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Integrating Indigenous Building Techniques into Modern Housing: Case Studies from KwaZulu-Natal, South Africa, and Kurdistan, Iraq

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Abstract
Climate change, resource depletion, energy consumption, and the loss of cultural identity present major challenges for modern housing. Indigenous and vernacular architecture offers valuable knowledge developed in response to local climatic, material, and social conditions. This study explores the integration of indigenous building techniques into contemporary housing through a comparative analysis of traditional housing in KwaZulu-Natal (KZN), South Africa, and the Kurdistan Region of Iraq (KRI). Using a qualitative comparative case-study approach, the study examines climate-responsive design, indigenous materials, construction techniques, spatial organization, environmental performance, and cultural values. Despite significant climatic and geographical differences, both regions demonstrate common sustainability principles, including the use of local materials, passive environmental strategies, resource efficiency, and community-oriented planning. Traditional Zulu houses respond to humid subtropical conditions through lightweight structures, natural ventilation, earth-based materials, and communal settlements. Conversely, Kurdish vernacular architecture in Tawela village adapts to a mountainous continental climate through compact forms, south-facing orientation, thick stone masonry, thermal mass, and passive solar strategies. The findings highlight indigenous techniques as valuable for improving thermal comfort, reducing energy demand, enhancing affordability, and preserving cultural identity. The study proposes an integration framework based on environmental responsiveness, sustainable materials, cultural continuity, and technological adaptation to support resilient and locally appropriate contemporary housing.

Keywords*:* Vernacular architecture, indigenous building techniques, KwaZulu-Natal, Kurdistan Region of Iraq, sustainable housing.

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1. Introduction
The construction industry is one of the biggest users of natural resources and energy globally and contributes significantly to greenhouse gas emissions across the life cycle of buildings. As a result,

sustainable housing has emerged as a global priority in the face of climate change, dwindling resources, accelerating urbanization, and growing energy needs. The concept of sustainability has been defined by the United Nations in the Brundtland Report in 1987 as "development that satisfies the needs of the present without harming future generations' ability to satisfy their own needs. The concept includes three dimensions: environmental, economic and social sustainability (Karakul, 2016). In the built environment, environmental sustainability aims to reduce the adverse effects of buildings over their entire life cycle, from material extraction to construction, operation, maintenance and demolition (Piquer, 2003).

To overcome these challenges, sustainable design approaches have become more common in modern architecture, focusing on energy efficiency, renewable energy, resource conservation, indoor environmental quality, water efficiency, waste reduction, and the use of local materials (Halıcıoğlu, 2012). However, in many developing countries, residential developments are still being built according to industrialized construction models based on Western architectural practices. These systems offer standardized and fast construction, but often fail to consider local climatic conditions, indigenous knowledge, and cultural identity, leading to higher energy consumption, thermal discomfort, and environmental impact (Markard et al., 2020).

The increasing awareness of these constraints has brought a renewed interest in indigenous and vernacular architecture as a source of sustainable design knowledge. Vernacular comes from the Latin vernaculars, which means native or indigenous (WordSense.eu Dictionary, n.d.). Vernacular architecture is defined as the architecture that is developed from the local needs, materials, environmental conditions, and cultural traditions, not from formal architectural education (Definitions, n.d.; Sari et al., 2017). (Alkubaisi, 2021) also defines vernacular architecture as a "progenitor's core" of knowledge that has been built up over centuries of experimentation and adaptation. Indigenous communities developed construction methods through trial and error that integrated buildings with their local ecosystems and met functional, cultural, and environmental needs.

The previous studies have shown that vernacular architecture is an effective way of combining climate-responsive building forms, passive environmental strategies, and locally available materials to provide thermal comfort with minimum energy consumption (Ahmed A. Q., 2013; Halıcıoğlu, 2012; Hosseini & Shangapour, 2010). In hot-arid climates, traditional courtyard houses use shading, evaporative cooling and natural ventilation to moderate harsh climatic conditions (Abdulac, 1982). Similarly, in mountainous regions, traditional stone houses use walls up to 60 cm thick to store heat and coolness by thermal mass, which enhances the thermal comfort of the interior (Çetin & Ülgen, 2022). Many indigenous settlements around the world have similar environmentally responsive strategies.

The Kurdistan Region of Iraq (KRI) and KwaZulu-Natal (KZN), South Africa, offer two unique but similar examples of indigenous housing traditions that developed in different climatic environments. Vernacular settlements in mountainous areas of Kurdistan are defined by the stepped mountain villages, thick stone masonry, compact urban form, and passive thermal regulation appropriate to the semi-arid continental climate in the mountainous area (Raof et al., 2020). The indigenous architecture of KwaZulu-Natal, on the other hand, evolved lightweight beehive-shaped houses, stabilized earth construction, and thatched roofing systems suitable for humid subtropical conditions. While developed in different environments, both of these construction systems show advanced adaptation to climate using locally available materials and passive environmental design. The use of vernacular building technologies has been identified as crucial in preserving heritage and promoting a healthier environment whilst incorporating contemporary building designs in KwaZulu-Natal and the City of Durban (Bodei, 2022). Balancing the use of indigenous architecture and the significance of promoting climate resilience in housing designs has been identified as a strategic approach by Pardo (2023), to achieve sustainable human settlements.

Indigenous construction methods are still decreasing at a fast rate, even though they have environmental and cultural significance. Traditional materials have been replaced by industrialized materials such as reinforced concrete, fired bricks and imported finishing materials. This is often referred to as a "prestige gap" by Ahmed et al. (2024), who describe indigenous housing as being

"outdated" or "poor" instead of being recognized for its environmental performance. This has led to the adoption of construction methods that are not appropriate to the climate, increasing the reliance on energy, and also diminishing the local identity and traditional knowledge.

While there are many studies that have explored vernacular architecture from environmental, cultural, historical and conservation angles, few have explored how indigenous building techniques from various climatic and cultural contexts can be systematically incorporated into contemporary housing. There are still very few comparative studies of indigenous housing traditions in Africa and the Middle East. This study therefore compares the indigenous building techniques of KwaZulu-Natal with those of the Kurdistan Region of Iraq and identifies the design principles that can be transferred and a framework for the integration of traditional knowledge into modern housing. The study seeks to offer practical suggestions for architects, planners, policy makers, and housing developers, while highlighting the potential of indigenous construction techniques in promoting environmental sustainability, cultural continuity, and resilient housing.

1.1 Literature Review

1.1.1 Theoretical Perspectives on Vernacular Architecture

Vernacular architecture is the architecture that is not designed by a professional, but rather by local knowledge, adaptation to the environment, and cultural traditions (Definitions, n.d.; Sari et al., 2017). Alkubaisi (2021) has recently defined vernacular architecture as a "progenitor's core" of accumulated knowledge, which is the outcome of centuries of experimentation and adaptation. This perspective is on vernacular architecture as a living knowledge system, rather than a building style.

The theoretical knowledge of vernacular architecture can be structured in three interrelated aspects: philosophy, bioclimatic performance, and tectonics.

Philosophy: The philosophical aspect sees vernacular architecture as a reflection of the relationship between people and place. Traditional buildings are not just shelters, but they represent local cultural values, social organization, privacy, family structure, and community identity (Alkubaisi, 2021). Raof et al. (2020) refer to this as the "spirit of place," in which architectural forms are directly shaped by the environment and culture. Likewise, the spatial organization of traditional courtyard houses in the Middle East illustrates the spatial organization that is a compromise between privacy, family interaction and environmental performance (Abdulac, 1982).

Bioclimatic Principles: The bioclimatic dimension is the ability of vernacular buildings to control the indoor environment without the use of mechanical systems. Thermal mass, natural ventilation, building orientation, shading, and compact urban forms are the key elements of traditional architecture for achieving indoor comfort (Ahmed et al., 2024). Thick stone and adobe walls act as a heat reservoir during the day and release the heat gradually at night, helping to moderate the temperature fluctuations in hot-arid climates (Çetin & Ülgen, 2022). Passive environmental strategies can greatly reduce energy consumption and increase comfort for occupants.

Tectonics: The tectonic dimension relates to construction techniques, craftsmanship and material choice. Indigenous architecture generally uses locally sourced stone, earth, timber, bamboo or thatch, reducing the energy used in transportation and embodied carbon, and promoting local economies (Abbas, 2017). Local materials also enable buildings to adapt to local climatic conditions in a natural way. These include basalt masonry in Turkey, mud-brick construction in Syria, stone architecture in Morocco, and palm-frond structures in Oman (Abdulac, 1982; Murat & Bekişoğlu, 2022).

1.1.2 Indigenous Building Techniques and Sustainable Housing

Many studies have shown that indigenous building methods play a major role in environmental sustainability. (Sari et al., 2017) concluded that vernacular housing in Banda Aceh can be obtained by local wisdom, thermal comfort, and low embodied energy to achieve environmental quality. Karakul (2016) found ecological principles in traditional settlements in Cappadocia which are still relevant to sustainable architecture. Similarly, Bougiatioti et al. (2013) reported on climate-responsive elements

in Greek vernacular settlements, and Al Tawayha et al. (2019) found that traditional Mediterranean settlements are generally more environmentally sustainable than contemporary developments.
All of these studies indicate that indigenous construction techniques offer important lessons in energy reduction, thermal comfort and building-ecosystem integration.

1.1.3 Contemporary Challenges Facing Indigenous Housing

Although indigenous building systems are gaining recognition for their environmental benefits, there are still a number of challenges.
The first challenge is thermal failure of many modern residential buildings. In hot climates, modern reinforced concrete houses often suffer from high indoor temperatures and reliance on mechanical cooling systems due to their thin walls, sealed windows, and lack of passive ventilation (Ahmed et al., 2024; Murat & Bekişoğlu, 2022).
The second challenge is the prestige gap, in which indigenous construction methods are seen as indicators of poverty or backwardness, rather than as sophisticated environmental adaptations (Ahmed et al., 2024). As a result, communities are increasingly using imported industrial materials that are not necessarily suited to local climatic conditions, and which often do not perform as well as locally appropriate materials.
A third challenge is related to sustainability transitions. The Multi-Level Perspective suggests that industrialized construction has established itself as a socio-technical regime with regulations, economic investments, industrial supply chains and consumer expectations, while vernacular architecture is a marginal innovation that has not yet had a significant impact on mainstream housing production (Geels, 2024; Markard et al., 2020). This imbalance can only be addressed through coordinated technological, institutional, social and policy changes.
Last but not least, housing affordability is a major concern in many developing areas. Bayoumi and Zhao (2020) suggest that sustainable housing policies should incorporate financial and social reforms to enhance affordability and bolster local livelihoods. Recent research also indicates that the use of vernacular design principles in modern housing can lead to environmental sustainability, cost-effective construction, social resilience, and cultural continuity (Alnaim, 2026; Gyamfi et al., 2026; Bhattacharjee et al., 2026).

1.1.4 Vernacular Architecture in Kurdistan and KwaZulu-Natal

The studies on Kurdish vernacular architecture have been mainly concerned with environmental adaptation, sustainable construction, thermal performance, and cultural identity. The studies of Morad and Ismail (2017), Khoshnaw (2019), Rostam (2017), Hosseini and Shangapour (2010), and Raof et al. (2020) show that the Kurdish indigenous settlements are very sensitive to mountainous semi-arid climates by using thick stone walls, compact forms, stepped topography, and passive environmental strategies.
Studies of indigenous housing in KwaZulu-Natal have recorded the climatic suitability of traditional Zulu houses, such as beehive-shaped houses, stabilized earth houses and thatched houses which are well adapted to humid subtropical conditions. In spite of their higher economic and environmental costs, however, many rural communities have increasingly abandoned these techniques in favor of industrialized construction systems. (Msimang, 2021) indicate that South African public housing programmes in KwaZulu-Natal need to take into consideration cultural norms and values in response to housing the growing urban population. Vernacular architecture has been identified as crucial element in creating a conducive platform for achieving environmental sustainability. (Colijn, 2023) put it succinctly that vernacular architecture can assist the South African government to cope with challenges associated with carbon emissions.
There is a considerable amount of literature on each region separately, but there are no comparative studies between Kurdistan and KwaZulu-Natal.

1.2 Research Gap

Previous studies have shown that indigenous architecture plays a vital role in environmental sustainability, climate adaptation, cultural identity, and resource efficiency. However, most of the studies are limited to a specific geographical area or to the documentation, conservation or environmental performance of vernacular architecture.

There is little research that has examined the indigenous building methods of various climatic zones and compared them to find transferable principles for contemporary housing. Moreover, there are limited studies that have created practical integration frameworks that integrate indigenous building knowledge with modern construction technologies, taking into account environmental performance, affordability, cultural continuity and policy implementation.

This study aims to fill these gaps by comparing indigenous building methods in KwaZulu-Natal and the Kurdistan Region of Iraq. It aims to find common and context-specific principles, assess their environmental performance and establish a framework for incorporating indigenous knowledge into modern housing design. This not only contributes to the development of sustainable architecture, but also resilient, culturally responsive and locally appropriate housing policies.

1.3 Objectives and Hypotheses

The overall aim of this study is to investigate the potential of integrating indigenous building methods from KwaZulu-Natal, South Africa and the Kurdistan Region of Iraq in modern housing design to enhance environmental sustainability, cultural continuity and housing resilience. This study is designed to accomplish this with the following objectives:

- To determine the indigenous building techniques, materials, construction methods and spatial characteristics of vernacular houses in KwaZulu-Natal and the Kurdistan Region of Iraq.
- To explore the environmental, cultural and technical considerations of indigenous housing systems in both regions, focusing on passive environmental strategies, locally available materials and climate-responsive design.
- To compare the similarities and differences between the two indigenous housing traditions in terms of climatic adaptation, construction technologies, spatial organization, material selection, and socio-cultural values.
- To create a conceptual framework and practical design guidelines for the incorporation of indigenous building techniques into contemporary housing, while meeting current functional, technological, and regulatory needs.

The following hypotheses are used to guide this study:

- H1: Indigenous building techniques in both KwaZulu-Natal and the Kurdistan Region have climate-responsive properties that have a significant impact on the environmental performance of the houses, when compared to the conventional contemporary houses.

- H2: Indigenous housing traditions in KwaZulu-Natal and Kurdistan have similar sustainable design principles that can be adapted to other contexts.

- H3: The combination of indigenous construction methods and modern building technologies can enhance the thermal comfort, energy efficiency, cultural identity and sustainability of modern housing.

1.4 Significance and Structure of the Paper

This research is a contribution to sustainable architecture as it shows how the traditional building methods can be used in the design of modern houses. It compares the Kurdistan Region of Iraq with KwaZulu-Natal, South Africa, and identifies design principles that are climate responsive and culturally appropriate to enhance environmental performance, energy efficiency, affordability and resilience. The proposed integration framework provides practical guidance for architects, planners and policy makers, and can be used to maintain indigenous knowledge and to ensure sustainable, locally adapted housing development.

The paper is divided into six sections. The literature review is included in the introduction which discusses the vernacular architecture, indigenous building techniques and the lack of research in this area. The methodology section outlines the comparative case study approach and research methods. The results of the Kurdistan and KwaZulu-Natal case studies are presented in the next sections, followed by a comparative analysis and the development of an integration framework for modern housing. The paper ends with a summary of the findings, implications and recommendations for future research and practice (see structure diagram in Figure 1).

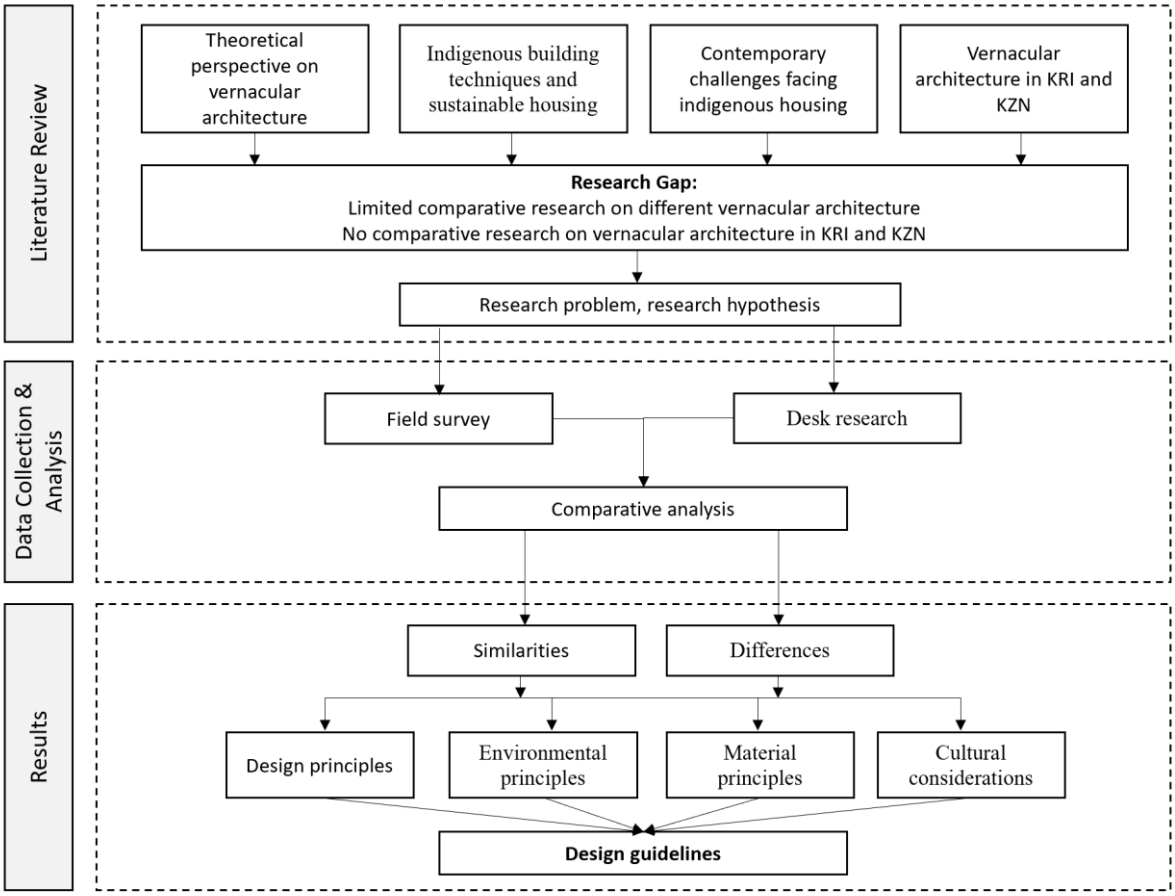

Figure 1. Research structure diagram

2. Materials and Methods

2.1 Study Design and Setting

The study uses a comparative qualitative case study method to examine the potential for the integration of indigenous building techniques into modern housing. The research is based on two geographically and culturally different regions: KwaZulu-Natal (KZN), South Africa and the Kurdistan Region of Iraq (KRI). The areas chosen were based on their strong indigenous architectural heritage, climatic variations and the continuing evolution of their traditional housing systems in response to contemporary building practices.

The study is concerned with vernacular residential architecture as a source of environmental and cultural knowledge. It explores indigenous building techniques, materials, spatial arrangements, climatic adaptation and socio-cultural features that have developed over time as a result of the long-term relationship between communities and their environments. The comparative approach allows for the identification of region-specific solutions and common principles that can be used to inform sustainable housing design in the present day.

KwaZulu-Natal is a humid subtropical climatic context in which indigenous Zulu housing evolved using locally available materials such as earth, timber and thatch, and forms and construction

techniques that were adapted to the local environmental conditions (Whelan, 2017). The Kurdistan Region of Iraq, on the other hand, is a semi-arid mountainous environment where traditional architecture developed through the application of stone masonry, earth-based materials, small scale and passive thermal strategies to cope with temperature fluctuations and climatic conditions.

2.2 Case Selection

The case studies were selected in a purposive manner to reflect indigenous housing traditions, climatic adaptation strategies, documented architectural features and relevance to current housing problems. For each region, a traditional indigenous housing is chosen. This approach enables the study to investigate the changes in indigenous knowledge and to evaluate the possibility of its integration into modern housing.

2.2.1 KwaZulu-Natal

The traditional Zulu houses selected for this study are located in the rural areas of Mlalazi Municipality and the surrounding areas of KwaZulu-Natal, South Africa, where traditional Zulu Umuzi houses still exist. These settlements are indigenous housing practices that have developed over the years to meet the local subtropical climate, material and cultural requirements. The traditional Zulu houses, such as the circular iQukwane and beehive houses, illustrate the use of locally available materials like earth, timber and thatch, and passive climatic strategies appropriate to the regional environment. Indigenous construction techniques are a manifestation of the relationship between the environment, social organization and cultural identity in the built environment (Ameed, 2025).

Furthermore, the modern housing cases in KwaZulu-Natal are chosen to explore the shift from indigenous building systems to the modern standardised housing systems. These developments are often based on industrialized materials and construction techniques, and tend to be fast built but less responsive to climate and less dependent on local knowledge. By comparing traditional and contemporary housing, the study can assess the potential benefits of the reintroduction of indigenous principles into contemporary housing (Colijn, 2023).

2.2.2 Kurdistan Region of Iraq

The traditional case study is based on the village of Tawela in the Hawraman region of the Kurdistan Region of Iraq, a mountainous region with a unique vernacular architecture and a close link between settlement form, climate and local resources. The indigenous construction knowledge is reflected in the use of local stone, compact building forms, stepped settlements and climate responsive spatial organization in Hawraman villages. The features are the result of long-term adaptation to the mountainous topography and semi-arid climate of the region (Hosseini & Shangapour, 2010; Rostam D. , 2017). The environmental, cultural and architectural values of Hawraman vernacular settlements have been pointed out in previous studies, which have shown that these settlements can play a role in sustainable design in the present era (Hamejani et al., 2018; Amini & Noori, 2019).

The contemporary residential projects in the Kurdistan Region are chosen to examine the change of traditional housing principles in the context of the contemporary construction practices. Like other rapidly growing areas, modern residential developments are increasingly using reinforced concrete, industrial materials and standardized building forms, with a decreasing use of local materials and passive environmental strategies. These projects offer a glimpse into the challenges and opportunities of incorporating traditional Kurdish construction practices into modern housing.

2.3 Data Collection and Analysis

The data were gathered using a qualitative method which involved literature review, document analysis, architectural study and comparative analysis of selected indigenous housing cases. Secondary data was gathered from previous academic research, field surveys, architectural documentation,

photographs, drawings and climatic analysis of traditional houses in KwaZulu-Natal, South Africa and Tawela village in the Kurdistan Region of Iraq. The data gathered were related to climatic conditions, settlement patterns, building forms, indigenous materials, construction techniques, passive environmental strategies and socio-cultural characteristics.

The collected data was analyzed qualitatively by applying the approach of qualitative comparative analysis to find out the common principles, contextual differences and transferable strategies between the two case studies. The analysis was organized into three dimensions: environmental performance, technical characteristics, and socio-cultural values. The environmental analysis included the following: climate responsiveness, passive design strategies, thermal performance, orientation, ventilation, and energy-efficiency approaches. The indigenous materials, construction techniques, structural systems and their adaptability to the current building technologies were assessed through technical analysis. Socio-cultural analysis investigated settlement patterns, spatial organization, community relationships, and cultural identity. The results were compiled using a comparative evaluation matrix to identify similarities, differences and opportunities for integration. Based on the results, a conceptual framework and design guidelines were developed for incorporating indigenous building knowledge into modern sustainable housing.

3. Case Studies

3.1 Case Study One: KwaZulu-Natal

The first case study is from KwaZulu-Natal.Case Study One is from KwaZulu-Natal.

3.1.1 Geographic Context

KwaZulu-Natal (KZN) is situated on the eastern coast of South Africa (see Figure 2) and is one of the most culturally important provinces in the country. It is the ancestral land of the Zulu people, the seat of the Zulu monarchy and the burial site of King Shaka Zulu, the founder of the Zulu Kingdom. The province has many rural settlements that retain traditional Umuzi homesteads and indigenous building techniques, which makes it a suitable case to explore vernacular housing and its significance in the context of sustainable architecture in the present day (Ndimande, 2026; Mhlaba, 2009).

Figure 2. Location of KwanZulu-Natal on the South Aferical Map. Source: https://www.d-maps.com/carte.php?num_car=23735&lang=en

3.1.2 Climate

The climate of KwaZulu-Natal is humid subtropical, with warm, humid summers, mild winters, seasonal rainfall and relatively high humidity. The indigenous Zulu housing has been greatly affected by these climatic conditions. Traditional housing was designed to provide thermal comfort by passive environmental strategies instead of mechanical systems. Their climate responsive shapes improve natural ventilation, minimize heat gain and create comfortable indoor climate all year round. This passive survivability is a major factor in energy efficiency and climate resilience (Kane et al., 2023).

3.1.3 Traditional Housing

The traditional Zulu settlements are called Umuzi, which are groups of circular huts grouped by family and social structure (see Figure 3). The design is based on cultural values, privacy, hierarchy and communal living, and is connected to the surrounding landscape. The architecture reflects a strong philosophy of place-making, where buildings are not imposed on the environment but are integrated with the local geography and cultural identity.

Figure 3. Mbongolwane Village in Eshowe, KwaZulu-Natal Province. Source: Authors

3.1.4 Indigenous Building Materials

The materials used in the construction of traditional houses in KwaZulu-Natal are almost exclusively natural resources, which reduces the environmental impact and transportation costs. Walls are typically made of adobe or stone because they have a high thermal mass, low heat transfer, are inexpensive, and are locally available. Foundation stones are made of stone, especially grey limestone, to enhance structural durability and moisture resistance. The roof structure is made from timber from the local woodlands and the roof is thatched with grass which has excellent thermal insulating properties and is lightweight (see Figure 4). The use of local materials highlights the interconnectedness between traditional building practices and sustainability (Zhang, 2021; Seethal, 2022).

Figure 4. Left: exterior view of the house structure, right: roof structure of the house, Source: Authors

3.1.5 Construction Techniques

The building methods used in KwaZulu-Natal have been developed over time, and are used to suit the local environment (see Figure 5). While built from local materials and techniques, vernacular architecture has evolved over time to include some modern materials and concepts, while still adhering to traditional construction methods and principles (Abdallah et al., 2025; Saunders, 2000).

Figure 5. Structural components of a typical vernacular house in KwaZulu-Natal. Sources: left: https://www.openheritage.org.za/sites/default/files/docs/attacheddocs/2016/12/07/VernacularArchitecture_EasternCape_Doc_FINAL4.pdf, Right: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQFEbA0b- IPmxoXDWAZXUIdf2zM4VGpWtlT (Accessed online on 20 May 2026)

3.1.6 Environmental Performance

Passive design features and the use of local materials are examples of traditional Zulu housing that shows high environmental performance. The thick earth and stone walls provide thermal mass to control the indoor temperature and the light weight thatched roofs reduce the heat transfer and improve thermal comfort (see Figure 6). Spatial layout of settlements promotes natural ventilation and air circulation, reducing the need for mechanical cooling systems (Abdulkareem & Al-Maiyah, 2025). Studies have shown that vernacular housing can have positive effects on the indoor environment, energy consumption and climate resilience, and environmental sustainability (Hernández et al., 2023; Mhlaba, 2009).

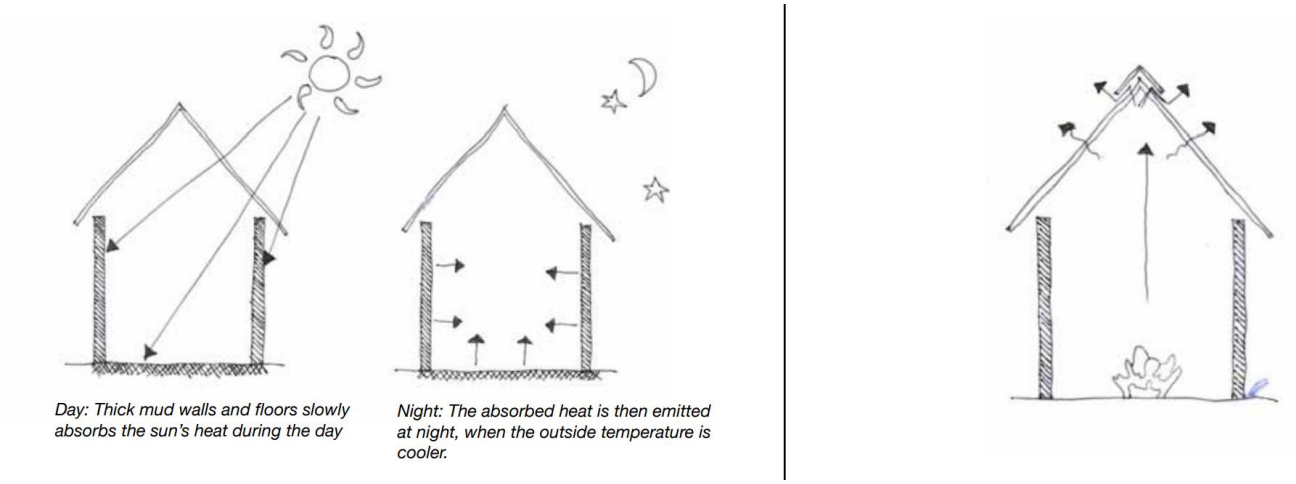

Figure 6. Thermodynamics and aerodynamics of a typical vernacular Zulu house. Source: https://www.openheritage.org.za/sites/default/files/docs/attacheddocs/2016/12/07/VernacularArchitecture_EasternCape_Doc_FINAL4.pdf

3.1.7 Cultural Significance

Traditional housing in KwaZulu-Natal is not only an expression of environmental performance, but also of Zulu cultural identity. The design of the Umuzi, the choice of materials and construction techniques are all traditional knowledge that has been passed down from generation to generation. Vernacular buildings are a product of local craftsmanship, serve to strengthen community identity and cultural continuity in the era of urbanization and modernization. Indigenous building materials and construction techniques not only promote environmental sustainability but also help to preserve cultural heritage, as mentioned by (Seethal, 2022).

3.1.8 Lessons for Modern Housing

The case of KwaZulu-Natal shows that indigenous building methods are still very relevant in the present-day housing market (see Figure 7). Passive climatic design and the use of local materials and culturally suitable spatial arrangement can play a significant role in the sustainability and affordability of modern residential developments. The contemporary housing can be designed in a hybrid manner, using traditional design principles and modern building technologies and standards, rather than replacing the indigenous knowledge with standardized construction systems. The integration can result in cost savings during construction, improved thermal efficiency, preservation of cultural heritage, and more sustainable housing development.

Figure 7. Modern Building using Traditional Methods, Source: Authors

3.2 Case Study Two: Kurdistan Region, Iraq

3.2.1 Geographic Context

The Kurdistan Region of Iraq (KRI) is located in the northern part of Iraq, and it has a variety of mountainous terrain (see Figure 8). The study is carried out in the Tawela village in the Hawraman region, which is one of the most unique mountainous cultural landscapes in Kurdistan. The total area of the Hawraman region is approximately 1840 km2 and is renowned for its unique vernacular architecture created due to the close link between the local culture, the mountainous topography and environmental conditions (Hamejani et al., 2018). The traditional building techniques continue to reflect centuries of local knowledge and Tawela is one of the best preserved examples of Kurdish indigenous settlements.

Figure 8. Location of Tawela in the KRI on the Iraq map. Source: https://www.d-maps.com/carte.php?num_car=52649&lang=en

3.2.2 Climate

The Köppen Climate Classification system classifies Hawraman as a continental climate (Dsa) with warm, dry summers and cold, wet winters (Kottek et al., 2006).The average annual rainfall is about 440 mm, with the bulk of the rainfall falling from November to May, and summers are generally dry (weatherbase, n.d.).The temperature range is quite large, with an average of approximately 25°C in July and −2.6°C in January (weatherbase, n.d.). These distinct seasonal changes have had a significant impact on the development of indigenous housing, with buildings designed to harness the sun's warmth in winter and to keep heat in while keeping the occupants warm and dry in winter (see Figure 9).

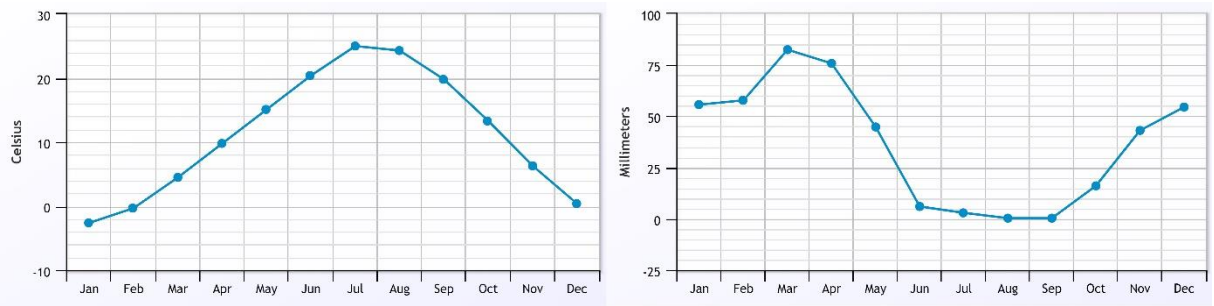

Figure 9. left: annual average temperature; right: annual average percipitation in Tawela; source: (weatherbase, n.d.)

3.2.3 Traditional Housing

The traditional houses in Tawela are very much in harmony with the mountainous landscape (see Figure 10). The village is laid out on a terraced site, with houses built on steep south-facing slopes to ensure that they receive the maximum amount of sunlight in the winter months (Khoshnaw, 2019). The settlement is divided into three neighbourhoods by two rivers, which give it a distinctive Y-shaped urban form. The buildings are compactly arranged to reduce exposure to cold winds, while providing unobstructed sunlight, natural ventilation and scenic views (Hosseini & Shangapour, 2010).

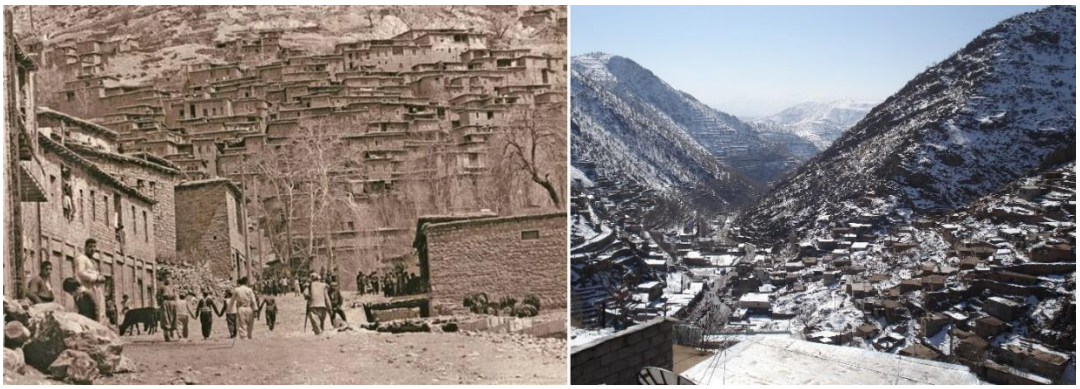

Figure 10. Tawela village, left: (William Carter, 1965), right: (Authors)

The houses are mostly rectangular, compact and two storeys tall (see Figure 11). The ground floor is typically dedicated to storage, livestock and service areas, while the upper floor is for living areas, kitchens and bedrooms (Amini & Noori, 2019) (see Figure 12). Semi-open spaces (heywan) and open terraces (barheywan) offer seasonal living spaces and a gradual transition between indoor and outdoor spaces (Rostam D. , 2017). The settlement pattern, pedestrian alleys, shared rooftops and lack of boundary walls also promote high level of social interaction and strengthen community cohesion (Hamejani et al., 2018).

Figure 11. Typical vernacular house in Tawela, (Photos: Authors)

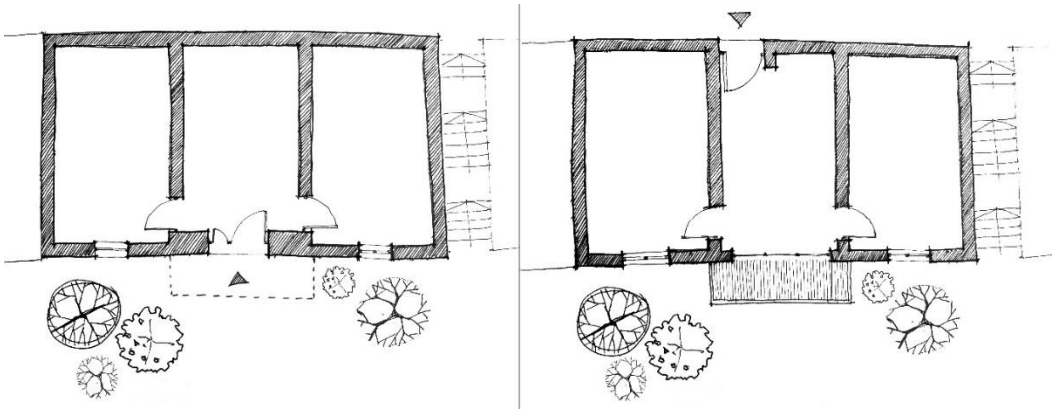

Figure 12. Typical vernacular house plans, Left: Ground floor plan, Right: First floor plan, (Sketch by authors)

3.2.4 Indigenous Building Materials

The indigenous architecture of Tawela is almost entirely based on the use of locally available stone, timber and soil, thereby reducing transportation costs and environmental impacts (see Figure 13). Stone is the most common material for foundations and load-bearing walls due to its durability, resistance to moisture, and thermal mass. Timber is used for columns, beams, doors, windows and roof structures, and soil is used as mortar, plaster and waterproof roofing material (Rostam A. , 2011). The use of these natural materials not only provides visual harmony with the surrounding landscape, but also environmentally responsive construction (Hamejani et al., 2018).

Figure 13. building construction components and materials in Tawela vernacular house, (photos: Authors)

3.2.5 Construction Techniques

The traditional houses use load-bearing stone masonry structure, and the external wall is made of clay brick, which is composed of inner and outer stone layers and filled with clay mortar and crushed stone. These composite walls not only offer structural support but also thermal insulation due to their ability to minimize heat transfer (Amini & Noori, 2019). The use of indigenous construction also includes the use of unique timber elements called dimak and mrola, which are mainly made of mulberry wood, and are used to reinforce masonry walls, prevent cracking and improve the resistance to earthquakes by connecting the layers of the wall and anchoring the structures to the mountain (Amini & Noori, 2019; Rostam A. , 2011).

The flat roofs are made by stacking thin stone (dela), mud, straw and fine aggregates on top of timber beams. Roofs are compacted every so often with a stone roller (bantlin) to keep them waterproof and are often used as outdoor living areas in the summer (Rostam, 2011). The openings are carefully designed based on climatic requirements: small windows minimize winter heat loss, and larger south-facing glazed openings (jamkhana) maximize passive solar heat gain and daylight (Hosseini & Shangapour, 2010).

3.2.6 Environmental Performance

Tawela's vernacular architecture is very adaptive to the environment. All these elements, including compact building shapes, terraced settlement layouts, thick stone walls, optimized orientation, minimum external openings and use of local materials, help to lower energy consumption and improve indoor thermal comfort (see Figure 14). The buildings are mainly oriented towards the south to gain the maximum solar gain in winter and the shared walls and compact forms reduce the exposed surface area and heat loss (Hosseini & Shangapour, 2010). Stone walls and floors offer thermal mass to store solar heat during the day and release it slowly at night, reducing temperature fluctuations. In addition, the density of the settlement, the surrounding landforms and vegetation protect against prevailing cold winds and allow for natural ventilation during warmer times (Hosseini & Shangapour, 2010) (see Figure 15).

Figure 14. Windows and door in vernacular houses in Tawela, (Photos, Authors)

Figure 15. Openings and multiple shading elements in vernacular house in Tawela, (photo: Authors)

3.2.7 Cultural Significance

The traditional houses of Tawela are not only environmentally sustainable but also represent the cultural identity and collective memory of the communities in Hawraman. The settlement is a product of centuries of indigenous knowledge in adapting architecture to the mountainous terrain, climate and lifestyle. Spatial organization, construction methods and material use reflect local traditions and foster good social interaction through common pedestrian spaces, rooftops and semi-open living spaces (Hamejani et al., 2018). The architecture is thus a functional reaction to the environment and an important part of the Kurdish cultural heritage.

3.2.8 Lessons for Modern Housing

The Tawela case study shows that the use of indigenous building techniques is still very relevant in the context of sustainable housing in the present day. Passive solar design, compact building forms, terraced site planning, high-thermal-mass construction, and the use of locally available materials are effective strategies for enhancing thermal comfort and reducing operational energy consumption. Just as important, the incorporation of indigenous spatial ideas like semi-open living spaces and community-oriented settlement patterns can enhance social sustainability and cultural continuity. Instead of copying the old buildings, the principles of traditional buildings can be applied to contemporary housing by using modern construction technologies and engineering standards to create environmentally responsive, culturally appropriate and resilient residential development (Hosseini & Shangapour, 2010; Khoshnaw, 2019; Rostam, 2017).

4. Results

4.1 Comparative Analysis

The comparative study of the two case studies shows that, although the climate, geographical location and cultural background are different, the indigenous housing traditions of KwaZulu-Natal (KZN), South Africa and the Kurdistan Region of Iraq (KRI) have some common basic principles. Both traditions have developed over time to fit the local environment and resources, and have evolved housing systems that are environmentally responsive, resource efficient and culturally appropriate. Four key similarities were found: climate responsive design, use of local materials, passive environmental strategies, and community-oriented planning. Conversely, the indigenous housing of both regions varies significantly in terms of their adaptation to climate, resources, construction techniques, settlement form and socio-cultural environment. These differences are due to the different environmental and cultural contexts in which each architectural tradition developed.

4.1.1 Similarities

Climate-responsive design: The two indigenous housing systems show a good adaptation to the climatic conditions. The traditional Zulu houses in KwaZulu-Natal are designed to ensure natural ventilation, minimise solar heat gain and provide thermal comfort in humid subtropical climate. They are lightweight, have a good shape and are oriented to allow air to flow through them, reducing overheating in the interior. Vernacular houses in the Kurdistan Region, on the other hand, are designed to deal with a cold continental mountain climate by using compact forms, south facing orientation, terraced settlement patterns and high thermal mass construction that maximizes the winter solar gain and minimizes heat loss. The architectural solutions vary depending on the climate, but both traditions use design strategies that focus on passive adaptation to local environmental conditions rather than relying on mechanical heating or cooling systems.

Local materials: The second common characteristic is the use of locally available natural materials. The traditional houses in KwaZulu-Natal are made from adobe, stone, timber and grass thatch from the local environment, while vernacular houses in Kurdistan are predominantly made from locally quarried stone, timber and soil. The materials have relatively low embodied energy and construction costs, as they are relatively easy to transport and process. They also possess physical characteristics which assist in thermal control and environmental performance. Local resources further reinforce the link between architecture, landscape, regional identity and also help to preserve indigenous construction knowledge.

Passive environmental strategies: In both case studies, the passive environmental strategies are highly developed and contribute to the comfort of the interior and to the reduction of the operational energy demand. Thermal comfort is achieved in KwaZulu-Natal by natural ventilation, lightweight roof systems, appropriate settlement spacing and passive cooling methods appropriate to a humid climate. Passive performance in Kurdistan is achieved through the use of thick stone walls with high thermal mass, compact building forms, optimized orientation, limited window openings, shared walls, and the use of semi-open spaces like the heywan in the seasons. While the methods vary depending on the climate, both traditions illustrate that indigenous knowledge can be used to create effective low-energy solutions that can help to keep indoor spaces comfortable year-round.

Community-oriented planning: The two indigenous settlements also demonstrate good community-based planning principles. The traditional Zulu Umuzi homestead is structured around family and communal relationships, which are based on social hierarchy, privacy and communal living. Likewise, the village of Tawela in Hawraman has terraced neighbourhoods, pedestrian alleys, shared rooftops and linked outdoor spaces that facilitate daily interaction between the people. In both settings, settlement organization is not limited to the individual buildings, but is also manifested in the development of socially cohesive environments that support cultural identity, foster community connections, and encourage sustainable living patterns. The results show that indigenous housing is not only environmentally efficient but also socially sustainable, providing insights for modern residential planning.

4.1.2 Differences

Climatic conditions: The most important distinction between the two regions is the climate in which they are situated. The climate of KwaZulu-Natal is humid subtropical, warm, humid and seasonal. Consequently, traditional Zulu houses are designed to provide ventilation, shade and protection from too much solar heat. The climate of the Kurdistan Region is continental mountainous, characterized by hot dry summers and cold wet winters, in contrast to the other regions. The indigenous houses of the Kurds are therefore designed to retain heat, to harness passive solar heat and to shield from strong winter winds by being compact, with thick walls and facing south.

Construction materials: The choice of building materials is based on the natural resources of each region. Traditionally, KwaZulu-Natal uses earth, adobe, timber, grass thatch and locally available stone to create lightweight structures with good ventilation properties. In contrast, vernacular architecture in Kurdistan is mainly based on local stone, timber and clay. The thick stone masonry

walls offer high thermal mass and structural stability and are integrated into the mountainous landscape. Therefore, although both traditions rely on local materials, the properties of the materials vary with the geology, vegetation and climatic needs of the region.

Structural systems: The structural systems are also very different. The traditional Zulu house is usually made of light timber frames, earth or adobe walls and thatched roofs, making them flexible for humid environments. By contrast, the houses of the Kurds are vernacular, built of load-bearing stone masonry and have flat timber roofs with thick structural walls. Indigenous reinforcement techniques like dimak and mrola enhance structural integrity and earthquake resistance. The contrasting systems illustrate how indigenous builders adapted structural solutions to the materials and environmental conditions available in their area.

Spatial organization: The organization of space differs in response to both environmental and social factors. The traditional Zulu settlements (Umuzi) consist of groups of separate circular huts grouped around communal open spaces in a hierarchical order and social organization. The settlement pattern of Tawela is compact and terraced, following the steep mountainous topography, in contrast. Houses share walls, roofs and circulation spaces, and pedestrian alleys link neighborhoods. The internal layout of the Kurdish houses shows a distinct vertical functional division, with the service spaces on the ground floor and the living spaces on the upper floor, while the Zulu houses are generally horizontally organized.

Cultural influences: The two architectural traditions are both strongly influenced by local culture, albeit in different ways. The arrangement of the Umuzi and the symbolic form of the beehive hut are expressions of indigenous social organization, communal living and family structure in Zulu housing. Vernacular architecture in Kurdistan is a reflection of the cultural traditions of the Kurds, adaptation to mountainous life, seasonal living and the integration of private, semi-open and communal spaces like heywan and barheywan. The differences show how cultural values affect settlement planning and architectural form, and how they are harmonious with the natural environment.

4.2 Comparative Evaluation Matrix

The comparative assessment is based on the key sustainability and architectural criteria and compares the performance of the indigenous housing systems in both regions (see Table 1). The matrix does not seek to compare one system with another, but rather highlights the strengths of each tradition and its potential for use in contemporary housing.

Table 1: Comparative analysis of indigenous building techniques in KwaZulu-Natal (South Africa) and the Kurdistan Region (Iraq)

Criterion	KwaZulu-Natal	Kurdistan Region of Iraq
Climate Response	Excellent passive cooling, natural ventilation, shading, humidity control	Excellent passive solar heating, thermal mass, wind protection
Thermal Performance	High performance in warm and humid climates	High performance in cold mountainous climates
Materials	Adobe, earth, timber, grass thatch, local stone	Stone, timber, clay, earth, locally sourced natural materials
Sustainability	High use of renewable local materials with low embodied energy	High use of durable local materials with excellent environmental integration
Construction Cost	Low to moderate due to locally available materials	Low to moderate using locally sourced stone and traditional techniques
Cultural Identity	Strong expression of Zulu traditions and communal lifestyle	Strong expression of Kurdish culture, mountain settlements, and local craftsmanship

Modern Adaptability	High potential for integrating passive cooling, natural materials, and community planning into modern housing	High potential for integrating thermal mass, passive solar design, local materials, and terraced planning into modern housing

The comparison reveals that both traditional housing systems are effective in integrating the concepts of environmental adaptation and resource efficiency with cultural identity. Although the architecture is different in different regions and different in different climates, the principles are very similar. The findings indicate that the traditional construction techniques of both KwaZulu-Natal and the Kurdistan Region are good models to develop climate responsive, affordable and sustainable modern housing.

5. Discussion

5.1 Framework for Integrating Indigenous Techniques into Modern Housing

The comparative study of KwaZulu-Natal and Kurdistan demonstrates that there is indigenous knowledge of housing systems that is valuable to the environment, the technical aspects of housing, and the socio-cultural aspects of housing that can be transferred to sustainable housing in the present day. But it is not enough to simply copy the traditional forms; it is necessary to reinterpret the principles and adapt them to the use of modern technologies, construction standards, and lifestyles. The results of the research are presented in the form of an integration framework, which is based on four interrelated dimensions: environmental, material, cultural and technological principles.

5.1.1 Design Principles

Environmental Principles: They include:

- In both case studies, indigenous housing illustrates the importance of climate responsive design as a key element of sustainability. Passive environmental strategies from vernacular architecture can be adapted to modern housing.
- Passive ventilation: Traditional Zulu houses use natural ventilation and openness of the settlement to minimize overheating, and Kurdish houses use the careful positioning of openings, semi-open spaces (heywan) and settlement density to control ventilation. Modern houses can incorporate cross-ventilation, suitable openings and transitional areas to minimize reliance on mechanical cooling.
- The thick stone walls of the houses in Hawraman show the effectiveness of high thermal mass in maintaining indoor temperature stability, and earth-based materials in KwaZulu-Natal offer similar benefits. Stone, rammed earth, adobe or other high-mass materials can be used in modern applications with better insulation systems.
- Solar orientation: Solar access is important in cold climates as seen in the housing patterns of Tawela, whereas shading in KwaZulu-Natal is important for solar heat gain in warm climates. Climate orientation, solar access and shading devices should be the main considerations for contemporary design.

Material Principles: The case studies show the need for locally available, low impact materials and their adaptation in contemporary construction systems.

- Local stone: Kurdish vernacular construction is a testament to the durability, thermal insulation and aesthetic qualities of locally sourced stone. Local stone can be used for structural, façade or thermal applications, and still be regional.
- Stabilized earth: KwaZulu-Natal's earth-based construction offers a chance to integrate traditional knowledge with contemporary stabilization methods to create more durable, efficient, and acceptable structures.
- Sustainable timber: Both areas are showing the significance of timber as a renewable building material. Responsible sourcing and engineered timber technologies can enhance its suitability for contemporary housing.

- Hybrid systems: The most suitable solution is not to go back to traditional construction but to develop hybrid systems that integrate the traditional materials and principles with modern structural and building technologies.

Cultural Considerations: Indigenous housing is an example of sustainability that has social and cultural aspects. Modern houses should maintain local character and meet contemporary needs.

- Collective spaces are important in fostering community relationships, as seen in the Umuzi organisation in KwaZulu-Natal and the shared pedestrian spaces of Tawela.
- Privacy: Traditional spatial hierarchy, especially in the Kurdish house, offers lessons for culturally appropriate contemporary housing.
- Local aesthetics: Materials, forms and construction details should be understood rather than copied, and modern housing should be connected to the local identity.

5.1.2 Design Guidelines

From the comparative results, the following conceptual guidelines are suggested for the integration of indigenous techniques in modern housing:

- Use local climatic data to design: Building orientation, form, openings and materials should be designed based on local climatic data.
- Utilize locally available materials and modern improvement techniques: Local stone, earth and timber should be stabilized, treated and improved using modern construction techniques.
- Focus on passive environmental performance: Natural ventilation, thermal mass, solar control and daylighting should be incorporated before mechanical systems.
- Integrate indigenous spatial concepts into the present lifestyle: Semi-open spaces, courtyards and community planning should be adapted to the present housing needs.
- Create hybrid construction systems: Indigenous materials and knowledge should be integrated with contemporary structural and regulatory needs.
- Maintain cultural identity through interpretation: Contemporary housing should be interpreted in terms of materials, proportions, spatial concepts and craftsmanship to reflect local character, not superficially imitate it.

5.2 Findings

The results show that indigenous architecture offers practical solutions to some of the problems of modern housing, such as energy consumption, environmental degradation, affordability and loss of cultural identity. The examples from KwaZulu-Natal and Kurdistan show that vernacular systems are not primitive alternatives, but rather evolved responses to the environment and social adaptation.

This study is an extension of the previous studies on vernacular architecture, as it moves beyond the individual regional study to a comparative study between two geographically distant but conceptually related contexts. It emphasizes that the principles of sustainability that are inherent in indigenous architecture can be transferred if they are interpreted in line with the local climatic, cultural and technological context.

The practical implication of this research is that the indigenous knowledge can be used as a tool for sustainable housing development by architects, planners and policy makers. The use of vernacular principles in modern design can help to create affordable, climate-friendly, and culturally relevant housing solutions, while also minimizing the reliance on energy-intensive construction methods.

6. Conclusion

Summary of Key Findings: This study examined the possibility of the contribution of indigenous building techniques to the sustainable housing of the contemporary era by comparing the indigenous building techniques of KwaZulu-Natal, South Africa, and the Kurdistan Region of Iraq. The study

shows that vernacular architecture is a complex knowledge system that has been continuously created by the adaptation process between community and environment, and the available resources. Indigenous techniques are not relics of bygone building methods, but rather offer important lessons for today's issues of energy use, environmental sustainability, housing affordability, and cultural identity.

The comparative analysis showed that although the climate and geographical conditions differ, both the indigenous housing systems in KwaZulu-Natal and Kurdistan have similar sustainable principles. Both traditions illustrate high levels of climate responsive design, use of locally available materials, passive environmental strategies, and community oriented spatial organization. These parallels validate the idea that indigenous architecture emerges from a profound knowledge of the local environmental context and that the principles of indigenous architecture can be transferred to contemporary housing design.

The study also revealed that climatic and cultural contexts had significant differences, however. The traditional Zulu house adapts to the warm and humid climate by using lightness, natural ventilation, shading and social organization of the settlement. On the other hand, vernacular houses in the Kurdish region respond to cold mountainous conditions by using compact form, thick stone walls, thermal mass, solar orientation and protection from harsh winds. These differences highlight the need for sustainable housing solutions to be tailored to the environmental and cultural context rather than relying on universal design approaches.

The study emphasizes the significance of indigenous materials and construction skills in minimizing environmental effects. The use of earth, stone, timber and other locally available materials minimises embodied energy, promotes local economies and improves the connection between buildings and their environment. However, the results suggest that the integration of indigenous concepts into modern housing must be a hybrid approach, incorporating indigenous concepts with contemporary technologies, better building standards, and modern construction needs.

The proposed integration framework shows how indigenous knowledge can be applied to four key aspects of modern housing development: environmental performance, material sustainability, cultural continuity, and technological innovation. The principles of passive ventilation, thermal mass, solar orientation, local materials, community-oriented planning, and culturally appropriate spatial concepts can be reimagined in contemporary housing systems to create more resilient and sustainable results.

Contribution of the Study: The study builds on previous research by going beyond the documentation of individual vernacular traditions and creating a comparative understanding of indigenous housing principles in two far-flung cultural and climatic settings. It shows that sustainability principles that are part of indigenous architecture are not confined to a particular region, but can be generalized when suitably adapted to local conditions.

Recommendations for Future Research: The results indicate that indigenous knowledge is a valuable resource for architects, planners and policy makers in future housing strategies. The development of contemporary housing should not be a replacement of traditional knowledge by standardized industrial solutions, but rather a combination of traditional knowledge and proven indigenous principles with modern technologies to produce environmentally responsive, economically viable, socially relevant and culturally relevant housing.

Further research is needed to explore the technical performance of hybrid indigenous-modern construction systems using simulation, post-occupancy evaluation and experimental prototypes. These studies can offer quantitative data on energy performance, construction costs, durability, and user satisfaction, which can help to promote the use of indigenous principles in sustainable housing development.

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CRediT author statement
Detail the specific contributions of each author in their respective sections. After adding the individual contributions please include the statement to the end of your text in this section: "All authors have reviewed and approved the final version of the manuscript."

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