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Benchmarking Traditional Earthen Construction Technologies for Sustainable and Affordable Housing in Tanzania

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Abstract: Traditional earthen construction technologies represent a significant yet increasingly underutilized resource for sustainable and affordable housing development in Sub-Saharan Africa. This paper presents the outcomes of the PURSUE Project inception study, which benchmarks vernacular housing systems through detailed field investigations conducted in Mbulu District (Manyara Region) Kondoa District (Dodoma Region) and Makumbusho village Dar es salaam Tanzania. The study documents and analyses a range of indigenous dwelling typologies, including Mwera, Iraqw, Hehe, Bembe, and Nyakyusa houses, focusing on their spatial organization, which based on daily activities such as food preparation, livestock management, and communal living, material composition, construction techniques, and environmental performance. These housing systems are predominantly built using locally available materials such as earth, timber, bamboo, grass, stone, lime, and ash, resulting in structures with low embodied energy, high thermal mass, and strong climatic responsiveness. The findings highlight how traditional construction practices integrate architectural form, material selection, and settlement patterns with landscape, climate, and cultural knowledge, achieving durable and resource-efficient housing solutions. The paper also examines the ongoing transition from earthen and thatched construction to burnt clay brick masonry and corrugated metal roofing, driven by urbanization, market accessibility, and changing socio-economic aspirations. While this transition often retains traditional spatial layouts, it signifies a gradual shift away from vernacular building wisdom toward standardized materials perceived as more modern and permanent. By systematically documenting traditional earthen housing technologies and their contemporary transformations, this study establishes a technical and cultural knowledge base to inform future research, capacity building, and the development of sustainable construction and rehabilitation strategies rooted in local contexts.

Keywords: Earthen construction; Sustainable housing; Sub-Saharan Africa; Tanzania; Cultural landscape

1. Introduction

Green building materials and construction techniques are coming to the forefront whereas the impact of building materials on global warming frequently discussed these days (Mehra, ve diğerleri 2022). Structural green materials such as; bamboo, soil, recycled steel, engineered timber have been promoted more all over the world while traditional construction techniques and materials have been also gotten attention by end-users, architects and engineers. Vernacular building traditions refers to buildings created by local communities, where design choices are shaped by cultural traditions. It differs significantly across regions due to variations in climate, landscape, and cultural context. These technologies are grounded in the use of locally available materials and indigenous knowledge systems, resulting in building forms characterized by low embodied energy and high contextual suitability with minimal cost (Matos, Milheiro-Oliveira ve Varum

2025). The main factor influencing the development of the vernacular construction practices is depending on geographical location, climatic conditions, cultural practices, and the accessibility of locally available building materials such as adobe (i.e., mud blocks, whole walls), masonry (i.e., stone, clay) and timber (Sassu 2002). Over time, vernacular dwellings have adapted to environmental conditions, resource availability, and societal needs. These traditions emerged through long-term trial and error, guided by the practical expertise of local builders who possess deep, place-specific knowledge, an asset that is increasingly diminishing in today's era of globalization and remote practices. Therefore, studying and integrating the principles of traditional vernacular architecture into contemporary design holds considerable value. Building layout, like circular, rectangular and linear plans, is another factor usually related to cultural, historical, and urban planning traditions.

Vernacular building traditions fall under sustainable construction which emphasizes on reducing environmental impacts while ensuring economic and social viability. The structures align remarkably well with contemporary environmental goals. Their reliance on local materials reduces transportation impacts, while their typically low energy consumption and capacity for reuse or natural decomposition make them environmentally sensitive solutions. The study done by Mora-Ruiz et al., (2025) confirm that such construction practices significantly lowers greenhouse gas emissions compared to cement-based materials and supports circular construction practices. In addition, the study by Fouad et al., (2025) affirmed that vernacular construction practice offers a low-carbon alternative suitable for sustainable housing delivery. In this sense, vernacular architecture is not merely a record of past creativity but also a valuable source of inspiration for developing resilient and sustainable construction practices today. On the contextual of spatial studies also show that vernacular structures maintain strong links with cultural identity and local livelihoods, reinforcing their relevance in sustainable development discourse (Zhang et al., 2024). These practices symbolize an extremely refined intelligence that branches not from formal design rules but from the lived experiences accumulated over generations. By utilizing local materials and construction techniques, such as natural ventilation in warm climates or thermal mass in arid regions that perfectly adapt to regional climates, these structures are inherently sensitive to their surroundings. This enables the construction of buildings that typically achieve high levels of energy efficiency without relying on mechanical systems.

Furthermore, vernacular building traditions e reflects the identity, values, and social practices of the communities that build and inhabit it; it creates spaces that are not only functional but also meaningful. The construction process typically fosters community participation and knowledge transfer, thereby strengthening social cohesion and continuity. The characteristics and scale of buildings vary according to their region, geographical context, climatic conditions which differ considerably across locations and the availability of local resources. Despite their low cost and excellent thermal and acoustic performance, these buildings are associated with several challenges, particularly related to wall erosion caused by water and wind. Additional issues arise from vegetation growth and the presence of termites and other insects. Most structural deficiencies are linked to the foundations, which are typically constructed as shallow trenches, approximately 30-40 cm deep, from which the walls are erected. These foundations are often inadequate, as the erosive action of water can undermine the walls to greater depths. As a result, erosion at the base leads to a loss of cohesion among the wall components, causing gradual yet continuous structural deterioration (Fumo ve Di Nardo 2015).

In recent years, processes such as globalization and rapid urbanization, obvious by the growth of urban populations, have increasingly challenged the continuity of vernacular building traditions and urban forms specifically in Africa. These include increasing pressure on the environment, existing infrastructure, and urban building stock, as well as limited time and insufficient access to appropriate construction materials for new housing and services. At the same time, a more deeply rooted pattern in African development is the prioritization of non-African architectural models over vernacular traditions. Formal architectural practices across the continent have long been shaped by European influences, reflecting broader historical processes in which African societies were compelled to adopt European languages, governance systems, and cultural norms during the colonial period. Although African cities existed and functioned effectively prior to colonization, their forms and structures did not align with European definitions of urbanity. Western concepts of urban form and building typologies continue to be regarded as superior, even when they conflict with local environmental conditions and cultural practices. Ones of the best examples of vernacular structures can be observed in Tanzania which is located on the Eastern coast of Africa and its population is over 61 million and one of the fastest growing countries in Africa. The total number of buildings is more than 14 million according to the CENSUS 2022 (The United Republic of Tanzania National Bureau of Statistics 2022). Urban population in Tanzania is 36% according to the World Bank data in 2024 (World Bank 2024). In Tanzania, homes are also built through self-help and/or community-based approaches. Most homes in the country do not comply with engineering standards, and informal settlements remain a major problem in the country. The 2011/12 National Population and Housing Census revealed that among more than 9 million households, the primary wall materials were cement bricks (20.3%), sun-dried bricks (26.3%), fired bricks (26.3%), and posts and mud (23.5%) (The United Republic of Tanzania National Bureau of Statistics 2022). The most common building types in Tanzania are traditional houses, unreinforced masonry structures made of adobe bricks, unreinforced masonry structures made of fired brick/concrete blocks, and reinforced concrete structures. The vast majority of residential buildings are vulnerable to damage and prone to collapse due to natural disasters (Silva, Tatar ve Henshaw 2021). Table 1 lists the common local building materials in Tanzania based on the region. Bamboo, grass, and mud are the most communal structural material in the country.

Table 1 - Tanzanian vernacular construction materials *(Runyoro 2020)*

Ethnic Group in Tanzania	Housing construction elements
Western Tanzania	Poles, sticks, bamboo, mud & grass, elephant grass roofing
South East Tanzania	Poles, sticks, bamboo, soil and grass
Southern Highlands	Bamboo (extensive), mud & grass
Coastal areas	Sticks, soil, palm leaves, mud & poles, grass thatch (common)
Central Tanzania	Bush poles, grass and soil
Inter lacustrine region	Poles, bamboo, sticks and grass
Nilo-Hamitics	Poles, sticks, grass and soil
Kosain&Luo	Mud and grass

This paper investigates the common vernacular building structures in Tanzania as a part of an EU funded project, PURSUE (PURSUE, PURSUE 2025). The PURSUE project aims to promote the usage of locally available, eco-friendly, and affordable construction materials, fostering collaboration among higher education institutions, professionals, and communities in Sub-Saharan Africa (SAR). The project involves collaboration between universities in Türkiye, Portugal, Mozambique, Tanzania, and Somalia, focusing on supporting sustainable development goals such as industry innovation, sustainable cities, responsible consumption, climate action, and partnerships for development. The main objectives of this study are:

- To document and benchmark traditional earthen construction technologies in Tanzania.
- To analyze the material systems and construction techniques used in vernacular dwellings.
- To evaluate the environmental and cultural significance of these housing systems.
- To identify lessons for sustainable and affordable housing development.

2. Vernacular Constructions in Tanzania

2.1 Cultural and Environmental Context

Traditional housing systems in Tanzania have evolved through long-term adaptation to climate, available resources, and social organization. Settlements often respond to topography, agricultural activities, and environmental conditions. In Mbulu District, for example, settlements are located in the Mbulu Highlands, characterized by undulating hills, volcanic soils, and seasonal water systems that influence building location and materials. Traditional communities such as the Iraqw people develop housing forms closely integrated with their agricultural landscapes and collective settlement patterns. The main challenge the users face is the regular maintenance of dwellings, such as reapplying mud plaster to the walls three or more times per year to prevent the structural failure. Moreover, the rectangular plan of the dwelling may cause problems with wall separation at the corner and connections and out-of-plane collapse under lateral loading such as a strong wind or earthquake.

2.2 Traditional Building Materials

Natural materials such as stone, timber, straw, sheep's wool, plant-based fibers (e.g., hemp), cork, and clay have long formed the basis of traditional construction practices. However, over the past fifteen years, particularly in Europe and the United States, there has been a renewed and growing interest in both natural and unconventional building materials.

Traditional (natural) materials can generally be categorized according to their function within a building system. As structural components, materials such as timber, stone, rammed earth, straw bales, and clay bricks are commonly employed in load-bearing construction. For insulation purposes, materials like sheep's wool, hemp fibers, and cork are widely used due to their favorable thermal properties. Additionally, natural materials also serve complementary roles in finishing applications, including plastering, painting, and flooring, where clay and cork are frequently utilized (Spišáková ve Mačková 2015).

Among these materials, stone remains one of the most prominent. It is a highly durable and low-maintenance option, characterized by its significant thermal mass. Stone is also highly versatile, available in a wide range of shapes, sizes, colors, and textures, making it suitable for applications such as flooring, walls, arches, and roofing. Furthermore, it integrates harmoniously with the natural environment and can be readily reused or recycled for various construction purposes. Stone is often incorporated at the base of walls or within foundations. Its primary function is to protect earthen walls from moisture ingress and erosion, thereby enhancing the durability and longevity of the structure. Earth serves as the primary material for wall construction in many vernacular buildings (Matos, Milheiro-Oliveira ve Varum 2025). It is typically used either in the form of compacted mud or shaped into sun-dried blocks, providing both structural capacity and thermal mass. Timber is commonly employed for structural elements such as frames and roof beams. It is generally sourced from nearby forests, making it a locally available and renewable material that supports the overall framework of the building. Grass and thatch are widely used in roofing systems. These materials not only offer effective protection against rainfall by shedding water efficiently but also provide natural insulation, helping to regulate indoor temperatures. Lime and ash are occasionally added as stabilizing agents in construction. These materials improve the strength and resistance of earth-based mixtures, contributing to better performance against environmental effects. These materials offer:

- low embodied energy
- strong thermal performance
- environmental compatibility
- Often mixed with cow dung to improve cohesion and durability

Table *2* shows the comparison of the building materials in Tanzania based on labor, cost, time consumption, and distance to transport material. The locally available materials do not require laboring, have the minimum cost, necessitate less the construction time with limited needs of transportation in comparison with the other structural materials in the country.

Table 2 - Comparison of the building materials in Tanzania *(Buccellato ve Reineccius 2013)*

Type	Building Materials	Labor	Cost (0-$$$)	Time of Construction	Distance to Transport Material
Wattle and Daub	Mud with ash or manure as binding agent	Local, not hired	0	2 days	0
	Sisal poles	Local, not hired	0	5 days (to strip bark & trim)	Up to 15 km on foot

	Sisal split stalks for holding together walls	Local, not hired	0	5 days to prepare, 1 day to put in place	Up to 15 km on foot
	Corrugated metal with lumber wood trusses	Local, hired	$$ (for labor and material)	1 week	45 km by vehicle
Concrete Masonry Units	Concrete block units	Not local, hired	$$$ (for labor and material)	2 to 5 years (based on funding)	15 to 45 km by vehicle
	Poured concrete foundation	Not local, hired	$$$ (for labor and material)	1 week (depends on funding)	15 to 45 km by vehicle
	Corrugated metal and lumber wood trusses	Local, hired	$$ (for labor and material)	1–2 weeks (usually larger, complex structures)	45 km by vehicle
Compressed Earth Bricks	Walls: Soil (40% sand, 25% gravel, 25% clay, 10% silt and water), Concrete & mortar, Rebar (not always)	Local, hired	$$	Up to 2 years (based on funding)	0 (soil), 15 to 45 km by vehicle (concrete)
	Poured concrete foundation	Not local, hired	$$$	1 week (depending on funding and size)	15 to 45 km by vehicle
	Corrugated metal roof with wood trusses	Local, hired	$$$	1–2 weeks (usually larger, complex structures)	45 km by vehicle

3. Methodology

3.1 Research Design

This study adopts a qualitative multiple case study design to benchmark traditional earthen construction technologies across different geographical and cultural contexts in Tanzania. The case study approach is appropriate for investigating complex, context-dependent phenomena such as vernacular architecture, where boundaries between the phenomenon and context are not clearly defined (Yin, 2018). The qualitative approach allows for an in-depth understanding of material use, construction techniques, and socio-cultural influences that cannot be adequately captured through purely quantitative methods (Creswell, 2014). This design is widely applied in studies of traditional construction systems and sustainable architecture.

3.2 Study Areas

Field investigations were conducted in Mbulu District, Kondoa District, and Makumbusho Village. These sites were purposively selected to capture climatic and cultural diversity, as well as well-preserved vernacular housing systems. This purposive selection is justified in qualitative research aiming for information-rich cases rather than statistically representative samples (Patton, 2015).

3.3 Sampling Strategy and Sample Size

A purposive sampling strategy was employed to select between 15 and 24 dwelling units, with approximately 5–8 houses examined per study site. Purposive sampling is appropriate for studies that focus on specific characteristics, such as vernacular housing typologies and traditional material use, as it enables the selection of information-rich cases relevant to the research objectives (Patton, 2015). The chosen sample size is consistent with qualitative research standards, where depth of analysis is prioritized over statistical generalization (Creswell, 2014). This approach ensured the inclusion of representative housing typologies, variations in construction techniques, and different levels of structural condition. In Mbulu District and Kondoa District, Tembe houses were selected as the dominant vernacular typology. In contrast, at Makumbusho Village, a broader range of indigenous housing types was examined, including Mwera, Iraqw, Hehe, Bembe, and Nyakyusa houses, reflecting the site's role as a cultural repository of diverse Tanzanian architectural traditions.

3.4 Selection Criteria

Selection criteria, guided by methodological rigor and relevance to research objectives, included: typological representation of dominant vernacular forms (Oliver, 2006); material authenticity focusing on traditional earthen systems (Houben & Guillaud, 1994); state of conservation for assessing durability; environmental context capturing climatic and geographical variations; and accessibility for detailed documentation.

3.5 Data collection methods

Data collection combined field and desk research: direct observation of construction, materials, and structural conditions; photographic surveys of building elements; measured sketches of spatial organization and construction systems; informal interviews with builders and occupants regarding construction practices and cultural context; and a literature review of earthen construction technologies and performance.

3.6 Analytical framework

This study uses a multi-criteria framework to holistically assess vernacular housing performance by integrating material (thermal, structural, durability), environmental (climatic responsiveness, embodied energy), socio-cultural (spatial organization, cultural practices), and construction technique (methods, adaptability) considerations. Multi-criteria analysis is a common method in sustainable construction research for evaluating complex systems (Kibert, 2016).

4. Vernacular Housing Typologies in Tanzania

4.1 Mwera (Banda) House

Mwera (Banda) House is traditionally built in a rectangular layout using natural, locally sourced materials, reflecting both environmental adaptation and cultural craftsmanship. Construction begins by digging small holes and placing sturdy wooden poles approximately two meters apart to form the main structural framework. Thinner miombo sticks are then woven horizontally between these poles at intervals of about 30 cm, creating a tight lattice that strengthens the walls and supports the clay render. Wet red clay mixed with water and sometimes small amounts of grass or cow dung for binding is applied over this woven frame to form thick, durable walls. A small window is intentionally left near the roofline to ensure sufficient ventilation and allow daylight into the interior without compromising security or heat control. The roof is supported by a network of wooden rafters and is meticulously thatched with layers of elephant grass. This type of thatching is not only lightweight but also provides excellent thermal performance, keeping the interior cool during hot seasons and warm during cold nights. The sloped form of the roof helps shed rainwater effectively, which is essential in the region's tropical climate. Figure 1 illustrates a typical Mwera house in Tanzania.

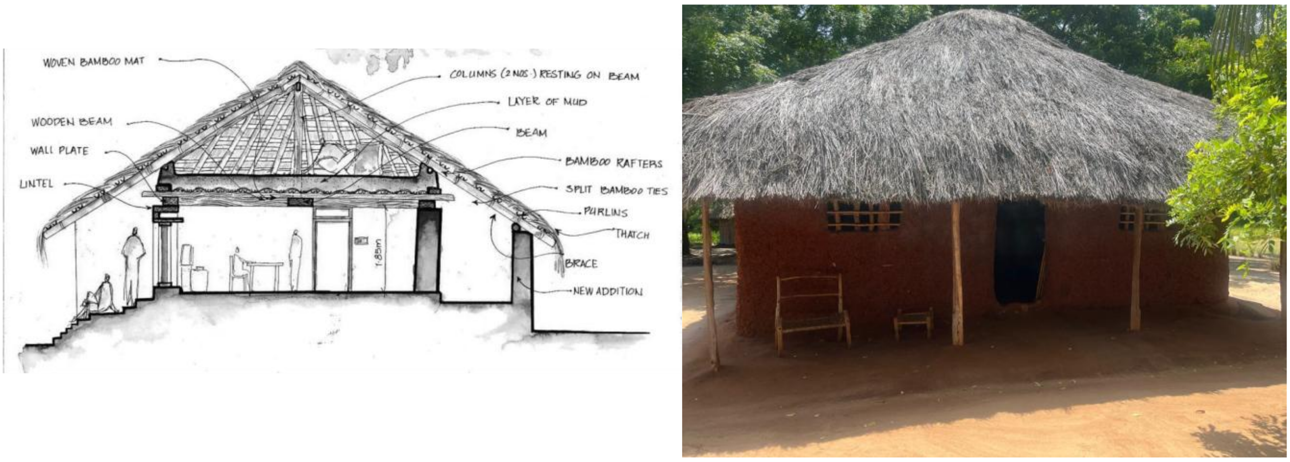

Figure 1 - Typical Mwera house in Tanzania

4.2 Iraqw House (Tembe)

Wa-Iraq Houses (Tembe) are traditionally rectangular dwellings characterized by their thick mud walls and distinctive flat earthen roofs. Built entirely from natural, locally available materials such as mud, clay, timber and cow dung. These houses demonstrate an efficient and sustainable architectural system well adapted to the Iraq tribe's environment. The walls are constructed either from sun-dried mud bricks or by applying layers of mud plaster over a simple wooden framework. This results in dense, thermally efficient walls that help keep the interior cool during the day and warm during cold nights. Cow dung is often mixed into the mud as a binding agent, improving the material's strength, durability and resistance to cracking. A defining feature of the house is its flat roof. Supported by strong timber beams laid across the main walls, the roof is topped with layers of compacted earth. This earthen roof is carefully tamped to enhance waterproofing and stability, allowing it to withstand wind, heat, and occasional rainfall. In some cases, grass or small branches are integrated beneath the mud layer to improve structural cohesion. Figure 2 displays a great example about Iraqw house in Tanzania.

Figure 2 - Typical Iraqw house in Tanzania

4.3 Hehe House

Hehe Houses (Tembe) are traditional rectangular or slightly oval structures built using wattle-and-daub techniques and natural local materials. Their construction begins with arranging strong wooden poles vertically into the ground to create the main frame of the house. Between these poles, smaller flexible sticks are woven horizontally to form a tight lattice that supports the wall structure. This woven framework is then plastered with layers of wet mud mixed with grass or cow dung, producing thick, sturdy walls that provide excellent insulation against heat and cold. The walls are often smoothened by hand and left to dry naturally in the sun. The roof is typically constructed from wooden rafters covered with dense thatching made of long grasses, often elephant grass or similar locally available varieties. This thatched roof is designed with a gentle slope to shed rainwater efficiently and maintain a cool interior temperature. Figure 3 shows a sketch and one existing Hehe house in Tanzania.

Figure 3 - Typical Hehe house in Tanzania

4.4 Bembe House

Bembe House (Msonge houses) are traditionally constructed using a flexible framework that forms a rounded, dome-like structure. The building process begins with bending slender poles and securing them together to create a curved skeletal frame. This arched framework provides both strength and resilience, enabling the house to withstand heavy rains and shifting weather conditions. Once the main frame is set, the walls are woven with reeds, banana fibres, or other flexible plant materials to create a tight lattice.

This woven surface acts as a supportive base for the wall covering. Layers of mud are then applied over the lattice, forming a firm, smooth exterior that strengthens the structure and provides effective protection against rain and wind. The roof is traditionally thatched with bundles of dried grass or overlapping banana leaves. These materials are carefully arranged in thick layers to ensure water flows off easily, preventing leaks and maintaining a cool, well-insulated interior. Figure 4 displays a typical bembe house in Tanzania.

Figure 4 - Typical Bembe house in Tanzania

4.5 Nyakyusa House

Nyakyusa houses (Bamboo House) are traditionally constructed using bamboo as the primary structural material, reflecting the tribe's close connection to the forested landscapes of the Southern Highlands.

Building a house is a communal activity, where relatives and neighbors gather to assist, reinforcing social unity and cooperation. The construction process begins by assembling strong bamboo poles to form the main framework of the house. These poles are arranged vertically and horizontally, then tied securely to create a stable skeleton. Additional bamboo pieces are woven or lashed into the structure to strengthen the walls and support the roof. Because bamboo is lightweight yet durable, the completed structure remains flexible an advantage in areas prone to heavy rain or strong winds. A distinctive cultural characteristic of Nyakyusa housing is the attention given to decoration and finishing. Significant effort is spent smoothing the surfaces, arranging bamboo neatly, and sometimes embellishing entrances or edges to showcase craftsmanship. The quality of finishing often reflects pride, skill, and social identity within the community. Figure 5 illustrates Nyakyusa houses in Tanzania.

Figure 5 - Typical Nyakyusa house in Tanzania

The comprehensive comparative analysis of vernacular housing typologies in Tanzania is summarized in Table 3.

Table 3 - Comparative analysis of vernacular housing typologies in Tanzania

Typology	**Structural System**	**Main Materials**	**Roof Type**	**Strength**	**Weakness**	**Environmental Performance**
Mwera House	Timber frame + wattle and daub	Wooden poles, woven sticks, mud, grass, cow dung	Sloped thatched roof (elephant grass)	Lightweight structure; good airflow; adaptable construction	Vulnerable to erosion; weak wall cohesion; low durability against moisture	Good thermal insulation; effective ventilation; suitable for tropical climate
Iraqw House	Load-bearing earthen walls	Mud, clay, timber, cow dung, stone (foundation)	Flat earthen roof	Thick walls provide strength and insulation; compact layout	Poor resistance to water infiltration; heavy roof load;	High thermal mass; stable indoor temperature (day-night balance)

					foundation erosion risk	
Hehe House	Wattle and daub system	Wooden poles, sticks, mud, grass, cow dung	Sloped thatched roof	Flexible structure; easy to construct; low-cost materials	Weak structural integrity; prone to biological degradation (termites, vegetation)	Good thermal performance; efficient rainwater drainage
Bembe House	Flexible curved frame (dome-like)	Bent poles, reeds, banana fibers, mud	Thatched (grass/banana leaves)	Aerodynamic form improves resistance to wind; structural flexibility	Limited load-bearing capacity; high maintenance of organic materials	Good climatic adaptation; efficient rain shedding; stable internal environment
Nyakyusa House	Bamboo frame structure	Bamboo, grass, earth (foundation)	Thatched roof	Flexible and resilient to environmental loads; community-based construction	Low durability; susceptible to decay, insects, and moisture	Good ventilation; lightweight; suitable for humid environments

5. Results and Discussion

Cross-case comparison across typologies and regions evaluated using standardized indicators for thermal performance, durability, structural stability, and material efficiency via comparative benchmarking.

5.1 Thermal Performance of Earthen Materials

The findings indicate that traditional earthen construction systems across the study areas exhibit strong thermal performance due to their high thermal mass. Materials such as compacted earth walls and mud-plastered roofing systems absorb heat during the day and release it gradually at night, thereby moderating indoor temperature fluctuations.

In semi-arid environments such as Kondoa District and Mbulu District, this thermal behavior contributes significantly to indoor comfort by reducing daytime overheating and maintaining warmth during cooler nights. Similarly, in the coastal context of Dar es Salaam, earthen walls help buffer high ambient temperatures, although ventilation plays a more critical role due to humidity. These findings confirm that earthen materials provide an effective passive cooling strategy, reducing dependence on mechanical systems and supporting climate-responsive housing design.

5.2 Durability Performance and Degradation Mechanisms

Despite their environmental and thermal advantages, earthen structures are susceptible to several durability challenges. The most common form of deterioration observed across the case studies is surface erosion, primarily caused by rain impact, surface runoff, and wind action. This results in gradual material loss and weakening of wall sections over time.

Another critical issue is foundation-related failure, particularly in structures lacking adequate plinth protection. In several cases, direct contact between earthen walls and the ground led to moisture ingress through capillary action, causing rising damp, material disintegration, and eventual structural instability.

However, buildings incorporating stone foundations or raised plinths demonstrated improved resistance to moisture and longer service life. This highlights the importance of integrating basic protective measures to enhance the durability of earthen construction.

5.3 Structural Performance and Failure Modes

The structural assessment revealed several inherent weaknesses in traditional earthen construction systems, particularly in relation to lateral stability and wall integrity. These vulnerabilities are primarily attributed to the low tensile strength of earthen materials and the absence of effective reinforcement mechanisms.

5.4 Out-of-Plane Failure:

Out-of-plane wall failure was identified as a major structural risk, especially in buildings constructed with unreinforced earthen walls and weak roof-to-wall connections. Under lateral loads, such as wind pressure, walls tend to bulge and may eventually collapse outward due to insufficient tensile resistance and lack of proper anchorage. This type of failure is particularly evident in structures with large unsupported wall spans and inadequate structural integration between wall and roof elements.

5.5 Corner Separation:

Corner separation and cracking at wall junctions were also commonly observed across the case studies. These failures are typically associated with poor bonding between intersecting walls, often resulting from construction techniques that do not ensure adequate interlocking or continuity at corners. The absence of reinforcement elements, such as tie beams or corner strengthening, further exacerbates this weakness. Over time, progressive cracking at these junctions compromises the structural integrity and stability of the entire building. Overall, these findings highlight the need for incorporating simple and effective reinforcement strategies such as improved bonding techniques, timber ring beams, and corner stabilization methods. These will enhance the structural performance of earthen construction systems without undermining their sustainability advantages.

6. Conclusions

The findings of this study demonstrate that traditional earthen construction technologies in Tanzania embody a highly efficient and context-responsive approach to housing, shaped by centuries of adaptation to local climatic, environmental, and socio-cultural conditions. The investigated vernacular typologies, Mwera, Iraqw, Hehe, Bembe, and Nyakyusa houses, reveal a sophisticated integration of locally available materials, construction techniques, and spatial configurations, resulting in structures that are not only affordable and resource-efficient but also environmentally sustainable. These systems exhibit low embodied energy, strong thermal performance, and a high degree of compatibility with their surrounding landscapes, confirming their relevance within contemporary sustainability discourse.

However, the study also highlights a significant ongoing transition toward modern construction materials such as burnt bricks and corrugated metal roofing, driven by urbanization, changing socio-economic aspirations, and perceptions of durability and modernity. While this shift often preserves certain spatial and cultural characteristics, it simultaneously risks the gradual loss of valuable vernacular knowledge and practices. In this context, the results emphasize the necessity of adopting a balanced and integrative approach that does not disregard traditional systems but rather enhances them through scientific validation and technological innovation.

The PURSUE project provides a critical framework for this transition by bridging traditional knowledge with modern engineering practices through education, capacity building, and technology transfer. By equipping stakeholders with the necessary tools and knowledge to improve the performance of local materials, the project supports the development of resilient, affordable, and sustainable housing solutions tailored to regional needs. Ultimately, this research underlines that the future of housing in Sub-Saharan Africa lies not in the replacement of vernacular systems, but in their informed transformation, ensuring that cultural heritage, environmental sustainability, and technical advancement are effectively aligned.

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