic stage: the site plan, ground and first floor plans, four elevations, two sections and two exterior perspectives. Dimensions are indicative; the site plan is redrawn from a hand-drawn sketch.

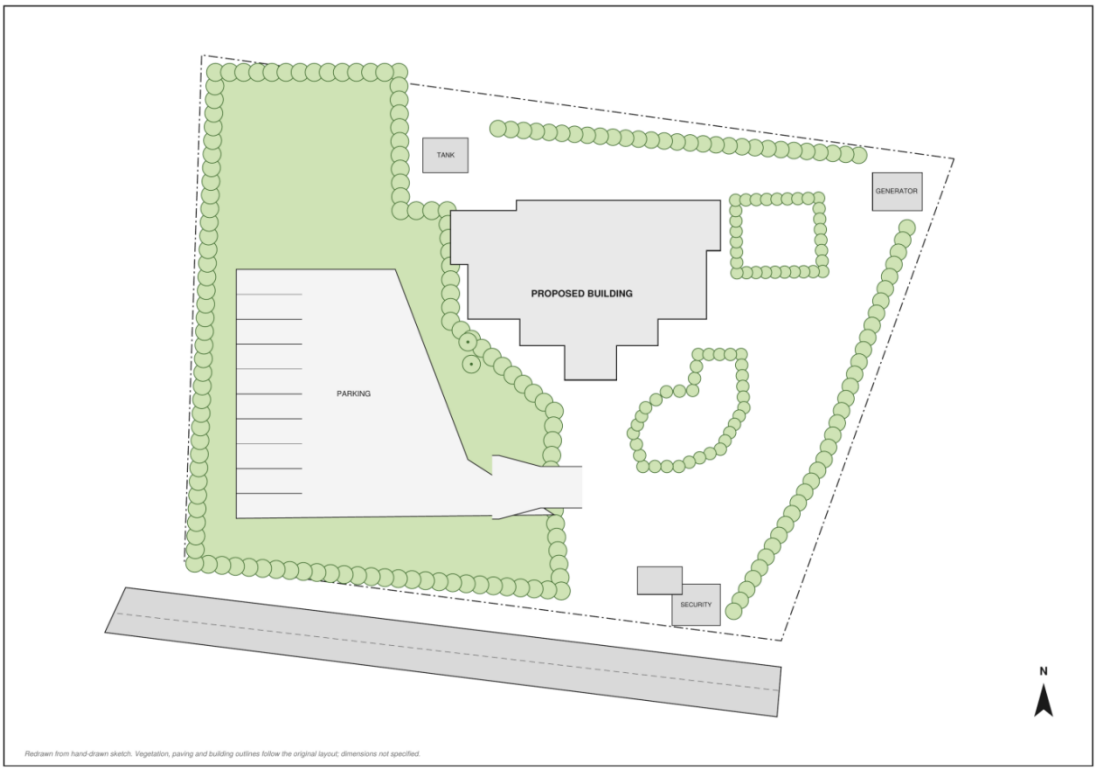


Figure D1. Site Plan.

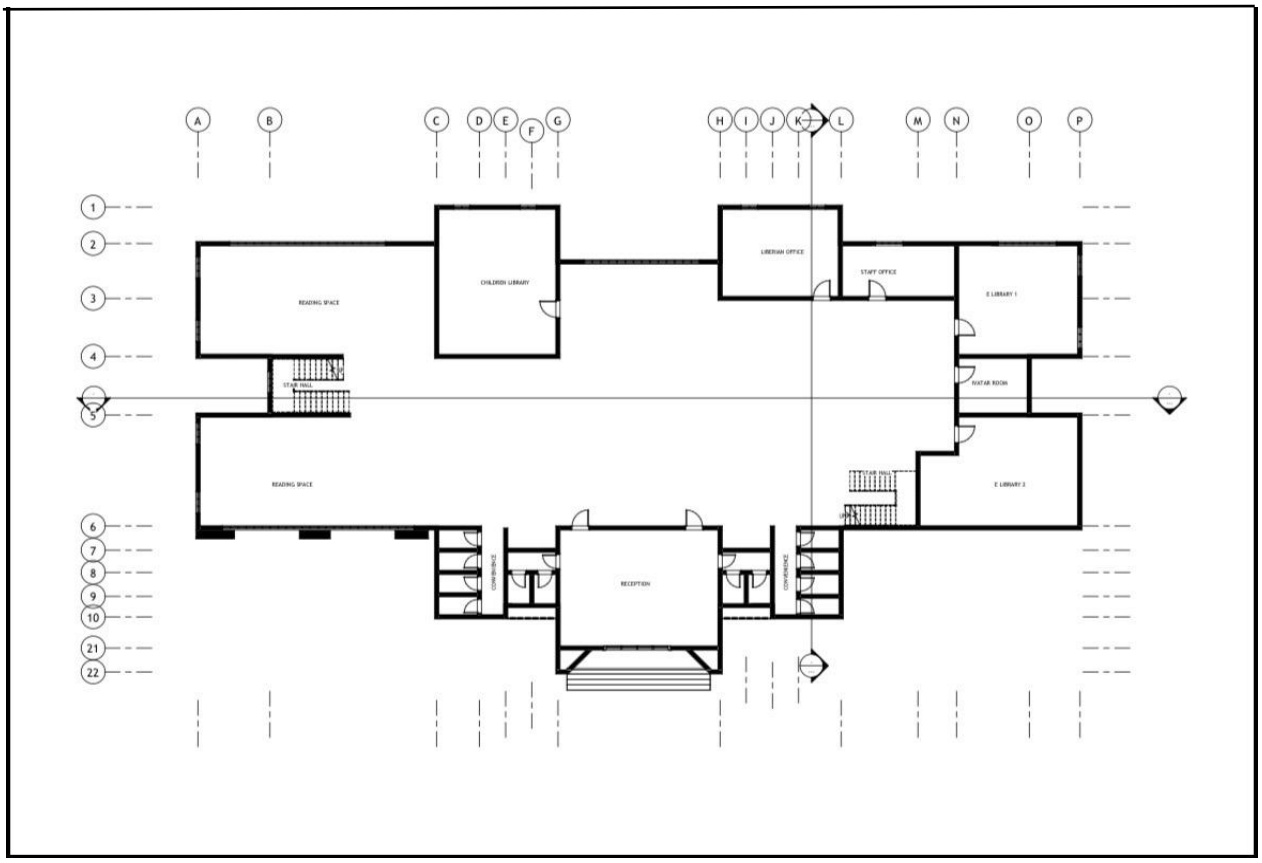


Figure D2. Ground Floor Plan.

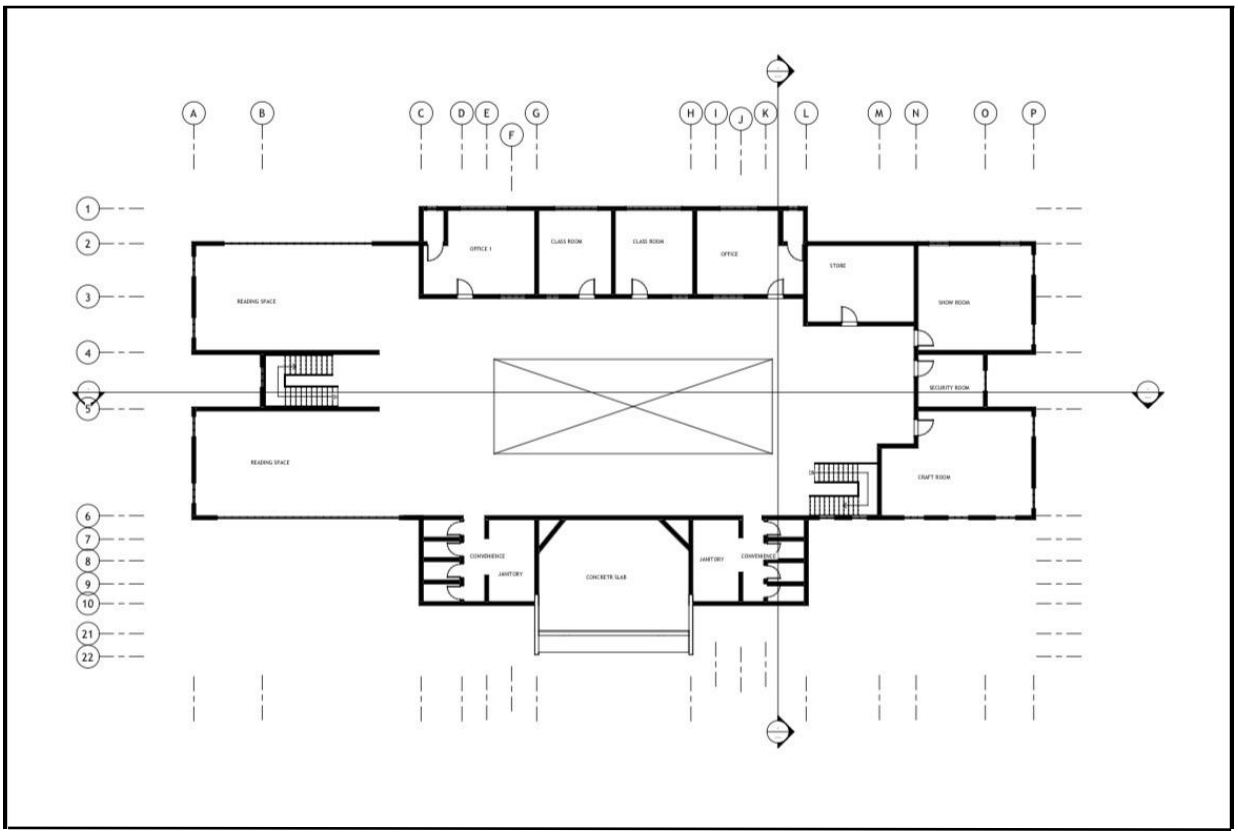


Figure D3. First Floor Plan.

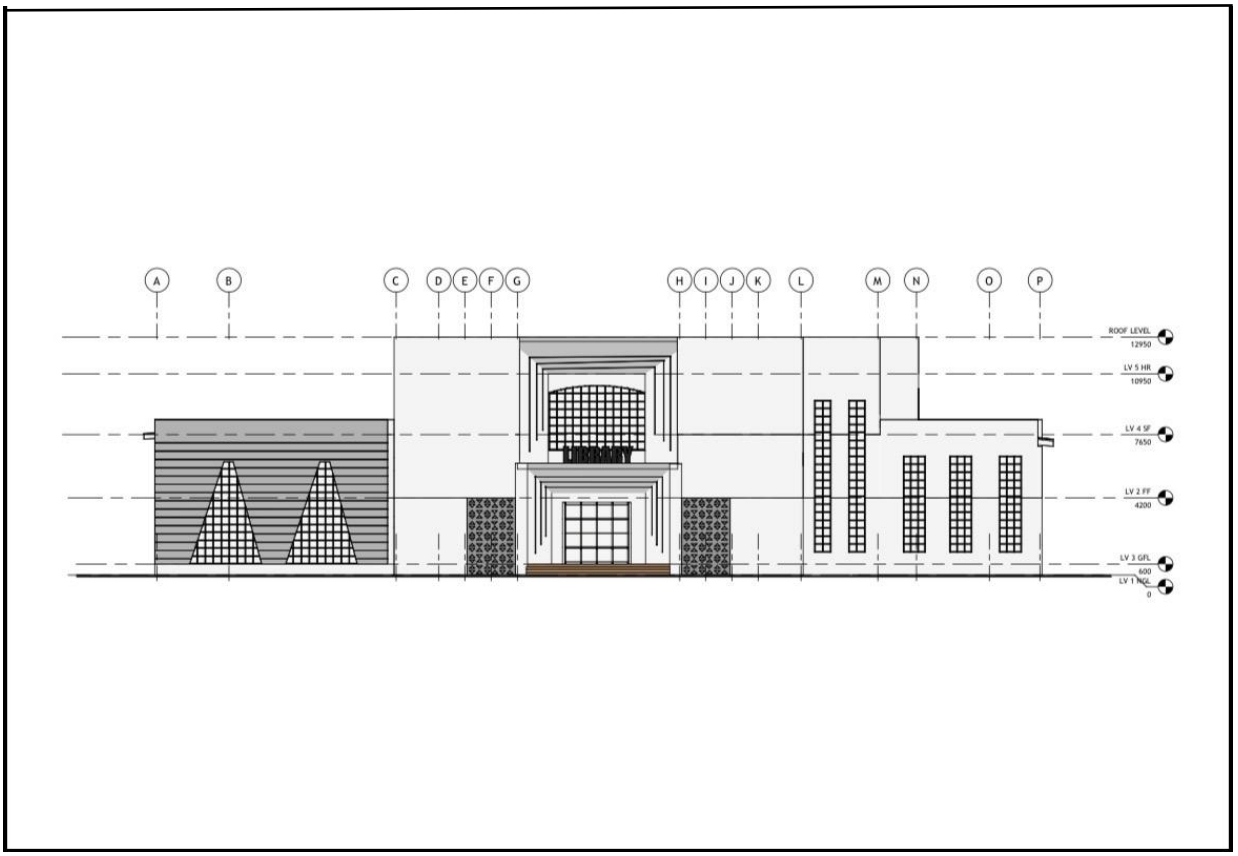


Figure D4. Front Elevation.

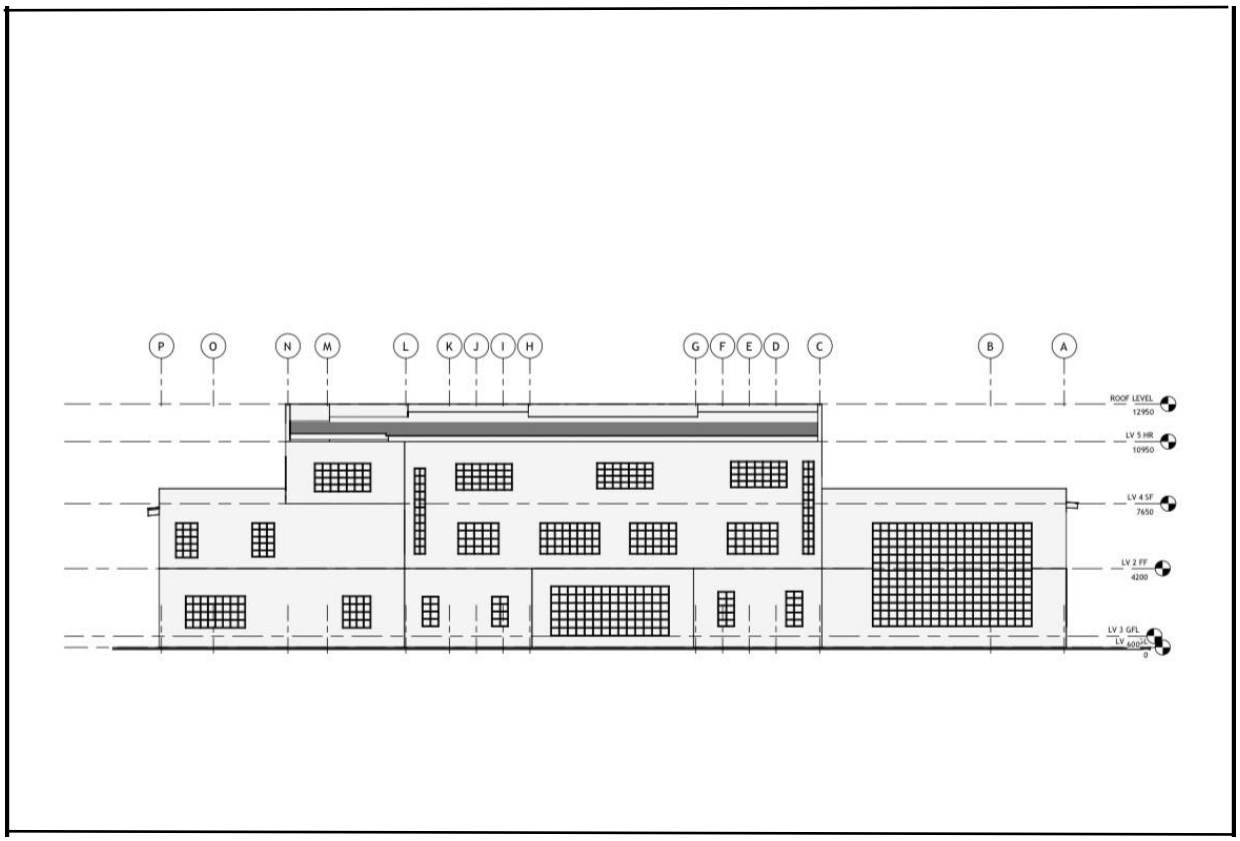


Figure D5. Back Elevation.

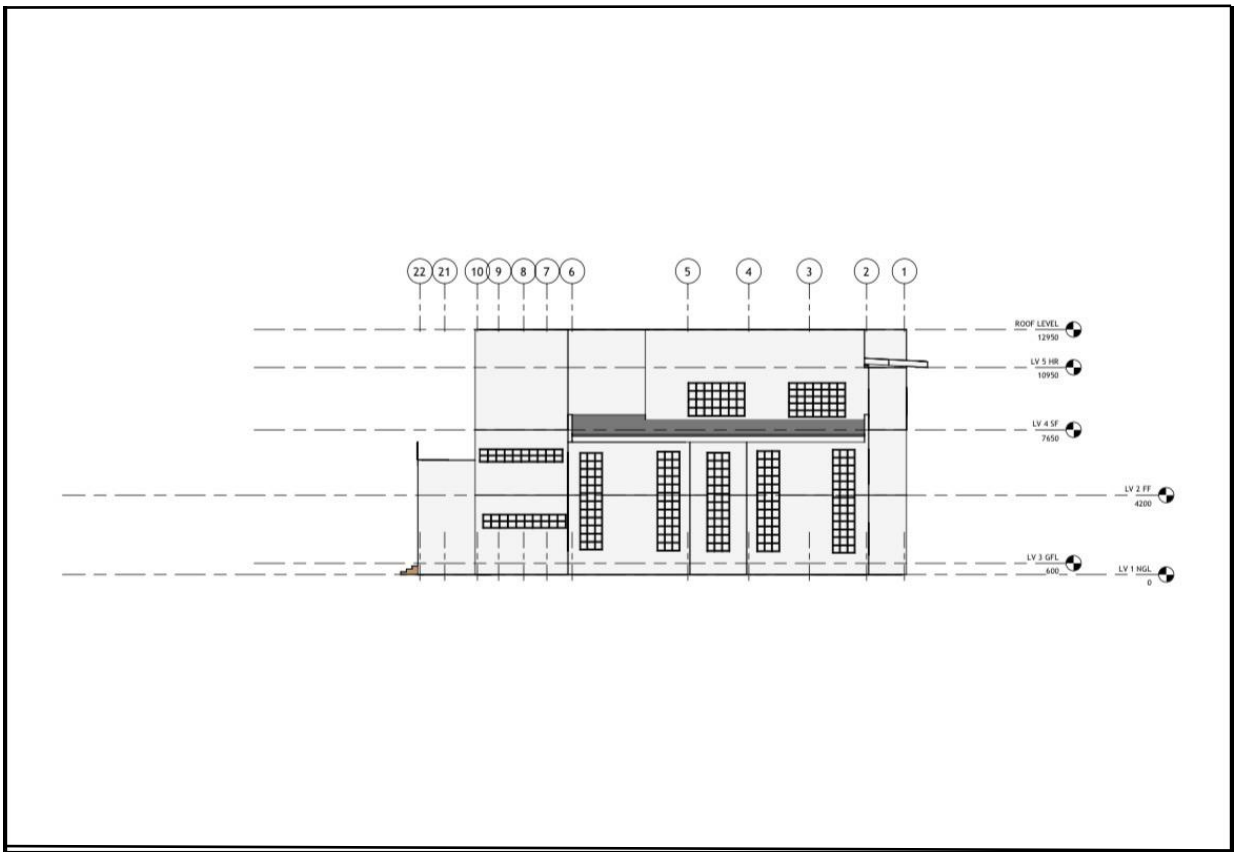


Figure D6. Right Elevation.

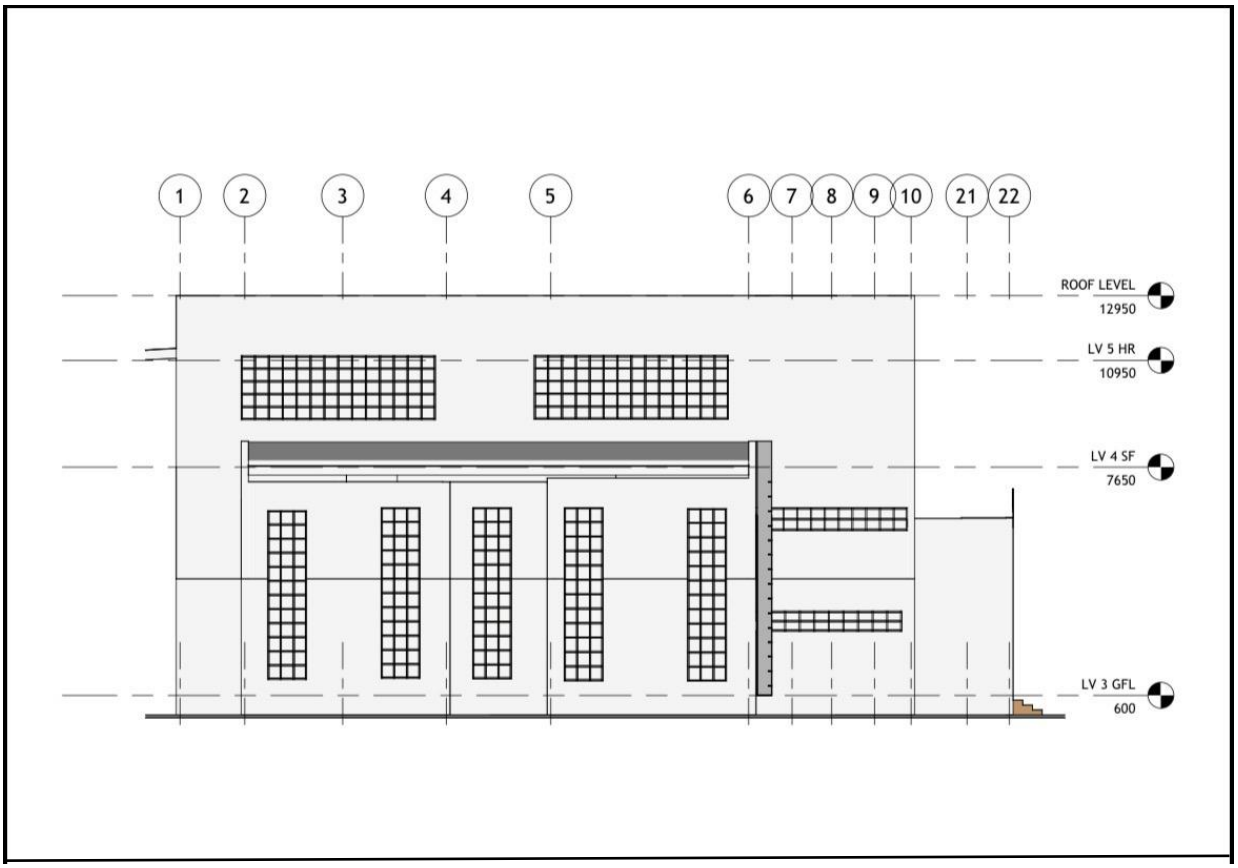


Figure D7. Left Elevation.

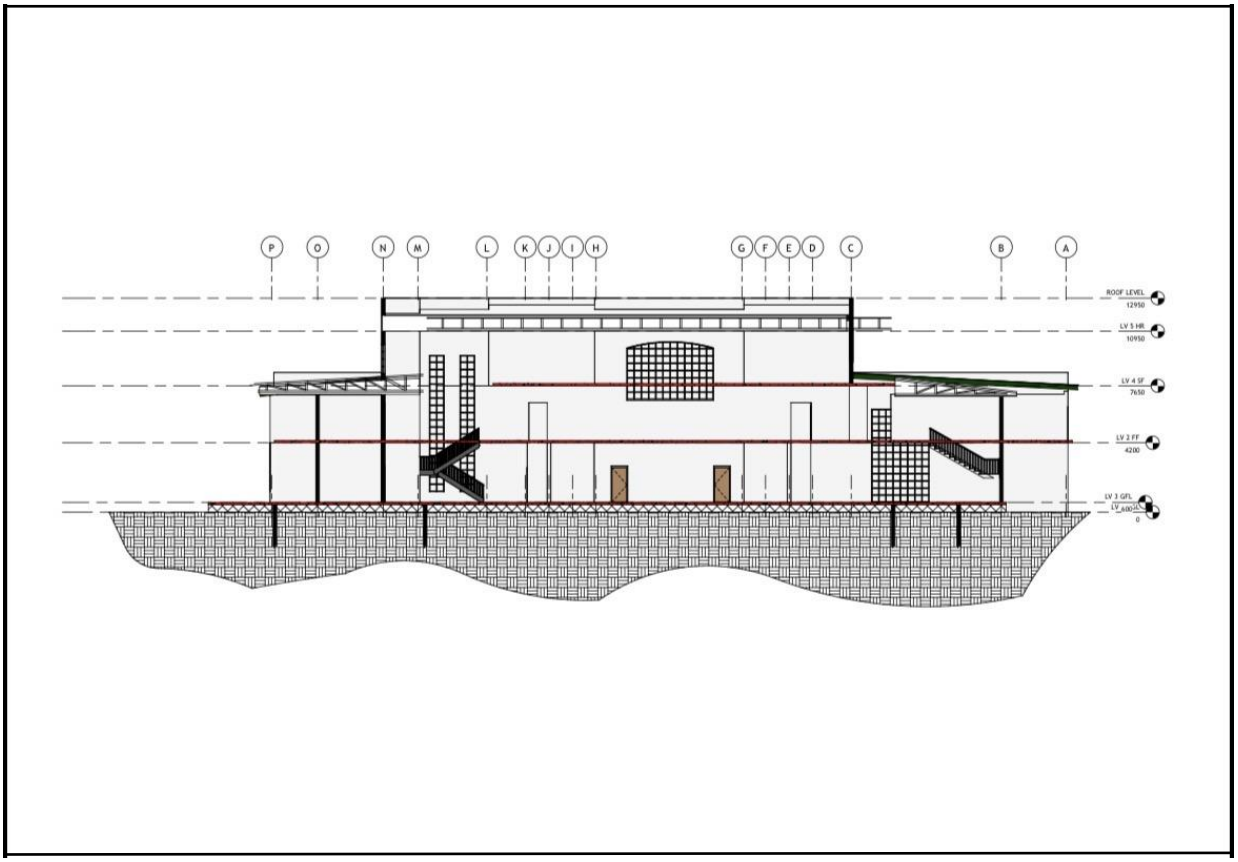


Figure D8. Section A–A

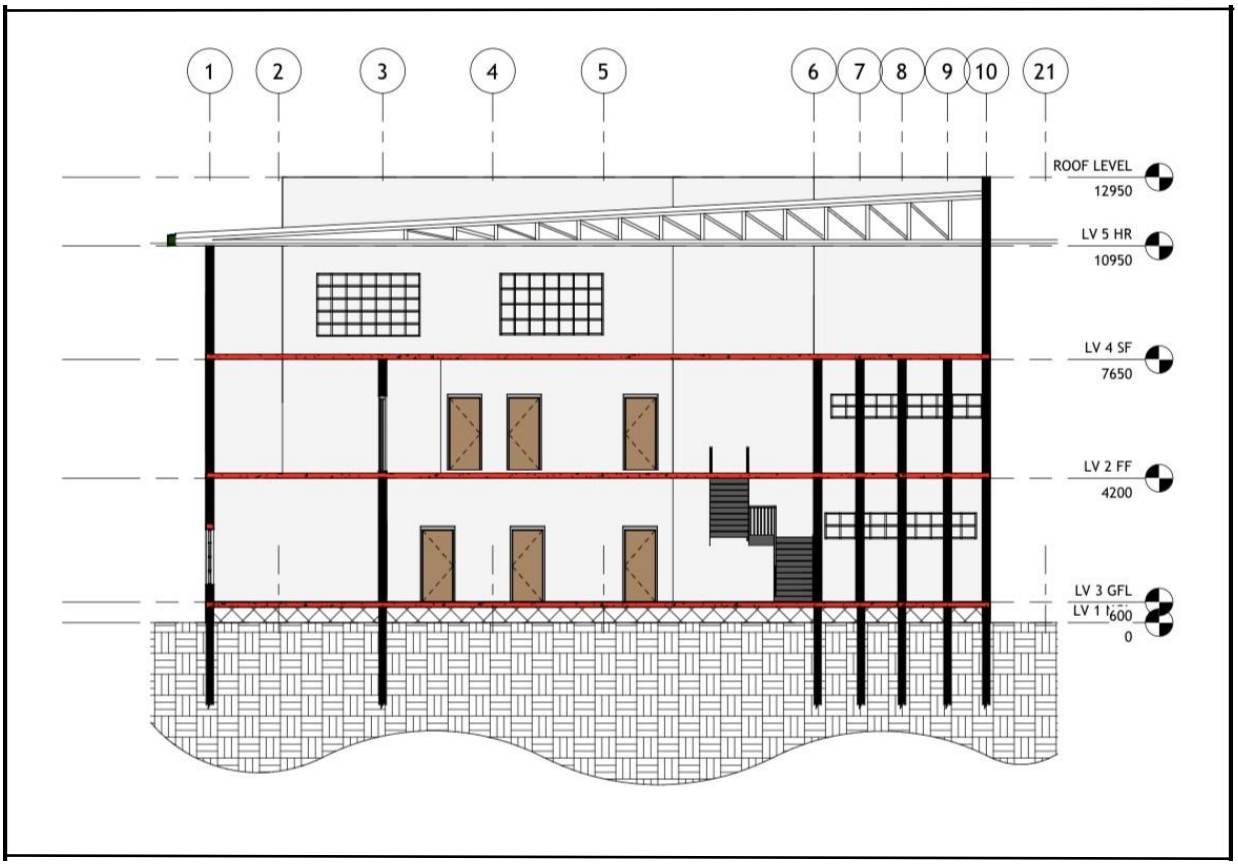


Figure D9. Section B–B.

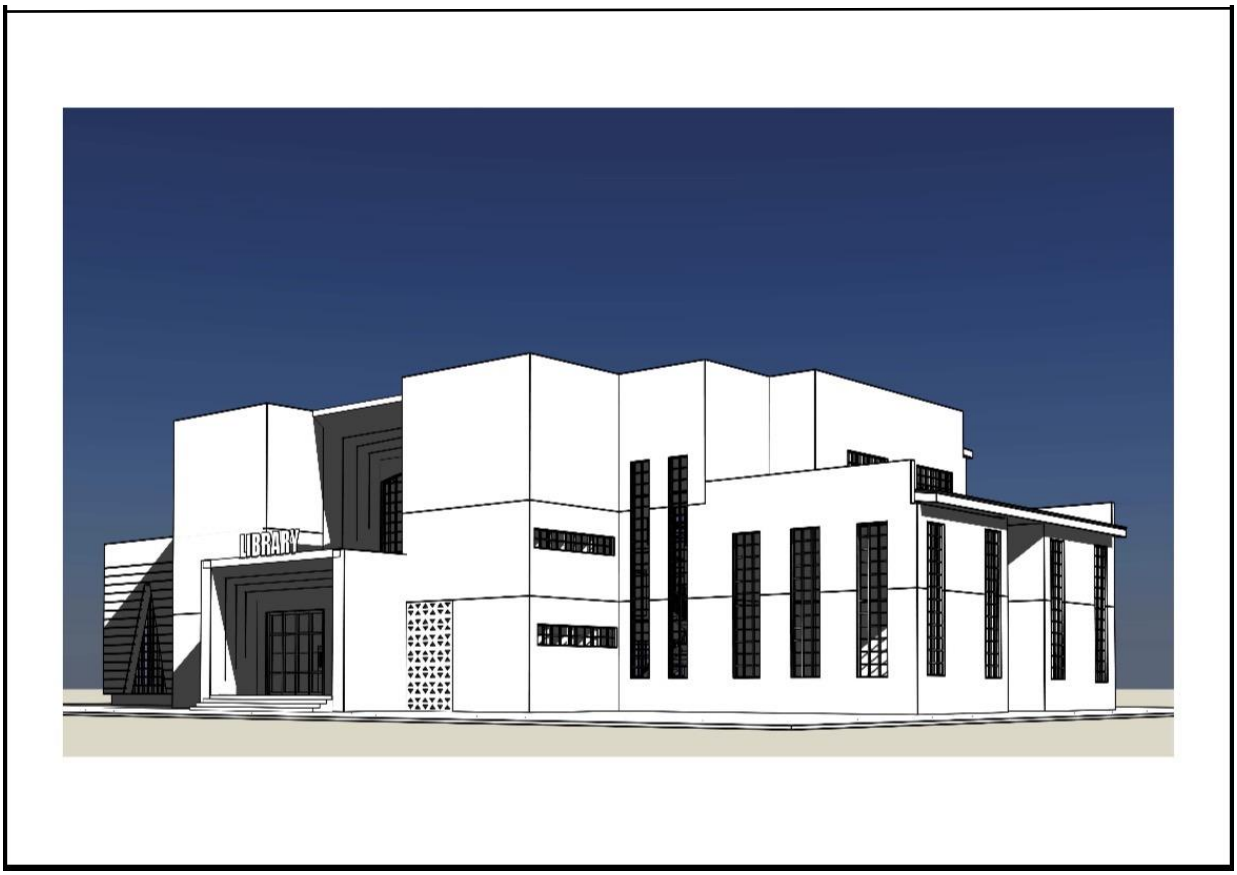


Figure D10. Exterior Perspective 1.

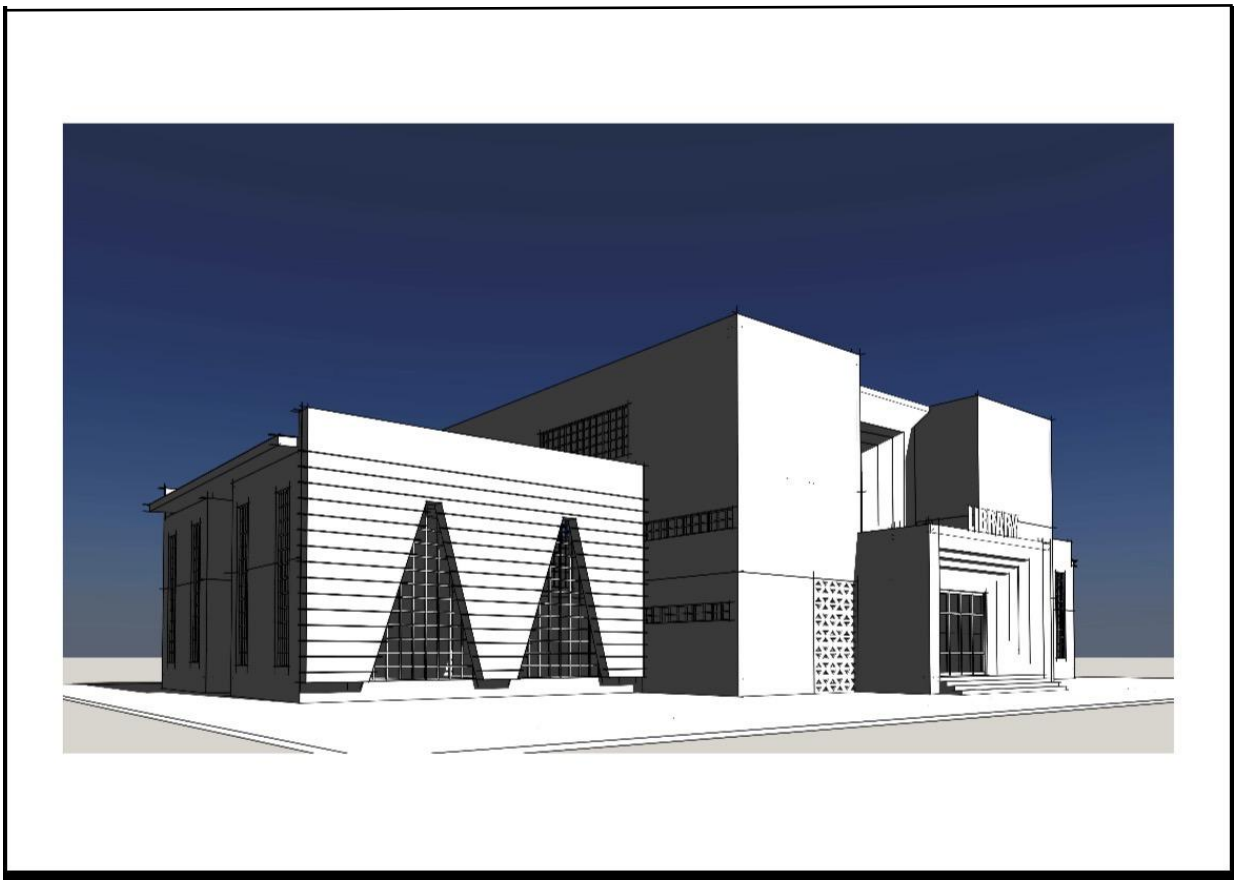


Figure D11. Exterior Perspective 2.

4. CASE STUDY ANALYSIS (RIGOR CYCLE)

4.1. Caritas University Library: The Nigerian Status Quo

Caritas University Library, built in 2005 in Amorji-Nike, Enugu State, Nigeria, is a two-storey reinforced concrete structure housing a reading hall, book stacks, and administrative offices [27]. Its spatial organization is conventional: a central circulation core, perimeter reading areas, and shelving along internal walls. The building is naturally ventilated, with ceiling fans providing supplementary air movement. Lighting is predominantly artificial, with limited daylight penetration due to deep floor plates and small window openings.

Analytical observations:

- Spatial efficiency vs. user comfort: The library prioritizes shelving capacity over user comfort. Reading areas are densely packed, and there is limited provision for group study or collaborative work.
- Technology deficit: The library lacks digital infrastructure, no computer terminals, no reliable internet, no digital catalog. This reflects a broader pattern in Nigerian academic libraries, where digital provision is often aspirational rather than actual.
- Maintenance and condition: The building shows signs of deferred maintenance, worn finishes, outdated electrical systems, and inadequate lighting. This is not a criticism of the institution but a reflection of the broader funding environment for Nigerian public infrastructure.

The Caritas case demonstrates the limitations of conventional Nigerian library design: functional in a minimal sense, but unable to support the hybrid, technology-augmented, socially embedded model that contemporary library discourse advocates [3], [9].

4.2. Helsinki Central Library Oodi: The Aspirational Model

Oodi, designed by ALA Architects and opened in 2018, represents a radically different conception of the library [8]. Its three floors are organized by activity intensity rather than collection type: the ground floor is a public living room, the second floor a maker and learning space, and the third floor a traditional reading environment ("Book Heaven"). The building's timber façade, extensive glazing, and open-plan interiors create a strong visual connection between interior and exterior. Passive design “strategies, daylighting, natural ventilation, thermal mass” are integrated with mechanical systems.

Analytical observations:

- Programmatic hybridity: Oodi integrates library functions with maker spaces, recording studios, meeting rooms, cafes, and public gathering areas. The library is not a destination for books but a platform for activity.
- Civic orientation: The building is explicitly framed as a gift to the city, a public living room, a democratic space. Its architecture expresses openness, transparency, and welcome.
- Climatic and contextual specificity: Despite its international acclaim, “Oodi is highly specific to Helsinki” its climate, its social democratic ethos, its public infrastructure. Its lessons are principles, not forms.

4.3

Table 2. Comparative Analysis: Transferable Principles.

Dimension	Caritas	Oodi	Transferable to Obudu?
Zoning	By collection	By activity intensity	Yes: activity-based zoning
Flexibility	Low	High	Yes: movable furniture, adaptable partitions
Technology	Minimal	Extensive	Partial: prioritize digital infrastructure
Civic orientation	Implicit	Explicit	Yes: frame as community infrastructure
Climate strategy	Passive + fans	Passive + mechanical	Yes: passive-first, mechanical backup
Cost model	Low	High	No: must be cost-conscious

The comparative analysis suggests that the transferable principles are activity-based zoning, programmatic flexibility, explicit civic framing, and passive-first climate strategy. The non-transferable elements are Oodi's high-cost materials and extensive mechanical systems.

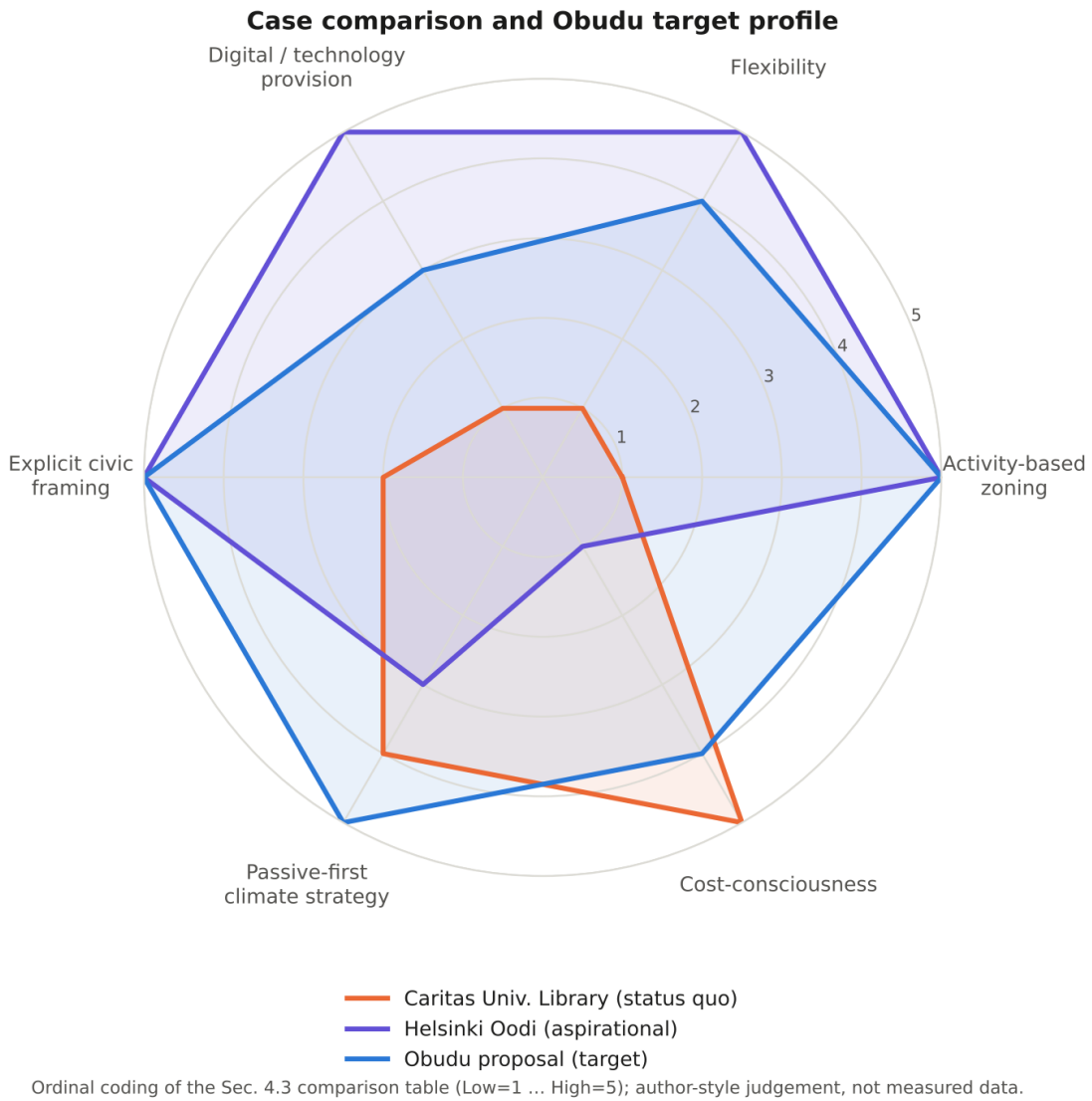


Figure 4. Case Comparison: Caritas, Oodi, and the Obudu Target.

Converts the qualitative comparison table into a 1–5 profile on six dimensions. The Obudu proposal inherits Oodi's zoning, civic framing, and flexibility, keeps Caritas-level cost-consciousness, and goes further on passive-first climate strategy.

Key result: Mean score: Caritas 2.33, Oodi 4.00, Obudu 4.33. This is an ordinal coding of the table, not measured data.

Equations

(4.1) Ordinal score

$$S_{c,d} \in \{1,2,3,4,5\}$$

1 = absent/minimal; 2 = low; 3 = moderate; 4 = high; 5 = extensive/explicit.

(4.2) Mean profile

$$\bar{S}_c = \frac{1}{6}\sum_{d=1}^{6} S_{c,d}$$

(4.3) Gap to the aspirational model

$$\Delta_d = S_{\text{Oodi},d} - S_{\text{Obudu},d}$$

Largest gaps: technology (2) and cost-consciousness {−3, Negative values indicate dimensions where Obudu outperforms Oodi (cost-consciousness)}.

Table 3. Parameters

Symbol / item	Value	Source
Scores	See figure	Judgement applied to the Section 4.3 table 2

4.4. From the Relevance and Rigor Cycles, the Following Requirements Were Derived

Table 4. Requirements Derived for the Design Artifact.

Req. ID	Requirement	Source
R1	Separate quiet study areas from collaborative and social spaces	Case studies [1], [9]
R2	Provide flexible, adaptable spaces for diverse activities	Case studies [9], [24]
R3	Prioritize passive climatic strategies (orientation, ventilation, shading)	Climate research [13], [14], [15]
R4	Ensure accessibility for all users, including persons with disabilities	Standards [31], [28]
R5	Integrate digital infrastructure (ICT, internet, digital learning)	Case studies [3], [9]
R6	Provide adequate noise control and acoustic separation	IEQ research [34]
R7	Incorporate safety and security measures (fire, egress, access control)	Standards [31]
R8	Allow for phased implementation responsive to budget constraints	Case study [27]

R9	Frame the facility explicitly as civic/community infrastructure	Theory [6], [2]
R10	Respond to site-specific climatic and topographic conditions	Site analysis
R11	Include children's spaces and early literacy provision	Theory [7]
R12	Provide adequate natural lighting while controlling glare	Climate research [16], [17]

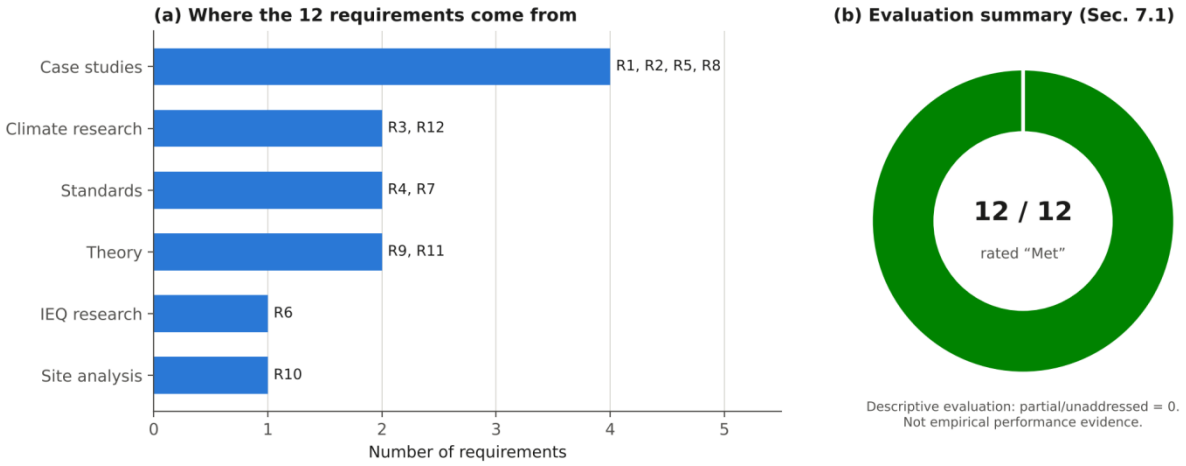


Figure 5. Requirement Sources and Compliance Summary.

Counts the 12 requirements by the source type the article lists for each and shows the 12/12 'Met' result from the evaluation table.

Key result: Case studies supply 4 requirements; climate research 2; standards 2; theory 2; IEQ research 1; site analysis 1.

Equations

(5.1) Requirements per source

$$q_s = |\{R_i : \text{source}(R_i) = s\}|, \qquad \sum_s q_s = 12$$

(5.2) Compliance index

$$CI = \frac{1}{12}\sum_i s_i = \frac{12}{12} = 1.00$$

Same definition as Figure 3.

5. SITE AND CLIMATIC ANALYSIS (RELEVANCE CYCLE)

5.1. Location and Topography

The proposed site is located within Obudu town at approximately 6°40′N, 9°10′E. The terrain is undulating, with the site occupying a relatively gentle, developable portion of land. The wider region contains hills, ridges, and valleys, with elevations ranging from approximately 100m to 1,500m above sea level.

5.2. Climate

Obudu's climate is tropical upland, characterized by [29]:

- Rainfall: 1,770–1,800 mm annually, with a peak in September (315 mm) and minimum in December (3 mm).
- Temperature: Warm throughout the year, with cooler conditions than lowland Nigeria due to elevation.
- Humidity: High, particularly during the wet season.
- Sunshine: Seasonal variation, with reduced sunshine during the wet season.

Design implications:

- Wide roof overhangs and effective drainage to manage heavy rainfall (R3)
- Raised floor levels in flood-prone areas
- Orientation and shading to minimize solar gain (R3)
- Cross-ventilation to manage humidity and thermal comfort (R3)
- Daylighting design that accounts for seasonal variation (R12) [16], [17]

5.3. Soil and Vegetation

The soil is predominantly lateritic, derived from weathered basement rocks. Lateritic soils have moderate bearing capacity but may require foundation design attention. Vegetation is savanna-like, with grassland and patches of forest, varying with elevation.

5.4. Land Use and Context

The site is within the Obudu urban area, surrounded by a mix of residential, institutional, commercial, and undeveloped land. Existing structures are predominantly low-rise residential buildings. The site is accessible from the main road and is within walking distance of schools and civic facilities.

5.5. Site Analysis Limitations

The site analysis builds upon reconnaissance field observation and secondary meteorological datasets rather than continuous on-site environmental measurement. Detailed geotechnical investigation, high-precision topographical survey, and long-term monitoring of local temperature, humidity, wind speed, and solar radiation were outside the scope of this exploratory DSR inquiry. Such primary site measurements will be required for detailed engineering design and high-fidelity building-performance simulation in follow-up work.

Furthermore, formal participatory community engagement, including structured surveys, focus-group discussions, and interviews with Obudu students, artisans, caregivers, and local administrators, was not undertaken within this research project. User needs for the community library are inferred through documentary sources, site observation, comparable African semi-rural case contexts, and existing library scholarship rather than collected via direct primary stakeholder consultation. While this inference is defensible for early-stage exploratory design-science research, it introduces uncertainty around local preference prioritization; participatory user-needs assessment is strongly recommended prior to any real-world implementation of the design proposal.

6. DESIGN PROPOSAL (DESIGN CYCLE)

6.1. Conceptual Framework: The Library as Civic Infrastructure

The design proposal is organized around a single conceptual proposition: the library as civic infrastructure. This means:

The library is not a building but a system "a network of spaces, services, and programs that support learning, production, and community life" (R9) [6], [3].
The library is public "not in the narrow sense of being state-owned, but in the deeper sense of being open, accessible, and accountable to the community it serves" (R4) [2].
The library is hybrid "it accommodates multiple activities (reading, digital work, vocational training, assembly) without diluting its core identity" (R2) [9], [24].
The library is climatically situated "its form and organization emerge from Obudu's specific climate, not from a generic typology" (R3) [13], [14].

6.2. Zoning Strategy: Predicted Zone Levels Are Computed Using Eq. (7.3) at Every Zone.

The building is organized into five zones, arranged by activity intensity and noise level:

Zone 1a: Public Interface (Ground Floor, Entry)

Main entrance, reception, information desk, security
Exhibition/orientation area
Cafe/social space
Multipurpose hall (subdividable)
Accessible toilets

Zone 1b: Children's library (separate entrance, R11)

Zone 2: Collaborative Learning (Ground Floor, Rear)

Group study rooms
Seminar/tutorial rooms
Digital collaboration spaces
Maker space/vocational information area

Zone 3: Digital Learning (First Floor, Front)

Computer laboratory
E-library/digital research area
Multimedia resource centre
ICT support and printing

Zone 4: Quiet Study (First Floor, Rear)

General reading area
Reference section
Individual study carrels
Periodicals

Zone 5: Administration and Support (Ground Floor, Side)

Librarian's office, staff offices, records
Staff lounge and facilities
Stores, server room, electrical rooms
Service entrance and loading

The zoning logic separates noisy, public activities (Zone 1) from quiet, concentrated activities (Zone 4), with transitional zones (2 and 3) mediating between them (R1, R6). This arrangement allows the library to accommodate diverse uses without conflict, "addressing the tension" Peterson [7] identifies between universal civic space and competing user claims (R11).

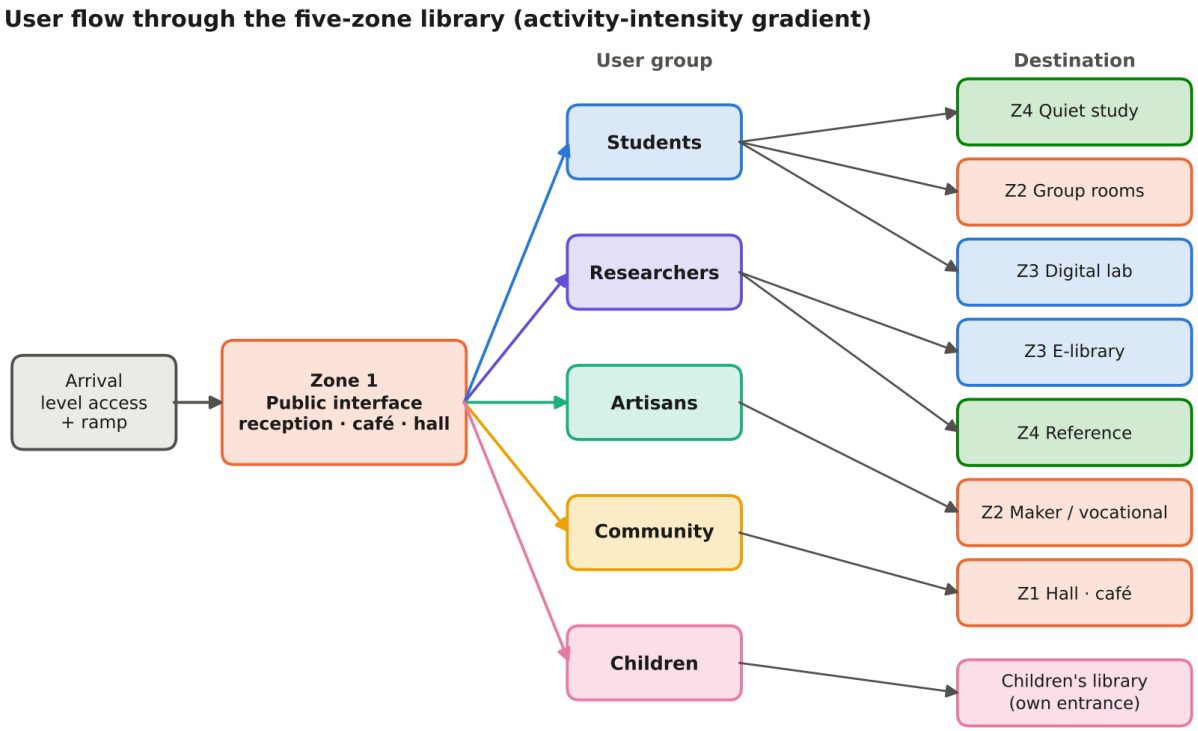


Figure 6. User Flow Through the Five-Zone Library.

Shows how the five user groups named in the article reach their destinations from a single public entrance, with the children's library on its own entrance.

Key result: Students reach three zones, researchers two, and artisans, community, and children one each.

Equations

(6.1) Zoning ordering rule

$$L_{Z1} \geq L_{Z2} \geq L_{Z3} \geq L_{Z4}$$

Zone 5 (Administration) is acoustically isolated and excluded from the public noise-gradient chain.
Noise should fall monotonically along the route toward quiet study; Figure 7 tests this.

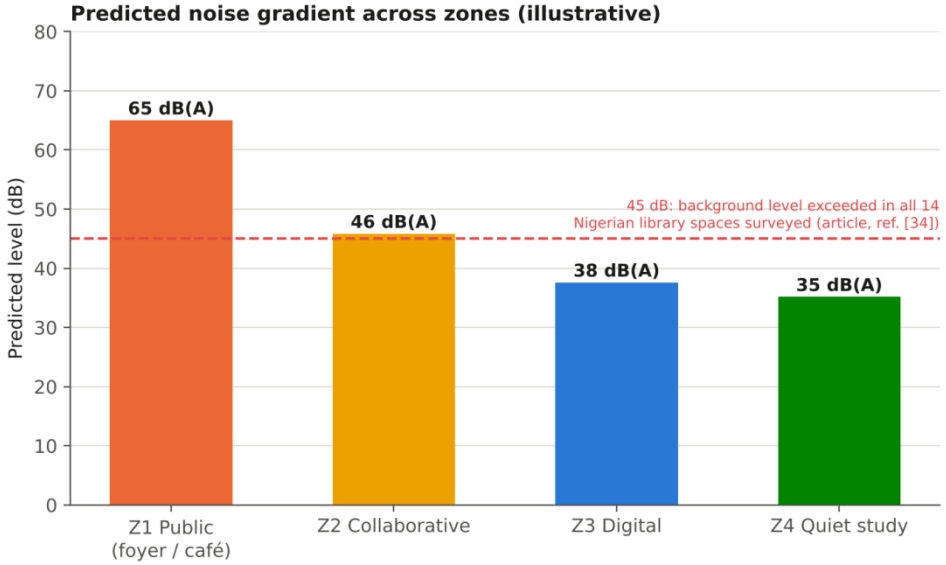


Figure 7. Predicted Noise Gradient Across Zones (Illustrative). Values Are Total Levels L_Tot, I From Eq. (7.3), Combining the Propagated Source Level (Eq. 7.2) With the 35 Db(A) Background. Zone 5 (Administration) Omitted—Separately Enclosed and Acoustically Isolated.

Applies spherical spreading and partition losses to a noisy Zone 1 to test whether the zoning separates noisy and quiet space. Under the assumed values, Zone 4 is about 35 dB(A), while Zone 2 sits at about 46 dB(A), just above the 45 dB benchmark the article cites for Nigerian libraries.

Key result: Predicted levels: Zone 1 65, Zone 2 46, Zone 3 38, Zone 4 35 dB(A).

Equations

(7.1) Spherical spreading

$$L(r) = L(r_0) - 20\log_{10}\left(\frac{r}{r_0}\right)$$

Point-source, free-field.

(7.2) Zone level

$$L_i = L_0 - 20\log_{10}\left(\frac{r_i}{r_0}\right) - \sum_{j \leq i} T\,L_j$$

TL_j is the transmission loss at each partition or slab.

(7.3) With background noise

$$L_{\text{tot},i} = 10\log_{10}\left(10^{L_i/10} + 10^{L_{bg}/10}\right)$$

Energy sum.

(7.4) Room-to-room reduction (reference form)

$$NR = TL + 10\log_{10}\left(\frac{A_R}{S_w}\right)$$

A_R is receiving-room absorption, S_w the partition area.

Table 5. Parameters

Symbol / item	Value	Source
L_0	65 dB(A) at r_0 = 5 m	Assumed (foyer level)
r_i	5, 15, 22, 32 m	Assumed
TL	0, 10, 8, 10 dB	Assumed
L_{bg}	35 dB(A)	Assumed
Benchmark	45 dB	Article, reference [34]

6.3. Climatic Design Strategy

The building's climatic strategy is passive-first, with mechanical systems as backup:

- Orientation: Long axis east-west, minimizing east and west solar exposure (R3) [13].
- Form: Compact plan with a central atrium providing daylight and stack ventilation (R12) [17].
- Envelope: High thermal mass (concrete block, stone) with insulated roof; shaded windows (R3) [15].
- Ventilation: Cross-ventilation through operable windows and atrium stack effect; ceiling fans for air movement (R3).
- Daylighting: Clerestory windows and light shelves to distribute daylight deep into floor plates; shading devices to prevent glare and heat gain (R12) [16], [20].
- Rainwater: Harvesting for non-potable uses; bioswales for stormwater management (R10).

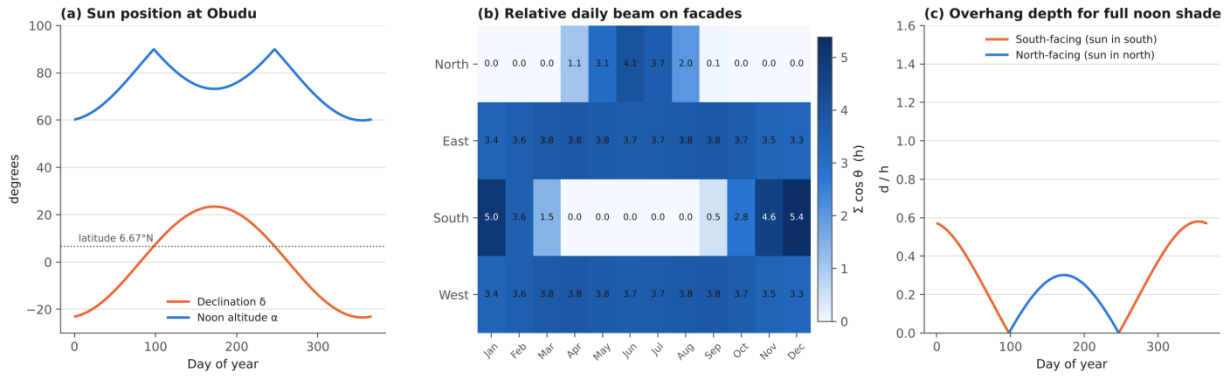


Figure 8. Sun Geometry at Obudu and Facade Exposure (Illustrative).

Computes sun position at latitude 6.67°N and the relative beam sunlight on north, east, south, and west facades through the year. East and west facades receive about 3.3–3.8 h-equivalents of low-angle sun in every month. North and south facades are exposed seasonally, and a modest overhang handles their high-angle sun. This supports the east–west long axis in Section 6.3.

Key result: Noon altitude ranges from 59.9° to 90°. The north facade is in shade October–March, and the south facade April–August. Full noon shading needs an overhang of at most 0.58 × window height.

Equations

(8.1) Solar declination

$$\delta(n) = 23.45^{\circ}\sin\left[\frac{360^{\circ}(284+n)}{365}\right]$$

n = day of year.

(8.2) Solar altitude

$$\sin\alpha = \sin\varphi\sin\delta + \cos\varphi\cos\delta\cos\omega, \qquad \omega = 15^{\circ}(t-12)$$

φ = 6.67°N (article: 6°40′N).

(8.3) Azimuth components

$$\cos\alpha\cos A = \frac{\sin\alpha\sin\varphi - \sin\delta}{\cos\varphi}, \qquad \cos\alpha\sin A = \cos\delta\sin\omega$$

A measured from south, positive west.

(8.4) Incidence on a vertical facade

$$\cos\theta_f = \cos\alpha\cos(A - \psi_f)$$

ψ: S = 0°, W = 90°, N = 180°, E = −90°.

(8.5) Daily relative exposure

$$E_f = \int_{\alpha>0} \max\left(0, \cos\theta_f\right) dt$$

Beam only, no atmosphere or diffuse light.

(8.6) Noon altitude

$$\alpha_{\text{noon}} = 90^{\circ} - |\varphi - \delta|$$

(8.7) Overhang depth for full noon shade

$$\frac{d}{h} = \cot\alpha_{\text{noon}}$$

d is overhang depth and h window height, for the facade facing the noon sun.

Table 6. Parameters

Symbol / item	Value	Source
φ	6.67°N	Article
Days	Mid-month days	Chosen

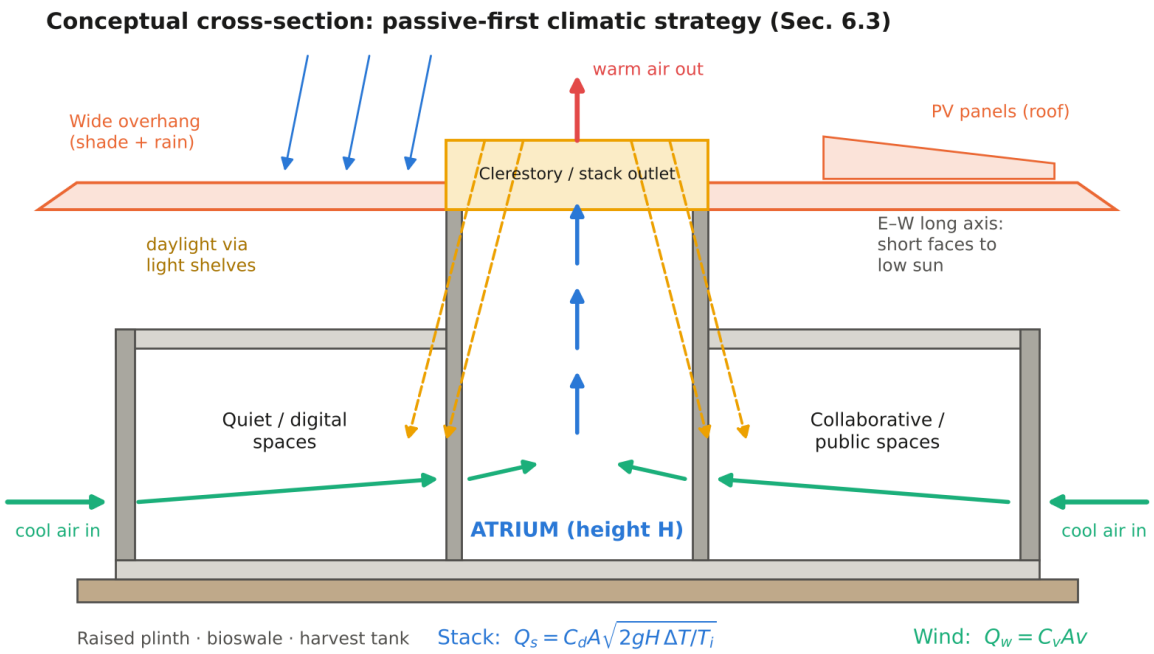


Figure 9. Passive-First Climatic Strategy: Conceptual Section.

Draws the Section 6.3 strategy in one section: raised plinth, wide overhangs, cross-ventilation inlets, a central atrium with a clerestory stack outlet, and light shelves. It carries the two ventilation equations used in Figure 10.

Equations

(9.1) Stack flow

$$Q_s = C_d A \sqrt{\frac{2gH(T_i - T_o)}{T_i}}$$

H is the height between inlet and outlet.

(9.2) Wind flow

$$Q_w = C_v A v$$

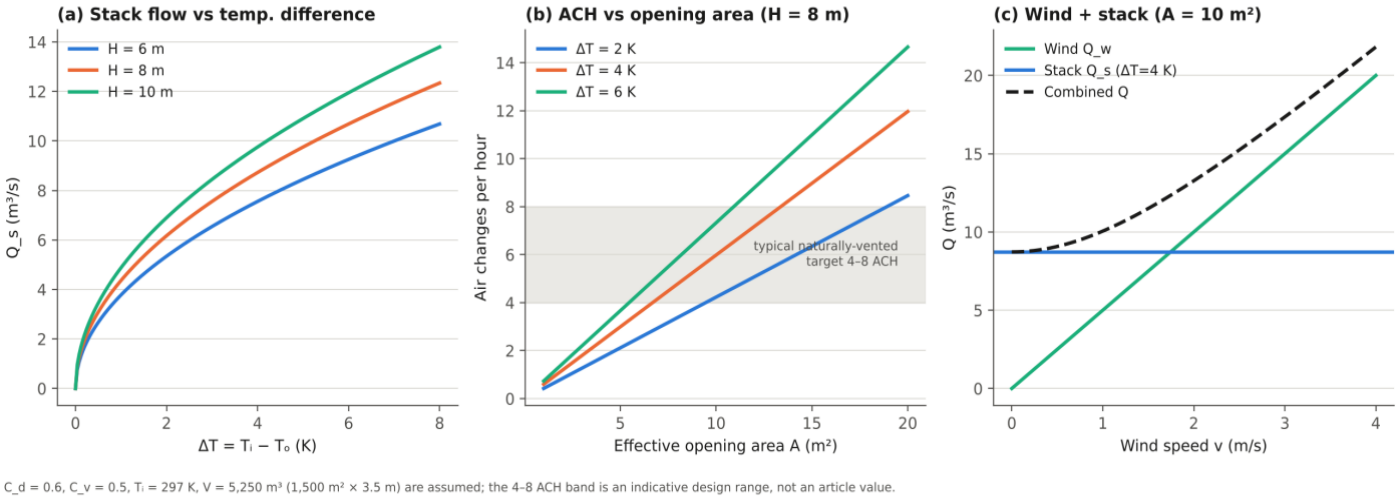


Figure 10. Natural Ventilation: Stack, Wind, and Air-Change Rate (Illustrative).

Plots stack flow against indoor–outdoor temperature difference, air changes per hour against opening area, and the combined wind-plus-stack flow. Obudu's cooler uplands give a small temperature difference, so opening area and atrium height do most of the work.

Key result: For H = 8 m, ΔT = 4 K and A = 10 m²: Q_s = 8.7 m³/s, which is 6.0 air changes per hour in a 5,250 m³ volume.

Equations

(10.1) Stack (buoyancy) flow

$$Q_s = C_d A \sqrt{\frac{2gH\Delta T}{T_i}}$$

(10.2) Wind flow

$$Q_w = C_v A v$$

(10.3) Combined flow

$$Q = \sqrt{Q_s^2 + Q_w^2}$$

Quadrature addition.

(10.4) Air changes per hour

$$\mathrm{ACH} = \frac{3600\,Q}{V}$$

Table 7. Parameters

Symbol / item	Value	Source
C_d	0.6	Assumed
C_v	0.5	Assumed
T_i	297 K	Assumed
A	10 m² (panel b: 1–20)	Assumed
V	5,250 m³ (1,500 m² gross floor area × 3.5 m storey height)	Assumed
ACH band	4–8	Indicative; not from the article

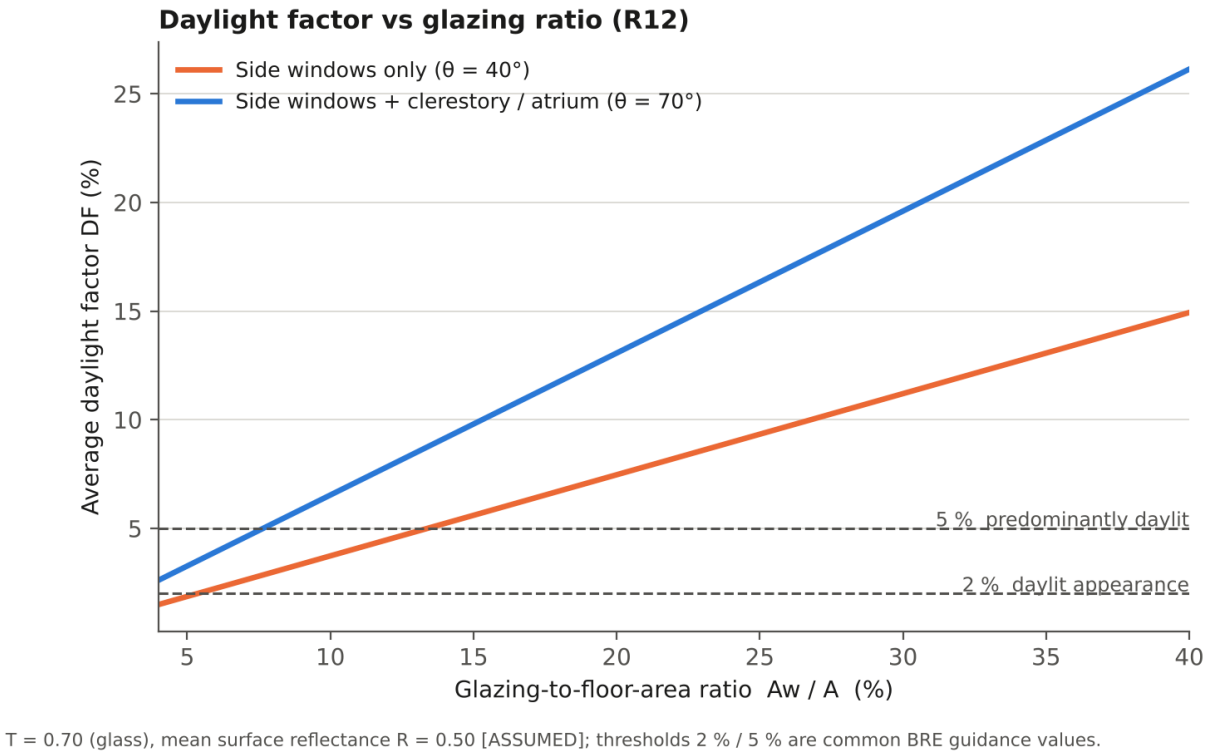


Figure 11. Day-Light Factor Vs Glazing Ratio (R12).

Uses the BRE average daylight factor to show how clerestory and atrium light raise the sky angle θ and therefore the daylight factor for the same glazing ratio.

Key result: 2% daylit appearance needs A_w/A ≈ 5.4% with side windows only and ≈ 3.1% with clerestory or atrium light. 5% needs ≈ 13.4% and ≈ 7.7%.

Equations

(11.1) Average daylight factor (BRE)

$$\mathrm{DF} = \frac{T A_w \theta}{A(1 - R^2)} \ [\%]$$

θ in degrees: the visible sky angle from the window centre.

(11.2) Glazing ratio for a target DF

$$\frac{A_w}{A} = \frac{\mathrm{DF}_{\mathrm{target}}(1 - R^2)}{T\theta}$$

Table 8. Parameters

Symbol / item	Value	Source
T	0.70	Assumed
R	0.50	Assumed
θ	40° / 70°	Assumed
DF thresholds	2% / 5%	Common BRE guidance

6.4. Structural System

The structural system is reinforced concrete frame with a regular column grid (6m × 6m) allowing flexible space planning (R2). Long-span beams over the multipurpose hall and reading areas minimize internal columns. Floor slabs are designed for heavy live loads (book stacks: 7.5 kN/m²; reading areas: 3.0 kN/m²) [11], [12].

6.5.

Table 9. Program and Spatial Allocation.

Space	Area (m²)	Notes
Entrance/reception	80	Includes security and information
Multipurpose hall	200	Subdividable; 150-person capacity
Children's library	120	Separate entrance; storytelling area (R11)
General reading	300	100 seats; shelving for 10,000 volumes
Digital lab	150	40 workstations; server room (R5)
Administration	120	-
Group study	100	4 rooms of 6–8 persons
Quiet study	80	20 seats
Support	150	-
Circulation	200	-
Total	1,500	Net 1,300 + circulation 200

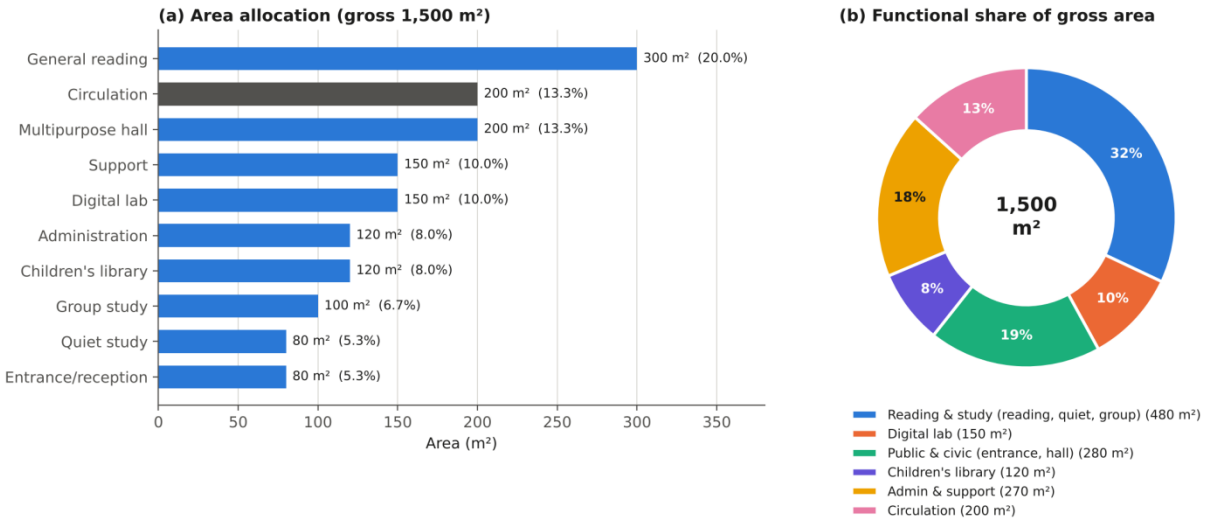


Figure 12. Programme Area Allocation.

Bar chart of the ten spaces in the programme table and a donut that groups them into functional families. The general reading room is the largest space (20%), and circulation is 13.3% of gross area.

Key result: Net area 1,300 m²; gross area 1,500 m².

Equations

(12.1) Share of gross area

$$p_i = \frac{A_i}{A_{\text{gross}}}, \qquad A_{\text{gross}} = \sum_i A_i = 1500\ \text{m}^2$$

(12.2) Circulation ratio

$$c = \frac{A_{\text{circ}}}{A_{\text{net}}} = \frac{200}{1300} = 0.154$$

(12.3) Gross from net

$$A_{\text{gross}} = A_{\text{net}}(1 + c) = 1300 \times 1.154 = 1500\ \text{m}^2$$

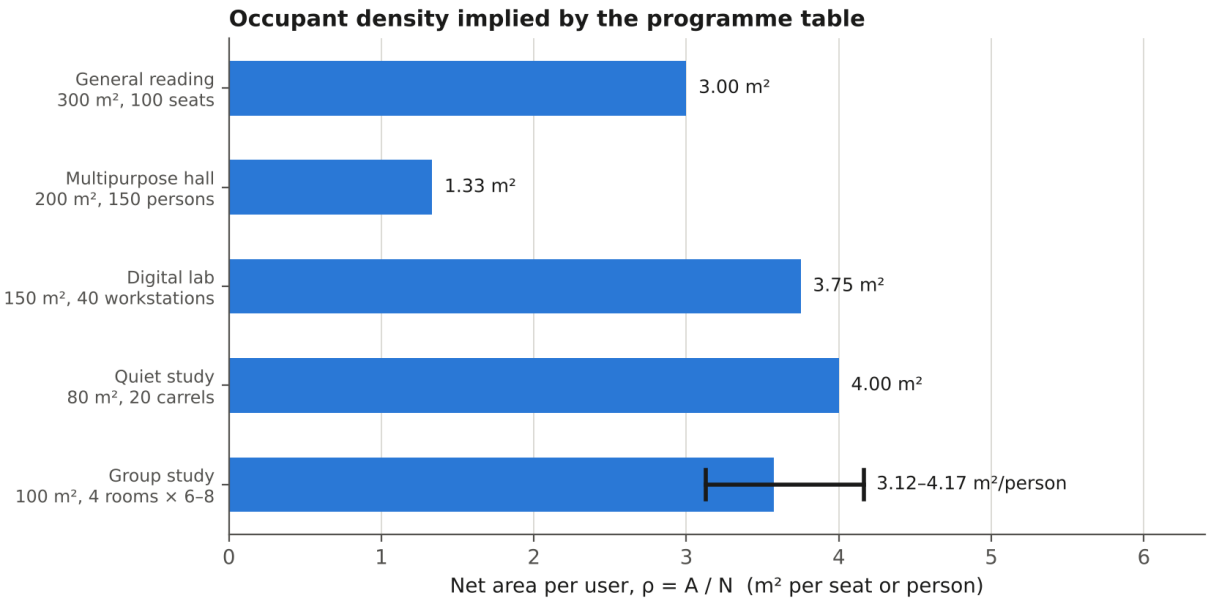


Figure 13. Occupant Density Implied by the Programme Table.

Divides each space's area by the seats or persons the article gives to check that the allocation is comfortable. The multipurpose hall is the densest at 1.33 m² per person, which is plausible for standing or assembly use but not for seated study.

Key result: Reading 3.00, hall 1.33, digital lab 3.75, quiet study 4.00, group study 3.12–4.17 m² per user.

Equations

(13.1) Area per user

$$\rho_i = \frac{A_i}{N_i} \ [\mathrm{m}^2/\mathrm{user}]$$

(13.2) Group study range

$$\rho_{\text{group}} = \frac{100}{4 \times n_r}, \qquad n_r \in [6,8] \Rightarrow 3.12 \leq \rho \leq 4.17$$

Four rooms of 6–8 persons.

Table 10. Parameters

Symbol / item	Value	Source
Seats / persons	100, 150, 40, 20, 4 × (6–8)	Article

6.6. Accessibility and Inclusivity

Level access at main entrance; ramps at all level changes (R4)
Accessible toilets on each floor (R4)
Lift to first floor (R4)
Wide circulation routes (1.8m minimum) (R4)
Accessible workstations in digital lab (R4)
Clear wayfinding and signage (R4)

Tactile and visual contrast for visually impaired users (R4)
Provisions aligned with National Building Code [31] and ISO standards [28]

6.7. Sustainability Features

Solar photovoltaic panels (roof-mounted) (R3)
Rainwater harvesting and storage (R10)
Water-efficient fixtures
Natural ventilation and daylighting (R3, R12)
Locally sourced materials (laterite blocks, timber) (R10)
Landscaping with native species
Waste segregation and recycling
Strategies informed by [14], [15], [30]

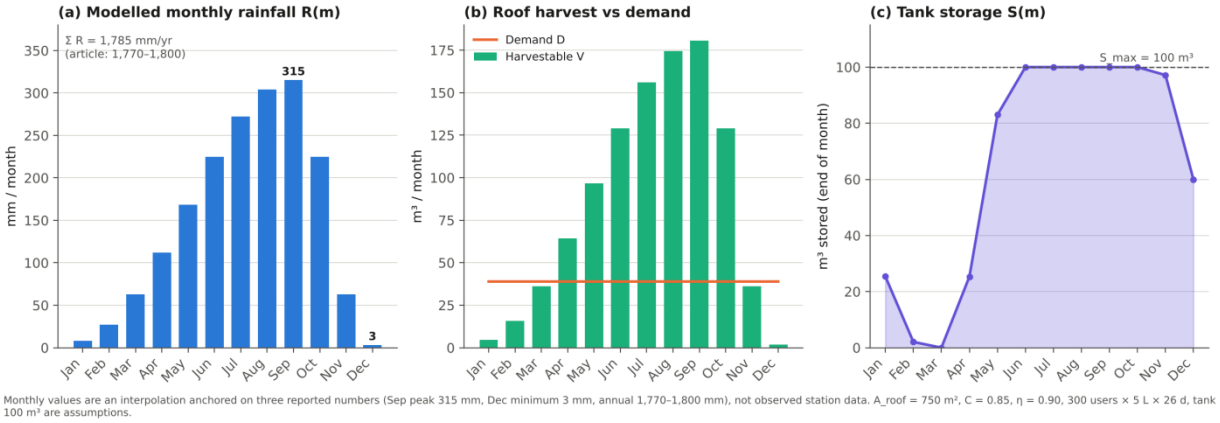


Figure 14. Rainfall Profile, Roof Rainwater Harvest and Tank Balance (Illustrative).

Turns the article's rainfall facts (annual 1,770–1,800 mm, peak 315 mm in September, minimum 3 mm in December) into a monthly profile, then estimates roof harvest against non-potable demand and tracks tank storage. This tests the rainwater-harvesting feature in Section 6.7.

Key result: Annual harvest ≈ 1,024 m³ against demand ≈ 468 m³. A 100 m³ tank fills by June but runs dry in March, so the dry season needs a larger tank or lower demand.

Equations

(14.1) Seasonal shape (t = months since December)

$$s(t) = \frac{1}{2}\left[1 - \cos\left(\frac{\pi t}{9}\right)\right],\ 0 \le t \le 9; \qquad s(t) = \frac{1}{2}\left[1 + \cos\left(\frac{\pi(t-9)}{3}\right)\right],\ 9 < t < 12$$

Slow rise from the December trough to the September peak, then a fast fall. The article gives no monthly series, so this is an interpolation.

(14.2) Monthly rainfall

$$R(m) = R_{\min} + (R_{\max} - R_{\min})\, s(m)^p$$

(14.3) Closure condition

$$\sum_{m=1}^{12} R\,(m) = R_{\text{ann}} = 1785 \text{ mm} \Rightarrow p = 1.189$$

Solved numerically; midpoint of the article's 1,770–1,800 mm.

(14.4) Harvestable volume

$$V_m = \frac{\eta C R_m A_{\text{roof}}}{1000} \ [\text{m}^3]$$

(14.5) Demand

$$D = \frac{N_u\, q\, d}{1000} \ [\text{m}^3/\text{month}]$$

(14.6) Tank mass balance

$$S_m = \min\{S_{\max},\ \max[0,\ S_{m-1} + V_m - D]\}$$

Run for two years so the start-up state does not matter.

Table 11. Parameters

Symbol / item	Value	Source
R_{min} (Dec)	3 mm	Article
R_{max} (Sep)	315 mm	Article
R_{ann}	1,785 mm	Article midpoint
A_{roof}	750 m²	Assumed (1,500 m² over two storeys)
C	0.85	Assumed runoff coefficient
η	0.90	Assumed first-flush efficiency
N_u, q, d	300 users, 5 L, 26 days	Assumed WC demand
S_{max}	100 m³	Assumed

6.8. Phasing and Implementation

Recognizing budget constraints, the design proposes a phased implementation (R8):

Phase 1: Core library functions (reading, digital lab, administration, entrance/reception and support spaces)
Phase 2: Multipurpose hall, children's library, maker space
Phase 3: Expansion of digital infrastructure, additional study spaces

This phasing allows the facility to become operational quickly while accommodating future growth.

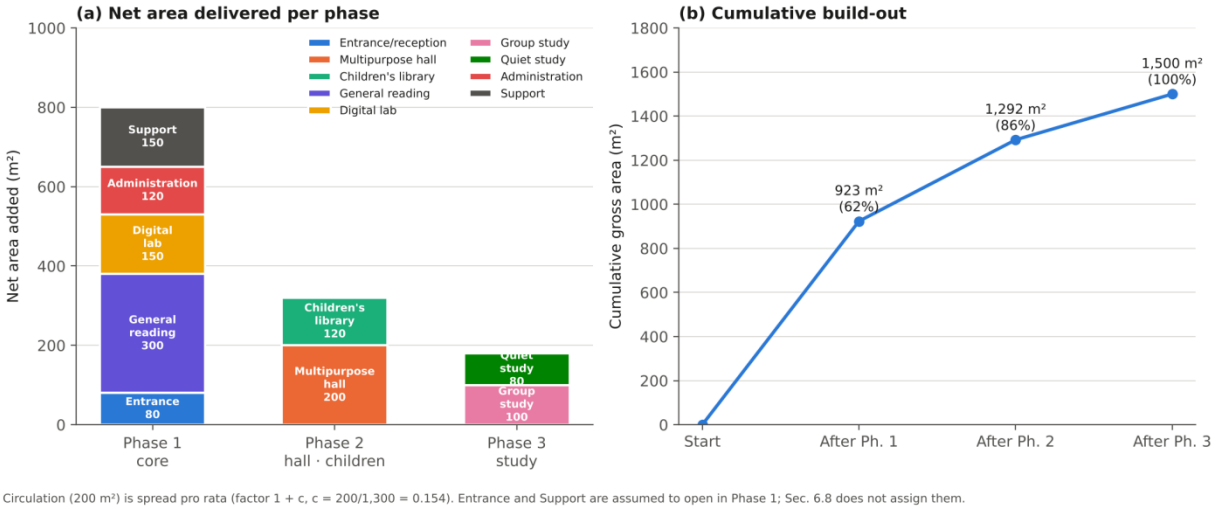


Figure 15. Phased Implementation and Cumulative Floor Area.

Allocates rooms to the three phases in Section 6.8 and shows how much floor area is delivered at each stage. About 62% of the gross area exists after Phase 1.

Key result: Gross area per phase: 923, 369, 208 m²; cumulative 923, 1,292, 1,500 m².

Equations

(15.1) Gross area of phase k

$$G_k = N_k(1 + c), \qquad c = \frac{200}{1300}$$

Circulation is spread in proportion to net area.

(15.2) Cumulative area

$$C_k = \sum_{j=1}^{k} G_j$$

C_3 = 1,500 m² recovers the programme total.

(15.3) Share built

$$f_k = \frac{C_k}{A_{\text{gross}}}$$

62%, 86%, 100%.

Table 12. Parameters

Symbol / item	Value	Source
Phase 1 rooms	Reading, digital lab, administration (+ entrance, support)	Section 6.8; entrance and support assumed
Phase 2 rooms	Hall, children's library	Section 6.8
Phase 3 rooms	Group study, quiet study	Section 6.8 ('additional study spaces'); assumed

7. EVALUATION, DISCUSSION, AND CONCLUSION

7.1. Evaluation of Design Against Requirements

The design proposal is evaluated against the requirements derived in Section 4.4. The following table presents the evaluation summary:

Table 13. Evaluation Summary.

Req. ID	Requirement	Evaluation	Evidence in Design
R1	Separate quiet from collaborative spaces	Met	Five-zone arrangement with noise gradient (Section 6.2)
R2	Flexible, adaptable spaces	Met	Column grid, movable partitions, multipurpose hall (Sections 6.2, 6.4)
R3	Passive climatic strategies	Met	Orientation, cross-ventilation, shading, thermal mass (Section 6.3)
R4	Accessibility for all	Met	Ramps, lift, accessible toilets, wide circulation (Section 6.6)
R5	Digital infrastructure	Met	Digital lab, server room, ICT support (Section 6.2, 6.5)
R6	Noise control	Met	Zoning separation, buffer spaces (Section 6.2)
R7	Safety and security	Met	Fire detection, egress routes, access control (Section 6.2)
R8	Phased implementation	Met	Three-phase strategy (Section 6.8)
R9	Civic/community framing	Met	Multipurpose hall, cafe, public interface zone (Section 6.1, 6.2)
R10	Site-specific response	Met	Orientation, materials, rainwater management (Sections 5, 6.3, 6.7)
R11	Children's spaces	Met	Dedicated children's library, Zone 1b (Sections 6.2, 6.5)
R12	Natural lighting with glare control	Met	Clerestory, light shelves, shading devices (Section 6.3)

The evaluation demonstrates that the design proposal satisfies all twelve requirements derived from the relevance and rigor cycles. However, this evaluation is descriptive and conceptual rather than empirical: the design has not been constructed, and post-occupancy evaluation has not been conducted. Future research should include quantitative performance assessment through building simulation (thermal, daylighting, airflow) and, eventually, POE after construction [1], [8], [21].

Notably, this evaluation confirms logical alignment between derived requirements and schematic design outputs, but does not offer quantified proof of real-world performance. Passive-design strategies are conceptually embedded in massing, orientation, envelope, and zoning, yet unvalidated by thermal comfort, daylight-glare, or computational fluid dynamics (CFD) simulation. Further digital performance testing would quantify whether the design delivers the intended indoor-environmental quality under Obudu Plateau's seasonal climatic conditions. Additionally, without direct local stakeholder input, we cannot confirm that the weighting of space allocations (e.g. relative sizes of children's library, quiet study, maker spaces) perfectly reflects community priorities.

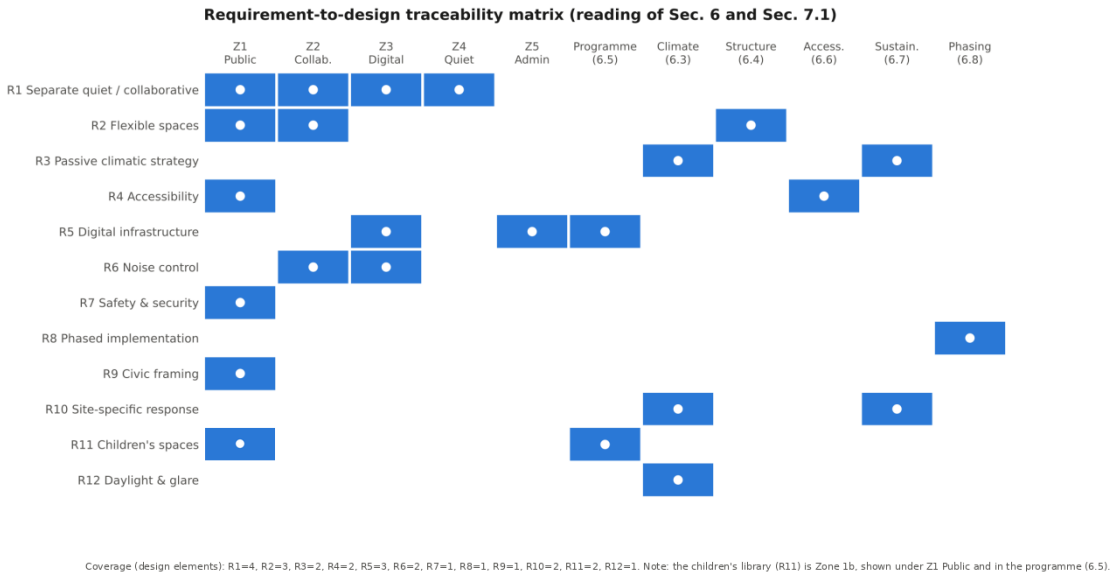


Figure 16. Requirement-to-design traceability matrix.

A binary matrix linking each requirement to the design elements that the Section 7.1 evidence column and Section 6 text point to. The children's library (R11) appears in the programme table and in Zone 1b, shown under the Z1 Public column.

Key result: Coverage per requirement: R1 = 4 elements; R3, R5 and R10 = 2–3 each; R7, R8, R9 and R12 = 1 element each; R11 = 2 elements.

Equations

(16.1) Traceability matrix

$$M_{ij} \in \{0,1\}, \qquad M_{ij} = 1 \Leftrightarrow \text{requirement} R_i \text{is evidenced by element} j$$

(16.2) Coverage

$$C_i = \sum_j M_{ij}$$

Elements evidencing each requirement.

7.2. Theoretical Implications

This paper has argued that the library, in contexts of institutional absence, must be understood as civic infrastructure, not merely a building but a system of spaces, services, and programs that make visible and actionable a community's demand for equitable learning environments [6], [3], [2]. This reframing has architectural consequences: it prioritizes flexibility, accessibility, and hybridity over collection storage; it embeds the library within a broader network of community services; and it positions the architect as an advocate for public provision, not merely a designer of buildings. It must be emphasised that this DSR produces an exploratory conceptual artefact. Its purpose is to advance prescriptive design knowledge rather than present a fully validated, ready-to-build final project. Empirical testing via simulation and stakeholder validation are required steps before physical implementation.

The application of design science research to architectural design in a semi-rural African context demonstrates the relevance of DSR beyond its origins in information systems. The three-cycle framework provided a structured methodology for integrating contextual analysis, knowledge synthesis, and design proposition, ensuring that the design artifact is grounded in both relevance (real-world problem) and rigor (existing knowledge) [5].

7.3. Methodological Implications

The DSR methodology employed here demonstrates the value of comparative case study analysis in architectural research. By selecting cases that represent distinct positions on a spectrum (Nigerian status quo vs. international exemplar), the study was able to identify transferable principles while remaining attentive to contextual specificity. This approach is particularly valuable in understudied contexts, where the absence of precedent makes comparative analysis a necessary substitute for local data.

The requirements derivation and evaluation framework offer a template for design-led research in architecture, providing explicit criteria against which the design artifact can be assessed. This addresses a common weakness in architectural design research: the absence of clear evaluation metrics [5].

7.4. Practical Implications

The design proposal offers a transferable framework for community library provision in semi-rural African contexts. Key principles include:

- Activity-based zoning rather than collection-based organization (R1) [9]
- Passive-first climatic design suited to local conditions (R3) [13], [14]
- Programmatic hybridity that accommodates diverse community needs (R2) [24]
- Phased implementation responsive to budget constraints (R8)
- Explicit civic framing that positions the library as public infrastructure (R9) [2]

7.5. Limitations

This DSR-based architectural inquiry has important limitations which must be transparent for peer review and for interpreting the study's outputs.

7.5.1.Constraints On Primary Stakeholder Data

This research did not conduct original surveys, interviews, or participatory workshops with Obudu community members. User requirements are inferred from secondary documentation, site reconnaissance, and analogous literature rather than empirical local stakeholder data. This approach is appropriate for exploratory early-phase DSR to generate candidate design principles, yet carries risk of mis-prioritising community needs. The findings should be treated as a starting framework; local participatory design activities are required before practical deployment.

7.5.2. Asymmetric Empirical Basis for Comparative Case-Study Analysis

The two comparative cases have uneven empirical grounding. Caritas University Library draws from on-site reconnaissance visit; Helsinki Central Library Oodi is analysed exclusively through published secondary documentation, without first-hand site observation. Richer on-site data for Oodi would yield finer-grained insight into operational workflows and spatial behaviours, improving the precision of transferred design principles.

7.5.3. Schematic Level of Technical Resolution

The design proposal is developed to architectural schematic design standard. Detailed structural calculations, mechanical-electrical-plumbing engineering, whole-life-cycle cost-modelling, and material durability analysis for Obudu's high-rainfall upland climate are conceptual only and not fully engineered. Real-world delivery would require full multidisciplinary engineering and cost appraisal.

7.5.4. Absence of Quantitative Building-Performance Simulation

While passive climate-responsive strategies are conceptually integrated, this paper contains no quantitative simulation outputs (EnergyPlus, IES-VE, CFD, daylight modelling). Consequently, claims for thermal comfort, natural ventilation efficacy, and glare mitigation remain logically argued but not numerically validated. Simulation-based performance assessment is a critical next research activity.

7.5.5. Reliance Upon Secondary Climatic Datasets

Climatic inputs depend on publicly available meteorological secondary data for Cross-River State, rather than multi-month on-site microclimate monitoring at the exact project parcel. Local-site micro-climate deviations may affect final passive-design tuning.

7.5.6. Artefact Representation: Limited Visual Documentation

As written, the manuscript is text-dominant and lacks high-quality visual artefact documentation, including annotated site plans, floor-plans, building sections, climatic-strategy diagrams, zoning schematics, and conceptual renderings.

7.5.7. Boundaries To Generalisability

The transferable DSR framework developed in this paper offers adaptable principles for semi-rural upland African contexts, but the specific spatial layout and area allocations of the Obudu Learning Centre proposal are site-specific. Direct replication in other communities will require re-calibration to local micro-climate, demography, infrastructure availability, and community priorities.

7.6. Future Research Directions

Addressing the above-identified limitations, future research work should pursue the following priorities:

- Conduct formal local user-needs assessment in Obudu and comparable semi-rural communities, deploying semi-structured interviews, focus-groups and participatory design workshops to validate or revise the requirements set developed in this paper.

- Undertake multi-phased building-performance simulation including thermal comfort, daylight-glare analysis and computational fluid-dynamics airflow modelling, using site-appropriate meteorological inputs, to quantify the performance of the schematic design proposal.

- Develop construction-cost modelling, operating-cost forecasting and alternative sustainable funding/governance models for community-led library facilities within low-resource Nigerian semi-rural settings. This should include analysis of long-term maintenance pathways.

- Where feasible, realise a scaled pilot or full-scale construction of the learning-centre concept and carry-out rigorous post-occupancy evaluation (POE) in a tropical upland climate, measuring indoor-environmental quality, user satisfaction and space-utilisation patterns.

- Expand the comparative-case-study dataset, adding further African community-library examples and where possible including first-hand site visits for international reference cases.

- Develop and test standardised POE protocols tailored for community-library buildings across tropical sub-Saharan Africa to enable cross-project comparison and cumulative design-knowledge building.

- Produce complete visual documentation of the DSR design artefact: annotated site plan, floor-plans, sections, zoning diagrams, climate-strategy diagrams and illustrative renders suitable for journal peer review and publication.

8. CONCLUSION

This paper began with the observation that Obudu, like many semi-rural Nigerian towns, lacks a public library. It has been argued that this absence is not merely a service gap but a spatial expression of uneven development, and that architectural design, in such contexts, operates as a form of infrastructural advocacy. Using design science research methodology, the study derived requirements from literature, case studies, and site analysis, developed an architectural artifact through iterative design cycles, and evaluated the proposal against those requirements.

The design proposal demonstrates that a community library can be climatically responsive, socially inclusive, and programmatically hybrid without sacrificing architectural quality. It offers a model for how architecture can intervene in contexts of infrastructural absence not by importing solutions from elsewhere, but by working from the specific conditions of place. The library, in this conception, is not a building. It is a claim on the future “a statement that the community of Obudu deserves a space for learning, for gathering, for becoming.” Architecture's role is to make that claim visible, spatial, and real.

While the study has limitations, “limited primary data, absence of user surveys, schematic technical design, and unexplored quantitative performance” these limitations delineate its scope and identify directions for future research. The DSR framework presented here is offered not as a definitive solution but as a structured design inquiry “a starting point for dialogue, refinement, and ultimately, realization”.

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