



## THE ROOF AS A FUNCTIONAL COMPONENT OF BUILDINGS: A CASE STUDY OF AREA C STAFF RESIDENTIAL QUARTERS, AHMADU BELLO UNIVERSITY, SAMARU, ZARIA

Emmanuel Uma Helen

Physical Planning & Works, Federal University Dutsin-Ma, Katsina State, Nigeria.

\*Corresponding authors' email: [uemmanuel@fudutsinma.edu.ng](mailto:uemmanuel@fudutsinma.edu.ng)

### ABSTRACT

The roof is a vital component of the building envelope, acting as the primary barrier against environmental elements while influencing thermal comfort, structural stability, aesthetics, and sustainability. In tropical savanna climates such as Zaria, which is characterized by high solar radiation, seasonal rainfall of about 1,100 mm, and temperatures ranging from 25–38°C, the roofing systems must effectively manage heat gain, rainfall, and wind loads. This study examines the functional performance of roofs using Area C Staff Residential Quarters at Ahmadu Bello University (ABU), Samaru, Zaria, as a case study. A qualitative approach was adopted, drawing on architectural documentation, institutional reports, field observations, and relevant literature. Predominant roof types identified include gable and hipped forms, mainly constructed with corrugated galvanized iron and long-span aluminium sheets. Findings indicate that while earlier designs adequately provided basic shelter, their performance has declined due to ageing materials, inadequate maintenance, and unsystematic modifications. Emerging sustainable solutions, particularly green roofs, demonstrate the potential to reduce indoor temperatures and significantly lower surface heat gain. The study recommends improved maintenance, retrofitting with reflective and insulated materials, and adoption of sustainable roofing strategies to enhance overall building performance.

**Keywords:** Roof Functionality, Tropical Architecture, Staff Residential Quarters, Green Roofs, Building Maintenance, Ahmadu Bello University, Zaria

### INTRODUCTION

Buildings in tropical regions face unique climatic demands that place the roof at the forefront of the building envelope's performance. In northern Nigeria's savanna zone, exemplified by Zaria, roofs must rapidly shed heavy seasonal rains, reflect intense solar radiation, and resist environmental stresses while supporting occupant comfort (Babalola et al., 2024). Area C Staff Residential Quarters at Ahmadu Bello University (ABU), Samaru, developed as part of the university's early residential masterplan with roots in the 1960s (and earlier colonial layouts), feature predominantly single-storey 3-bedroom bungalows designed for academic and administrative staff (Sagada, 2009).

These quarters typically include gable or hipped pitched roofs covered with corrugated sheets, reflecting cost-effective adaptations to local conditions. However, recent high-level inspections have highlighted widespread leaking roofs and general dilapidation across ABU staff quarters, underscoring the need to re-evaluate the roof not merely as a covering but as an integral functional component affecting occupant well-being, building longevity, and sustainability (Ahmadu Bello University, 2025).

This study therefore investigates the functional roles of roofs in tropical residential architecture with specific reference to Area C. The objectives are to: identify key functional roles of roofs in tropical contexts; describe the architectural characteristics and current condition of roofs in Area C; evaluate their performance in shelter, thermal regulation, durability, and sustainability; and propose evidence-based recommendations. The study is significant for ABU's planning units, similar Nigerian universities, and broader efforts toward resilient housing.

### Literature Review

#### *The Roof as a Multifunctional Component of Buildings*

Roofs perform multiple integrated functions: weatherproofing against rain and sun, thermal insulation to moderate heat gain,

structural load distribution, aesthetic definition of building form, and sustainability contributions such as rainwater harvesting and passive cooling (Babalola et al., 2024). In tropical climates, high solar reflectance, efficient drainage, and wind-resistant fixings are essential (Nwalusi, 2022).

#### *Roof Performance in Tropical and Nigerian Contexts*

Common materials like corrugated galvanized iron and long-span aluminium sheets dominate Nigerian roofing due to affordability and speed of installation but are prone to corrosion, poor insulation, and excessive heat transfer. Adesogan (2018) identified the primary causes of roof failures in and around Ibadan as poor workmanship (most frequent), design errors, age and environmental forces, material inadequacy, and suboptimal roof geometry or topography. Consequences include damage to belongings, exposure to weather, economic losses, and occupant stress. Similar patterns appear in broader Nigerian building failure studies, where substandard materials and poor supervision exacerbate issues (Oyadokun et al., 2026).

In hot-dry climates like Zaria, uninsulated metal roofs significantly elevate indoor temperatures. Salihu et al. (2020) conducted a field study on green roof thermal insulation performance in Zaria buildings, recording mean indoor temperatures of 32.97°C for bare roofs versus 31.37°C for green roofs, with strong validation against simulations. Salihu (2024) further explored thresholds for indoor temperature reduction with varying green roof depths, confirming surface temperature reductions of 10–25°C and supporting their viability as passive cooling strategies in hot-dry conditions.

#### *ABU-Specific Context and Housing Studies*

Area C quarters predominantly comprise 3-bedroom bungalows with central lobbies, living/dining areas, bedrooms, and kitchens; garages are frequently converted into additional rooms to suit larger Nigerian households, increasing loads on original roof structures (Sagada, 2009).

Incremental housing adjustments in ABU quarters, including Area C and nearby zones, have been documented as responses to evolving family needs (explored in related studies on ABU Phase-II and Silver Jubilee quarters).

Recent vice-chancellor visits to ABU staff residential quarters (Silver, Quarter II, and Quarter III) documented resident complaints centered on leaking roofs, water shortages, dilapidated roads, and toilet facilities, reflecting systemic maintenance challenges (Ahmadu Bello University, 2025). While direct studies on Area C roofs are limited, these reports align with patterns in Area C's historical layouts.

Literature gaps remain in detailed functional performance evaluations of roofs in northern Nigerian university staff housing, particularly integrating recent climate-responsive innovations. This case study addresses that gap.

## MATERIALS AND METHODS

This research adopts a qualitative case study design, suitable for in-depth contextual analysis (Yin, 2018). Data sources include: secondary architectural and planning documents on ABU staff housing (Sagada, 2009); official university reports on quarters conditions (Ahmadu Bello University, 2025); peer-reviewed literature on tropical roofing, roof failures in Nigeria (Adesogan, 2018), and green roof performance in Zaria (Salihu et al., 2020; Salihu, 2024); as well as observational synthesis of typical roof forms, materials, and degradation patterns.

Thematic analysis organized findings around core functionality dimensions (shelter, thermal comfort, durability, sustainability). Climate data for Zaria has therefore informed evaluation. However, there exist various limitations which include reliance on secondary and generalized observations rather than new primary empirical testing.

### Case Study: Area C Staff Residential Quarters, ABU Samaru, Zaria

#### Historical and Architectural Overview

Area C forms part of ABU's early residential clusters, featuring single-storey 3-bedroom bungalows alongside semi-detached units. Typical plans include a central lobby with living/dining spaces and bedrooms/kitchen/storage areas. Incremental modifications, such as garage conversions, are common due to family size demands (Sagada, 2009).

#### Roof Characteristics

- i. Form and Type: Predominantly gable or hipped pitched roofs optimized for rainwater shedding in the savanna climate (Babalola et al., 2024).
- ii. Materials: Corrugated galvanized iron or long-span aluminium sheets on timber/steel trusses, with minimal insulation and basic overhangs for shading.
- iii. Current Condition: Widespread leaking during rainy seasons, corrosion of metal sheets, and truss fatigue linked to age, poor maintenance, added loads from modifications, and environmental exposure. University leadership has expressed concern over dilapidation, including roofs, across staff quarters (Ahmadu Bello University, 2025).

These roofs historically fulfilled basic shelter functions but now exhibit vulnerabilities common in many Nigerian public buildings.

## RESULTS AND DISCUSSION

### Functional Performance Evaluation

The roofs in Area C Staff Residential Quarters at Ahmadu Bello University (ABU), Samaru, Zaria, were evaluated across four core functional dimensions, which include

weather protection and shelter, thermal regulation, durability and structural integrity, and sustainability and multifunctionality, drawing on empirical data from similar tropical contexts, field-validated studies in Zaria's hot-dry climate, and recent institutional reports. This evaluation reveals both the historical strengths of the original gable and hipped designs (predominantly corrugated galvanized iron or long-span aluminium sheets on timber/steel trusses) and their current limitations under evolving climatic and usage pressures. Each dimension has been discussed with reference to Area C's specific conditions, including reported leaking during rainy seasons and incremental modifications such as garage conversions that add dead loads (Sagada, 2009; Ahmadu Bello University, 2025).

Weather Protection and Shelter in Zaria's tropical savanna climate, with concentrated annual rainfall of approximately 1,100 mm over 4–6 months, will show that roofs must rapidly shed water while providing reliable shelter. The pitched gable and hipped forms in Area C were originally effective for this purpose, offering steep slopes that promote drainage and overhangs that provide shading and protection from driving rain (Babalola et al., 2024). However, dry-season performance remains adequate only in theory; peak rainy-season failures are widespread. Leaks stem primarily from degraded corrugated sheets (corrosion and pitting after 20–40 years of service), poor fixings (nails or screws loosening due to thermal expansion and wind uplift), and insufficient slopes or minimal overhangs (often less than 300 mm in modified or older units). These issues mirror national patterns documented in institutional buildings, where low-pitch and flat-roof styles exacerbate water ponding, clogged gutters, and valley leaks, accounting for over 68% of critical defects in public tertiary institutions (Nwankwo et al., 2025).

Adesogan (2018) similarly ranked poor workmanship and material inadequacy as leading causes of roof failures in Ibadan, with effects including water ingress that damages ceilings, walls, and belongings, while exposing occupants to health risks from dampness and mould. In Area C, university inspections in 2025 explicitly highlighted leaking roofs as a primary resident complaint across staff quarters, compounding water shortages and general dilapidation (Ahmadu Bello University, 2025). The result is compromised habitability: intermittent flooding during storms disrupts daily life, increases repair costs, and undermines the roof's fundamental shelter role. Without intervention, these failures perpetuate a cycle of reactive maintenance rather than proactive climate adaptation.

Thermal Regulation Uninsulated metal roofs in Area C has also contributed significantly to indoor heat gain, exacerbating discomfort in Zaria's hot-dry conditions (peak daytime temperatures 35–38°C and intense solar radiation). Corrugated sheets absorb and re-radiate heat rapidly, with surface temperatures often exceeding 70°C, transferring conductive and radiant heat into living spaces and elevating indoor temperatures by 5–8°C above ambient during peak hours (Salihu et al., 2020). This leads to thermal discomfort, higher reliance on mechanical cooling (where available), and reduced productivity for academic staff residents.

Green roof retrofits offer a proven, passive mitigation strategy tailored to Zaria. Salihu et al. (2020) conducted a field study on green roofs in hot-dry Zaria buildings, recording mean indoor temperatures of 32.97°C under bare metal roofs versus 31.37°C under green roofs, and the finding shows a reduction of approximately 1.6°C, with surface temperature drops of 10–25°C attributable to evapotranspiration, shading, and insulation from the growing medium. Salihu (2024) further established thresholds: a minimum 50 mm increase in growth-

medium depth yields statistically significant additional cooling, validating green roofs as scalable for residential retrofits. Complementary evidence from tropical contexts shows concrete or insulated roofs outperforming metal by up to 5.8°C indoors (Amankwaa et al., 2025), while cool/reflective coatings in hot-dry dusty climates reduce indoor temperatures by 3.7°C and energy loads by ~50 kWh/m<sup>2</sup>/year (Algarni, 2023). In Area C, where most units lack insulation, these interventions could transform roofs from heat sources into thermal buffers, aligning with Nigeria's Building Energy Efficiency Code recommendations for roof R-values  $\geq 1.25$  m<sup>2</sup>K/W.

Durability and Structural Integrity Age (many Area C roofs date to the 1960s–1970s), environmental forces (intense UV degradation, wind gusts, and seasonal rain), and incremental alterations (e.g., added rooms increasing truss loads) accelerate degradation in Area C. Corrosion of galvanized sheets, truss fatigue, and fixing failures reduce load-bearing capacity, heightening risks of partial collapse during storms. Oyadokun et al. (2026) analyzed collapsed buildings across Nigeria (2015–2025) and identified substandard materials, poor supervision, and inadequate maintenance as dominant factors, with roofs often the first point of systemic failure. Maintenance deficits, which is evident in delayed university responses, equally amplify these risks, as seen in broader institutional housing where leaking roofs and blocked drainage signal neglected upkeep (Nwankwo et al., 2025).

Moreso, in Area C, these issues manifest as visible sagging, rust stains, and truss weakening, directly linked to the 2025 vice-chancellor inspections noting widespread dilapidation (Ahmadu Bello University, 2025). Without regular inspections, material upgrades, or load assessments, durability erodes, shortening service life from the designed 30–50 years to under 20 years in practice and posing safety concerns for residents.

Sustainability and Multifunctionality Current Area C roofs largely function as single-purpose coverings, underutilizing opportunities for rainwater harvesting, and solar integration, or urban heat mitigation—key extensions of modern roofing in water-stressed northern Nigeria. Pitched designs facilitate collection, yet gutters and storage systems are absent or poorly maintained, missing potential for household supply augmentation (Makwe, 2024). Green or cool roofs could simultaneously provide thermal benefits, reduce urban heat islands, and support biodiversity, while reflective coatings or building-integrated photovoltaics (BIPV) enable energy generation without compromising structure (Babalola et al., 2024; Algarni, 2023).

Babalola et al. (2024) emphasize that well-supported gable roofs in tropical climates promote sustainability by minimizing heat gain and enabling passive strategies, contributing to SDG 11 (Sustainable Cities). In Area C, retrofitting could transform roofs into multifunctional assets: harvesting 70–80% of incident rainfall for non-potable use (after basic filtration) and lowering cooling demands by 20–30% through high-reflectance surfaces (Amankwaa et al., 2025). These upgrades would extend beyond basic functionality to climate resilience and resource efficiency.

Comparative Insights Area C roofs, rooted in mid-20th-century designs, lag behind contemporary climate-responsive standards seen in recent Nigerian pilots (e.g., green roofs in Zaria or cool roofs in hot-dry schools). While they retain adaptable potential through targeted retrofits, such as waterproof membranes, insulation, green overlays, or reflective coatings, as implementation requires institutional commitment. Compared to modern benchmarks, Area C performance falls short in thermal efficiency and

multifunctionality but offers a strong case-study foundation for scalable interventions in similar ABU and Nigerian university housing stock. Addressing these gaps would not only restore core functionality but position the quarters as exemplars of sustainable tropical architecture.

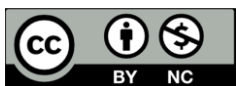
## CONCLUSION

The roof in Area C Staff Residential Quarters exemplifies the critical yet often compromised functional role of this building component in tropical institutional housing. While original designs addressed core shelter needs, climatic stresses, maintenance gaps, and usage changes have diminished performance. It is recommended that Short-term roof audits and elastomeric waterproofing or sheet replacement should address immediate leaks, while medium-term retrofits with insulated, reflective, or green roof systems guided by Zaria-specific thermal studies already inferred are recommended alongside a dedicated institutional maintenance framework with ring-fenced funding and sustainability criteria for future designs. Further empirical thermal modeling, life-cycle cost analyses, and post-occupancy evaluations across ABU zones are also advised. Implementing these measures would enhance occupant comfort, extend building lifespans, and position ABU as a model for sustainable tropical housing in Nigeria.

## REFERENCES

- Adesogan, S. O. (2018). A study of roof failures in and around Ibadan, Nigeria: Causes, effects and remedy. *Current Journal of Applied Science and Technology*, 26(3), 1–10. <https://doi.org/10.9734/CJAST/2018/12078>
- Ahmadu Bello University. (2025, September 14). Vice-Chancellor visits ABU staff residential quarters, expresses worry over dilapidation. <https://abu.edu.ng/vice-chancellor-visits-abu-staff-residential-quarters-expresses-worry-over-dilapidation/>
- Algarni, S. A. (2023). Experimental study of cool roof impact on building performance in hot-dry and dusty climates. In Proceedings of the 41st AIVC/ASHRAE IAQ Conference – 9th TightVent – 7th venticool Conference (pp. 1–8). Athens, Greece.
- Amankwaa, E. F., Roberts, B. M., Mensah, P., & Gough, K. V. (2025). Impact of roofing materials on school temperatures in tropical Africa. *Buildings & Cities*, 6(1), 139–157. <https://doi.org/10.5334/bc.581>
- Babalola, O. D., Nduka-Kalu, C. I., & Ugah, U. K. (2024). Appraisal of the application of gable roof in tropical climates. *International Journal of Medical Networks*, 2(9), 1–4. <https://www.opastpublishers.com/open-access-articles/appraisal-of-the-application-of-gable-roof-in-tropical-climates.pdf>
- Makwe, E. (2024). Rooftop rainwater harvesting as a sustainable solution for water security in northern Nigeria. *Sustainable Water Resources Management*.
- Nwalusi, D. M. (2022). Climate responsive design strategies for contemporary low-rise residential buildings in tropical environment of Enugu Nigeria. *IOP Conference Series: Earth and Environmental Science*, 1054(1), 012052. <https://doi.org/10.1088/1755-1315/1054/1/012052>

- Nwankwo, S. I., & Nwankwo, C. V. (2025). Investigation of deplorable infrastructural building defects and maintenance methodologies for tertiary institutions in tropical rainforest climates in Southeastern Nigeria. *Journal of Infrastructure Preservation and Resilience*, 6, Article 35. <https://doi.org/10.1186/s43065-025-00132-4>
- Oyadokun, J. O., Adeyinka, R., & Amao, F. L. (2026). Evaluation of collapsed buildings in Nigeria from 2015 to 2025: Causes, effects and control. *SSR Journal of Engineering and Technology*, 3(2), 36–45. <https://ssrpublisher.com/wp-content/uploads/2026/02/Evaluation-of-Collapsed-Buildings-in-Nigeria-from-2015-to-2025-Causes-Effects-and-Control.pdf>
- Sagada, M. L. (2009). *The impact of Ahmadu Bello University main campus on staff housing and student accommodation in Samaru, Nigeria* [Unpublished doctoral dissertation]. Ahmadu Bello University, Zaria.
- Salihu, M. M. (2024). Determining the threshold for variation in indoor temperature reduction capacity of green roofs with different depths in hot and dry climates. *Cadernos de Educação Tecnologia e Sociedade*, 17(se4), 154–169. <https://doi.org/10.14571/brajets.v17.nse4.154-169>
- Salihu, M. M., Salisu, A. S., & Tukur, R. B. (2020). A field study on thermal insulation performance of green roof in buildings of hot dry climate of Zaria, Nigeria. *Journal of Environmental Studies*, 4(11), 14–24.
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th Ed.). SAGE Publications.



©2025 This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license viewed via <https://creativecommons.org/licenses/by/4.0/> which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is cited appropriately.