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Integrating Vernacular Architecture into Sustainable Urban Housing: A Prototype Design for Resilient Communities in Afghanistan's Terrace Areas

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Abstract

In Afghanistan, vernacular dwellings are constructed to align with site-specific conditions, cultural practices, and available resources, addressing the daily needs of Afghans and resolving challenges in their lives. However, rapid urbanization and modernization pose a significant threat to this cultural identity, raising concerns about the loss of heritage and sustainable growth prospects for future generations. This research posits that the principles of Afghanistan's vernacular architecture can be effectively integrated into sustainable residential development to restore and preserve cultural identity. Recent studies underscore the negative consequences of neglecting vernacular architecture, particularly on health, culture, and the environment. This study aims to address this gap by examining how Afghanistan's traditional housing can enhance socio-cultural sustainability in contemporary urban development. The research is structured into three phases and employs a mixed-methods research design, including desktop surveys, interviews, local case study observations, and on-site sketches. Based on the socio-cultural attributes identified in this study, a prototype housing design was developed for Afghanistan's mountainous urban areas. The study proposes nine sustainability attributes, supplemented by expert input, which inform 58 design recommendations. Modular construction is advocated for its efficiency, with the potential to provide shelter for 8 million refugees and disaster victims while preserving cultural and environmental identity, reducing ecological impact, and promoting tourism in Afghanistan. In conclusion, the integration of vernacular architectural principles into urban housing offers a pathway to safeguarding Afghanistan's cultural legacy, attracting tourism, and fostering resilient communities.

Keywords: Cultural Identity Preservation, Prototype Design in Afghanistan, Resilient Communities, Socio-Cultural Sustainability, Vernacular Architecture.

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1. Introduction

Houses embody cultural practices, traditions, customs, climatic conditions, religious beliefs, economic factors, and locally available materials and construction techniques. In Afghanistan, residential buildings are designed to align with local climates, site conditions, cultural values, and economic capabilities, offering practical solutions to housing needs. The country's unique geographical location has fostered diverse architectural styles across its regions, reflecting its rich and varied history. Afghan architecture has been influenced by Zoroastrian, Buddhist, and Islamic traditions [1], [2]. Afghanistan's arid continental climate, characterized by significant seasonal variations in precipitation and temperature [3], further shapes its indigenous architecture, which adapts to the distinct climatic conditions of its diverse regions.

The evolution of vernacular architecture has been shaped by various factors, particularly the availability of local materials, which significantly influenced building forms and layouts [1], [2]. For instance, traditional homes in regions like Nuristan, Panjshir, Kunar, and Badakhshan were predominantly constructed using stone sourced from nearby mountains. In contrast, the central and border regions of Afghanistan, where stone was scarce and suitable timber for construction was limited, relied on mud, sun-dried bricks, and readily available forest tree trunks and branches for roofing (Fig.1).



Fig. 1. The images illustrate locally available materials used in construction. A) A surviving section of an ancient street in Kabul, where buildings have not received any rehabilitation attention [4]. B) Workers lifting woven mats onto the roof of a newly constructed primary school [2].

One of the most distinctive features of Afghanistan's traditional rural architecture is its use of decorative motifs and patterns. Traditional clay buildings often incorporate specific forms and ornaments, adhering to Islamic principles that prohibit the depiction of human or animal figures. Instead, walls are adorned with floral patterns, tree designs, and Islamic calligraphy [5], [6]. While exterior decoration is minimal in the near-central regions, with most ornamentation reserved for indoor spaces, the southern regions frequently use lime for embellishment. Additionally, the main doors of homes are sometimes painted in contrasting colors to create visual emphasis (Fig. 2).



Fig. 2. Afghanistan capital Kabul: The Asheqan-Wa-Arefan district's historic suburb undergoes restoration of its old homes [7]. A) Interior design, B) Exterior Design.

Vernacular architecture, characterized by using local materials and traditional knowledge, is typically constructed without the involvement of professional architects. It addresses local housing needs while reflecting the cultural, historical, and environmental context of its creation. Often referred to as "local architecture," it embodies the accumulated wisdom and knowledge of Afghan ancestors over centuries. Sustainability, on the other hand, focuses on implementing measures to ensure environmentally responsible living for future generations. By integrating vernacular principles into contemporary housing, Afghanistan can preserve its cultural heritage while advancing sustainable development.

1.1. Geographical Location of Afghanistan

Afghanistan, a mountainous and landlocked nation spanning 652,864 square kilometers, is strategically located in the heart of the Asian continent, straddling the Northern and Eastern Hemispheres. It shares borders with Iran to the west, Pakistan to the south and east, Tajikistan, Uzbekistan, and Turkmenistan to the north, and China to the northeast (Fig. 3) [8]-[12].

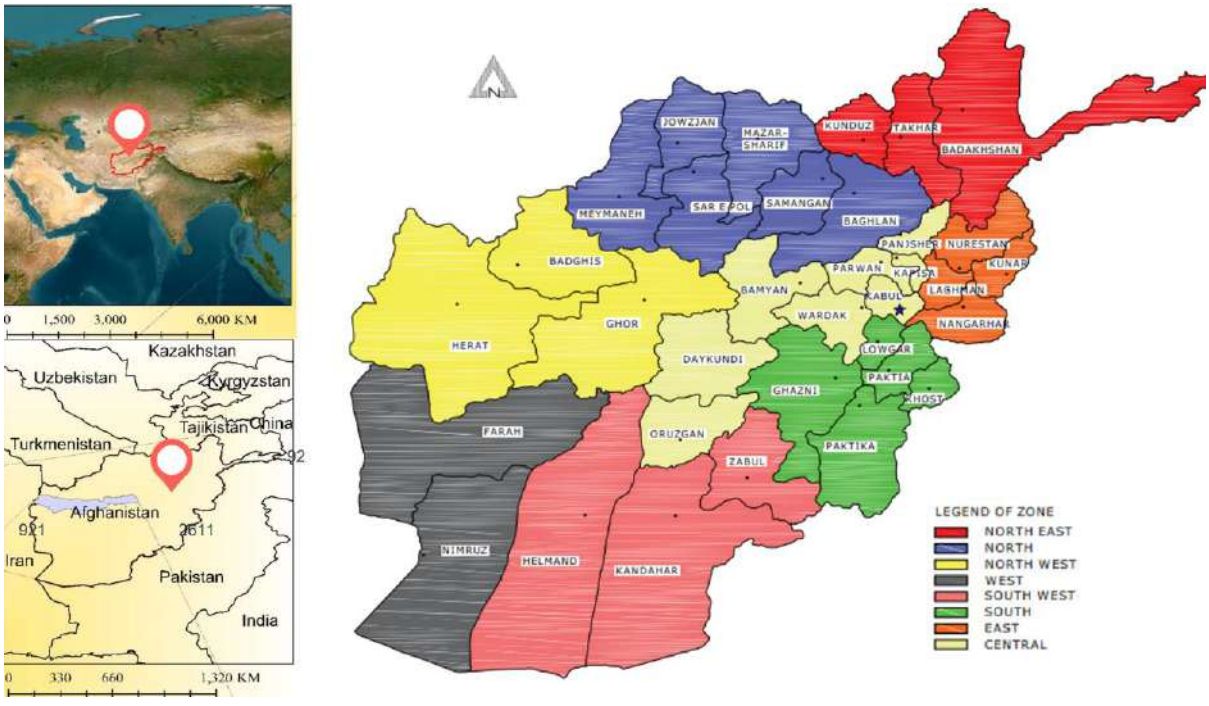


Fig. 3. Presents Afghanistan's geographical location and Map with 8 regions (Source: Google Earth and Author edit).

2. Literature Review

Physical surroundings significantly influence human behavior and needs. Built environments are not merely backdrops for human activity but are deeply intertwined with behavioral patterns, shaping habits and being shaped by human choices in materials and ethics [13]-[15]. Research indicates that many customs and beliefs, which form the core of cultural and social identities, are being eroded due to modern living conditions in older cities. This shift negatively impacts residents' behaviors and raises concerns about their quality of life [13].

Buildings reflect their environmental and cultural contexts, revealing the resources and values of the time and place they were constructed. Traditional architecture, once a fundamental response to human needs, has been overshadowed by contemporary designs. However, rising energy costs have revived interest in regionalism and traditional structures, which are proven to be energy-efficient and environmentally sustainable [16]. Historically, people in harsh climates used locally available materials to create resilient structures. In contrast, modern construction methods, while durable, generate significant waste. For instance, demolition, construction, and land excavation waste totaled 20.4 million tons in 2017, with commercial buildings also consuming substantial energy [17]. Amid rapid technological and urban development, vernacular architecture offers valuable lessons in sustainability. Traditional communities have seamlessly integrated sustainable practices into their daily lives, providing a timeless model for modern architecture [18]-[20]. Vernacular architecture not only embodies the culture, era, and location of its creation but also prioritizes sustainability, ensuring environmentally friendly lifestyles for

future generations. Its uniqueness lies in its adaptability and resourcefulness. Notably, Amos Rapoport's 1995 statistic highlights that only a small fraction of new buildings are designed by architects, with 95% of the global built environment consisting of vernacular architecture [21], [22].

Vernacular architecture relies on local materials and knowledge, often constructed without professional oversight. It includes diverse styles, customs, and practices, typically emphasizing practicality and functionality. In the Middle East, for example, vernacular architecture integrates cultural values into sustainable designs, reflecting local environments, lifestyles, and traditions. These methods were simple, effective, and eco-friendly, particularly in regulating indoor temperatures [19], [20], [23].

In summary, vernacular architecture is defined by its use of traditional resources, knowledge, and community-driven needs. It represents a built environment that embodies identity, legacy, civilization, and religious practices. To further explore this concept, the following definitions are examined:

2.1. Vernacular Architecture

Vernacular architecture refers to building practices that utilize locally sourced materials and traditional construction techniques, often developed without formal architectural training. It emphasizes sustainability, cultural relevance, and adaptation to local environmental conditions. This type of architecture represents the majority of pre-industrial structures worldwide, reflecting the customs, climate, and resources of a specific region [24], [25]-[29]. Notable architects like Norman Foster and Richard Rogers highlight its focus on local traditions, community needs, and environmental responsibility, making it a valuable model for sustainable design [30]-[32]. Vernacular architecture is deeply rooted in its context, integrating social, cultural, and environmental factors into its design [33], [34].

2.2. Urban Housing

Urban housing encompasses residential structures in densely populated areas, typically within 10 miles of a city with over 30,000 residents [35]. It includes apartments, townhouses, and suburban homes, providing shelter while facilitating access to employment, social services, and community networks [36]-[40]. Urban areas, derived from the Latin term "urbs" (city), are characterized by high population density and non-agricultural economies [37], [38], [39]. Towns, often considered smaller urban centers, bridge the gap between villages and cities, with populations ranging from 2,500 to 20,000 [37], [40].

2.3. Social and Cultural Sustainability

Social sustainability focuses on improving quality of life, equity, and community well-being, while cultural sustainability emphasizes preserving cultural heritage, diversity, and identity. Together, they form a foundation for sustainable development, recognizing the interdependence of human rights, cultural values, and environmental stewardship [41]-[44]. Cultural sustainability enriches economic and environmental efforts by fostering creativity, social cohesion, and intergenerational knowledge transfer [45]-[48]. Protecting

cultural wealth and ensuring its adaptive use for future generations are central to this dimension [49]-[57].

2.4. Vernacular Architecture Principles

Vernacular architecture is guided by principles of functionality, adaptability, and sustainability. It prioritizes practical solutions over aesthetics, utilizing local materials and traditional techniques. The design evolves through the accumulated knowledge of local builders, reflecting social, cultural, and environmental contexts. These structures often incorporate bioclimatic features, such as passive cooling and heating, to enhance energy efficiency and minimize environmental impact. Vernacular architecture serves as a culturally rich and ecologically responsible approach to building design [34], [35], [58], [59].

2.5. Sustainability Demystified

Sustainability aims to meet present needs without compromising future generations' ability to meet their needs [60]. It encompasses four interrelated dimensions: environmental, economic, social, and cultural [61], [62], [63]. These dimensions influence and depend on one another, requiring a holistic approach to balance trade-offs and synergies [64]. While this research focuses on the socio-cultural dimension, it acknowledges the interconnected nature of all four pillars (Fig. 4).

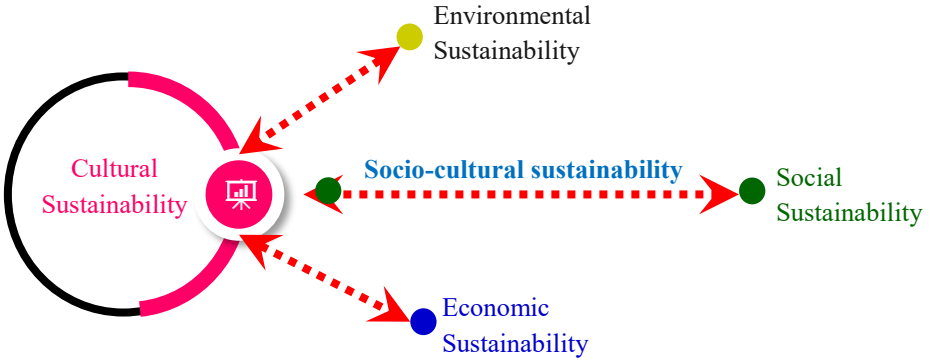


Fig. 4. A diagram illustrates the four dimensions of sustainability and their interconnected and interdependent relationships (Source, Author).

2.6. Social Dimension of Sustainability

The social dimension emphasizes human well-being, equity, and inclusion. It addresses access to basic amenities, education, healthcare, and social justice, fostering community resilience and cohesion [62], [63]. By empowering marginalized groups and promoting diversity, social sustainability enhances quality of life and strengthens societal bonds [65]-[67].

2.7. Cultural Dimension of Sustainability

Cultural sustainability preserves and promotes cultural diversity, heritage, and identity. It integrates cultural values into development policies, fostering creativity, innovation, and intercultural dialogue [63]. This dimension supports local economies, enhances well-being, and strengthens social capital, making it a vital component of sustainable development [68]-[71].

2.8. Lessons from Vernacular Architecture for Modern Design

Vernacular architecture offers valuable insights into modern sustainable design. Its emphasis on local materials, passive energy strategies, and cultural relevance aligns with contemporary goals of reducing environmental impact and enhancing community well-being. By studying vernacular practices, architects can adapt traditional techniques to address global challenges like climate change, housing shortages, and economic inequality [72]-[75]. Kenneth Frampton and Paul Oliver highlight its potential to inspire innovative, culturally sensitive, and environmentally responsible solutions, particularly in resource-constrained settings [76]-[82]. Therefore, this research explores Afghan vernacular architecture to identify lessons applicable to modern residential development.

2.9. Vernacular House Forms in Afghanistan

Historically, Afghan people have constructed low-rise vernacular shelters using locally available materials, designed to meet cultural, climatic, and religious needs. These structures are environmentally and culturally sustainable, reflecting local traditions and contextual considerations. Afghan vernacular housing can be categorized into two main types: houses with courtyards and those without (Fig.5). These architectural variations reflect the adaptation to different topographical and environmental conditions within the same village.

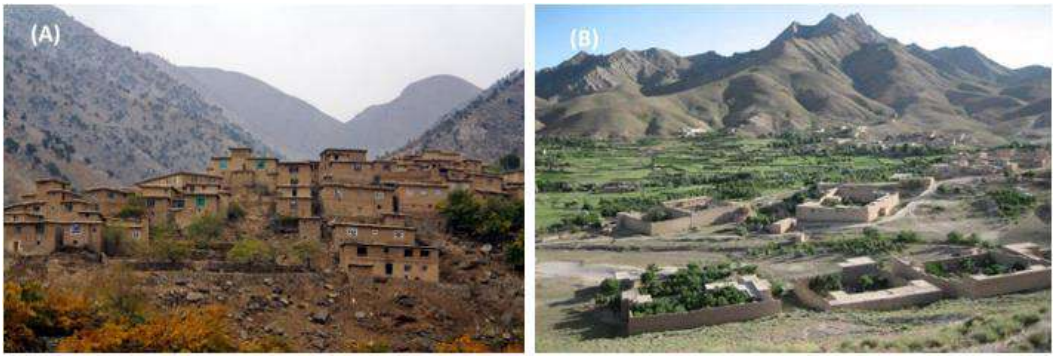


Fig. 5. illustrates two distinct types of vernacular houses in Tamaki village, located in the Karabagh region of Ghazni province, Afghanistan. (A) Depicts houses without courtyards, constructed on mountain slopes, while (B) showcases courtyard-style vernacular houses [83].

Courtyard houses are the most prevalent, particularly in rural and urban areas across Afghanistan. They are also common in neighboring countries such as Iran, Tajikistan, Uzbekistan, Turkmenistan, as well as in border regions of Pakistan like Waziristan and Khyber Pakhtunkhwa. These houses feature an open-air space enclosed by boundary

walls, which often form part of the main structure. The walls, typically rectangular or square, provide privacy while allowing natural light and ventilation. Courtyard houses are found in both flat and mountainous regions, as illustrated in Fig. 5B.

In contrast, houses without courtyards are less common and are primarily located in mountainous areas such as Kabul, Bamiyan, Daikundi, Jawzjan, and Nuristan, as well as in specific districts of the Hazara tribe in Ghazni province. These structures, typically built on mountain slopes (see Fig. 5A), lack boundary walls and are less prevalent in neighboring countries. Both housing types exemplify the adaptability of Afghan vernacular architecture to diverse geographical and cultural contexts.

Figs. 6 and 7, illustrate the distribution of all nine types of vernacular house forms across Afghanistan's eight provincial zones. The country is divided into these eight regions, each characterized by distinct vernacular architectural styles, with a total of nine house forms commonly observed throughout these zones.

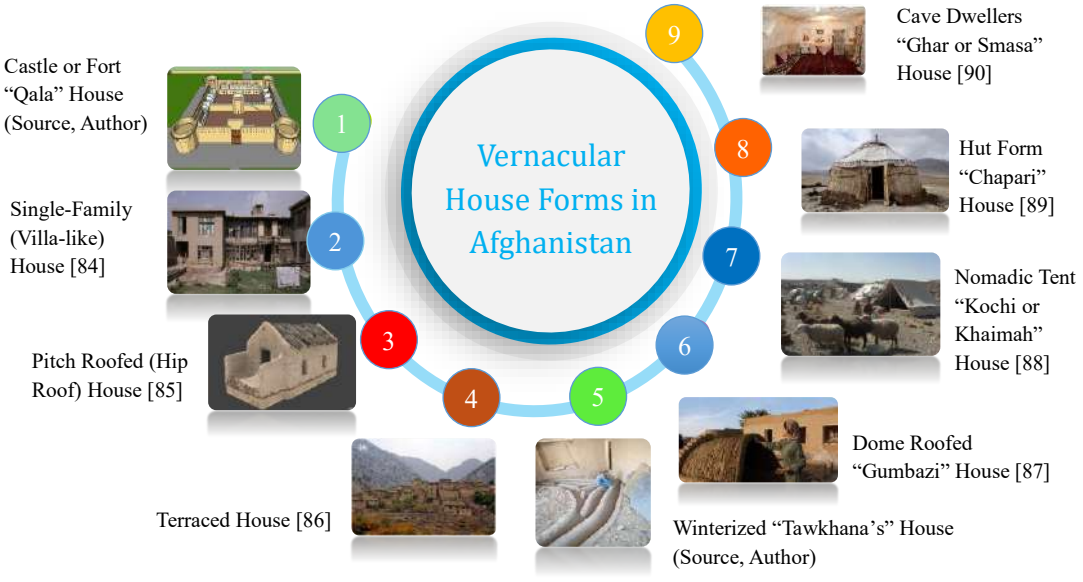


Fig. 6. The figure illustrates the 9 distinct types of vernacular house forms identified across all 8 regions of Afghanistan, as documented through literature review and field observations (Source, Author).

The design, form, and shape of Afghan vernacular houses are shaped by a combination of social, cultural, economic, and environmental factors. These include the geological characteristics of the land, locally available construction materials, soil composition, terrain slope, vegetation, structural elements, and climatic conditions. Additionally, the arrangement of interior rooms directly influences the exterior form and shape of these dwellings, reflecting a harmonious integration of functionality and regional context.

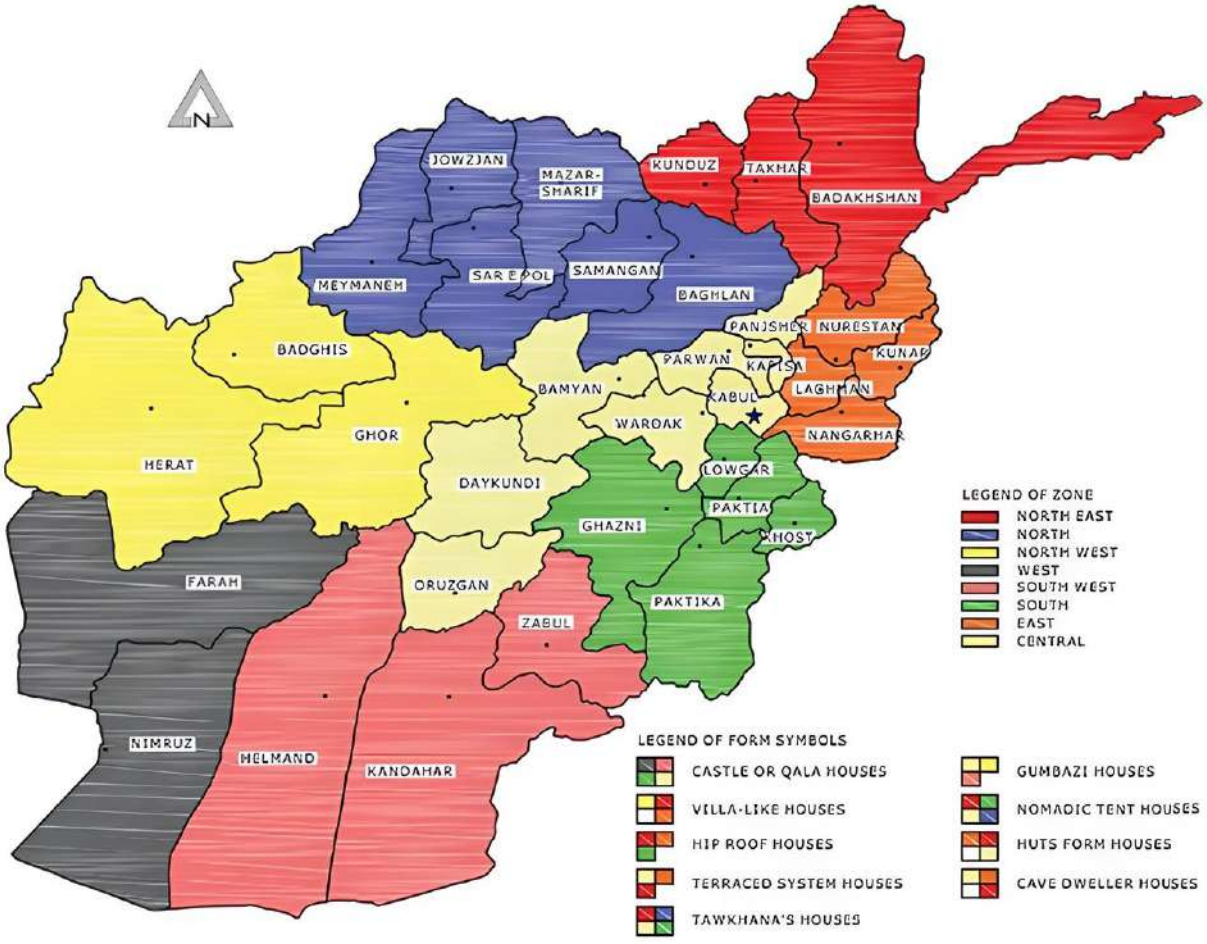


Fig. 7. Map of Afghanistan depicting 8 regions with 9 distinct vernacular house forms. The map illustrates the geographical distribution of these architectural types across the country, highlighting the location of each zone and its corresponding vernacular architecture (Source, Author).

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3. Problem Statement, Research Gap, and Objectives

Afghanistan is undergoing rapid transformation due to urbanization and modernization [91], [92], leading to the erosion of traditional lifestyles and socio-cultural identity in rural areas. Over four decades of conflict have exacerbated this shift, causing massive displacement from rural to urban centers in search of security and economic opportunities [93]. This migration has resulted in the proliferation of informal settlements and the adoption of foreign construction styles, which undermine local architectural identity and

pose significant social, cultural, economic, and environmental challenges for urban housing. In particular, the urban landscape has been dramatically altered over the past two decades, necessitating a re-evaluation of housing strategies to preserve cultural heritage and promote sustainability.

Vernacular architecture offers a potential solution to these challenges. Studies suggest that Vernacular architecture principles can foster socio-cultural sustainability and environmentally conscious urban development. However, research on the social and cultural sustainability component of Vernacular architecture in Afghanistan remains limited. For instance, [94] identified compressed earth blocks (CEB) as the most effective technique for mud brick construction in Kabul, with an optimal wall thickness of 505mm, while [95] highlighted sustainable architecture as a viable solution for reducing environmental pollution and enhancing building satisfaction. Additionally, [96] demonstrated that passive design strategies, such as courtyard layouts, wind-catching structures, and strategic window placement, can significantly reduce energy consumption in buildings. Despite these insights, there is a notable gap in the literature regarding the application of Vernacular architecture principles to contemporary urban housing in Afghanistan to achieve Social and cultural sustainability.

This study aims to address this gap by analyzing the role of Vernacular architecture in achieving social and cultural sustainability in Afghan urban housing. It seeks to develop design guidelines and a framework based on Vernacular architecture principles to inform future research, policy-making, and urban planning. This aim will be accomplished through the following steps:

- Through the literature review and analysis of the impact of social and cultural factors on various types of vernacular house forms in Afghanistan, assessing both the benefits and drawbacks of Vernacular architecture in residential development.
- Through the interviews with experts, to investigate how socio-cultural sustainability can be realized in Afghan residential development by applying lessons derived from vernacular architecture.

4. Significance of the Study

Afghanistan's rapid urbanization and modernization have led to a loss of cultural identity, making this research critically important. By demonstrating how vernacular architecture can inform contemporary housing design, this study contributes to the preservation of cultural heritage and the promotion of socio-cultural sustainability. While existing literature has explored aspects of Afghanistan's native architecture, there is a lack of focus on implementing Vernacular architecture principles in modern residential development. This study fills that gap by developing design guidelines and a framework based on Vernacular architecture, offering valuable insights for researchers, policymakers, architects, urban planners, and municipal administrators striving to create sustainable housing solutions in Afghanistan.

5. Methodology

To achieve the study's objectives, the authors structured their methodology into 3 distinct phases. Data collection was conducted through a combination of research methods, including a review of up-to-date literature, site observations, in-depth interviews, photography, and drawings. A prototype of a socio-cultural urban community model was developed to examine whether the attributes of vernacular architecture positively influence socio-cultural aspects in contemporary residential development in Afghanistan (Fig. 8).

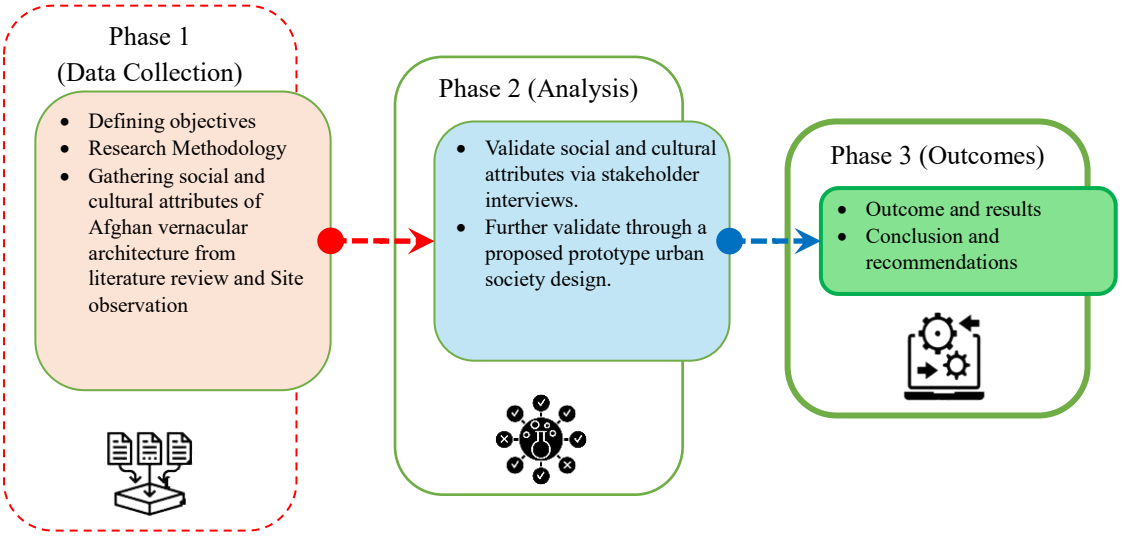


Fig. 8. Research Methodological Framework. This figure provides a graphical representation of the interconnected phases employed in this study.

Phase 1: In this phase, the research aim, objectives, and methodology are formulated to provide a clear direction for the study. This step ensures that the research goals are well-defined and achievable through appropriate resources and methods. A rigorous and up-to-date literature review is conducted, focusing on the social and cultural aspects, architectural design, features, and forms of Afghan vernacular architecture. The review also examines the social, cultural, topographical, geographical, and environmental conditions influencing residential development. Key activities in this phase include reviewing previous literature, analysing local cases of residential development, and extracting social and cultural attributes from vernacular architecture. Site visits and observations are also carried out to gather firsthand insights.

Phase 2: This phase involves conducting interviews with residents, professionals, provincial municipalities, the Ministry of Urban and Regional Planning, and other relevant authorities directly or indirectly involved in residential development. Engaging with local communities and stakeholders helps to understand their needs, preferences, perspectives, and experiences regarding residential development. Furthermore, the design ideas proposed by interviewees are incorporated into a prototype model for a socio-cultural sustainable urban community, which is then validated to ensure its applicability and relevance.

Phase 3: In the final phase, the data collected from various sources, including interviews and literature, is analysed and summarized. The findings from Phases 1 and 2 are synthesized to draw conclusions about how vernacular architecture principles influence socio-cultural sustainability in residential development. A set of design recommendations is formulated to guide the achievement of socio-cultural sustainability in Afghan residential development. The outcomes of this study aim to assist architects and designers in integrating vernacular architecture lessons into sustainable residential design, ensuring that modern developments align with local cultural, social, and environmental contexts.

5.1. Interviews Procedure and Results

To advance the methodology, the authors conducted field observations and interviews in four randomly selected provinces in Afghanistan: Kabul, Ghazni, Kunduz, and Herat. Semi-structured interview questions, developed through a literature review, were organized into 6 sections. Based on the responses, 58 design principles were identified and integrated into the framework presented in Fig. 10.

Initially, in-depth face-to-face interviews were planned to use semi-structured questions. However, due to accessibility challenges, some interviews were conducted online via email, WhatsApp, Facebook Messenger, Zoom, and phone calls. The process involved sharing field survey photographs with participants during interviews to gather their insights. To achieve saturation, proposed solutions from the first 10 interviews were analysed and shared with the subsequent 14 interviewees for feedback. After their approval, additional design principles were incorporated based on expert input. Saturation was reached after 24 interviews (22 analysed, 2 excluded) (see Fig. 9), as recurring design ideas emerged, prompting the conclusion of data collection.

Participants included experts, architects, urban planners, municipality managers, practitioners, architecture and construction firms, residents, and university professors (three Afghan nationals who were international experts from Washington State University, Oxford University, and Hiroshima University). Engaging these stakeholders provided diverse perspectives on residential development needs, preferences, and experiences.

The collected data, including recorded interview responses, were analysed and synthesized to establish a framework for developing a green and socio-culturally appropriate housing prototype. This section outlines the findings and their implications for the proposed design framework.

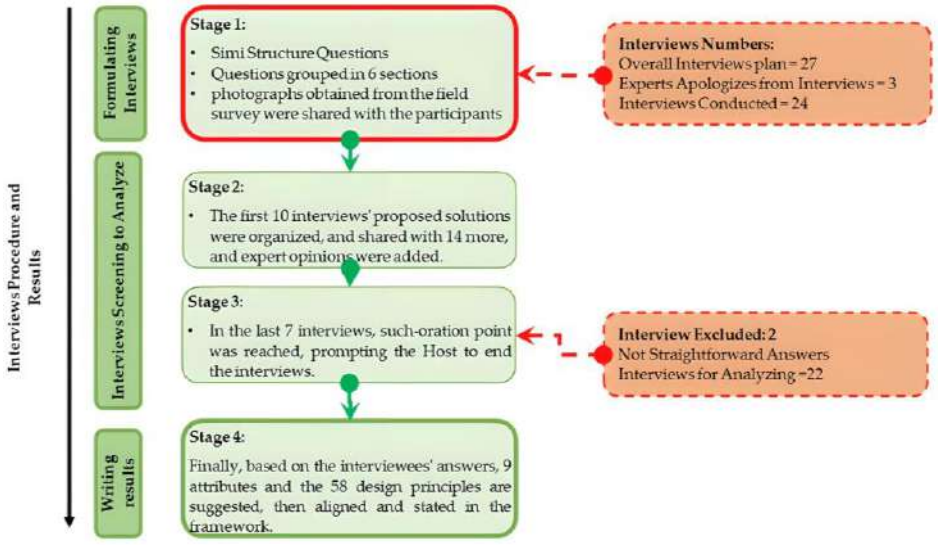


Fig. 9. illustrates the workflow of the interview procedure and results in this study.

6. Results and Discussion

6.1. Comparison of Socio-cultural sustainability indicators

Based on the literature review and participant feedback, 9 socio-cultural sustainability indicators for urban housing were identified, with an additional indicator of cultural adaptation, which is proposed by interviewees. The framework highlights those interviewees suggested 1 extra indicator beyond the literature review findings, while also aligning with 2 existing indicators: 1) dense neighborhood and social bonding, and 2) entertainment and interaction. Notably, both the literature review and site visits identified the same 9 attributes for Afghan vernacular houses' socio-cultural aspects. Table 1 compares these findings, revealing that 8 attributes from vernacular architecture could inform Afghanistan's urban housing planning to achieve socio-cultural sustainability. Interviewees emphasized the importance of incorporating cultural adaptability in design to preserve local identity.

Table 1. Comparison of socio-cultural sustainability principles in Afghan vernacular architecture, as reported by interviewees and literature review.

Indicators were proposed based on the interviewer's expertise	**Indicators based on literature review**	
• **Heritage Preservation and Restoration**	• Values	Sources: [84], [85], [87]-[90], [96]-[103].
• **Influence of Islam on behavior and ethics**	• Religion	
• **Social adaptability**	• Behavior	
• **Privacy**	• Privacy	
• **Security**	• Security	
• **Courtyard design**	• Family gathering place	
• **Walkability promotion**	• Motivation to walkability	
• **Community or social Integration**	• Dense neighborhood and social bonding • Entertainment and interaction	
• **Cultural adaptability**	• X	

Table 1 presents a comparative analysis of findings from the literature review, validated through site visits and aligned with principles suggested by interviewees. The nine indicators proposed by experts aim to promote urban social and cultural sustainability across Afghanistan rather than being specific location. These indicators serve as universal guidelines for achieving durability in urban housing throughout the country.

6.2. Framework of Design Principles for Socio-Cultural Sustainability

The proposed framework, illustrated in Fig.10, synthesizes 58 sustainability features derived from expert interviews. These features are intended to guide contemporary urban housing development in Afghanistan, ensuring socio-cultural sustainability and preserving local identity for future generations.

As illustrated in Fig. 10, the interviewers proposed a comprehensive framework of 58 design components to achieve socio-cultural sustainability in Afghanistan. These components are categorized into four groups: Group (A) with 15 principles, Group (B) with 16, Group (C) with 9, and Group (D) with 18. These principles, reflecting attributes of Afghan vernacular architecture (Table 1), were developed based on interviewee expertise and are adaptable to modern urban residential zones.

6.3. Developing a Socio-Culturally Sustainable Housing Prototype for Afghanistan's Mountainous Areas

This section presents a prototype model for socio-culturally adaptable housing in Afghanistan's mountainous regions, addressing 58 aspects proposed by interviewees to achieve socio-cultural sustainability. The prototype serves as a practical tool to evaluate the effectiveness of these principles in creating a living environment that preserves and promotes Afghan cultural traditions.

Mountains constitute approximately 80% of Afghanistan's land area [104], as depicted in Fig. 11. By incorporating the proposed design principles (illustrated in Fig. 10) into terrace housing, the model aims to enhance socio-cultural sustainability while ensuring suitability for urban mountainous areas. Additionally, prioritizing mountainous regions for residential development and reserving flatlands for agriculture and commerce supports economic and environmental sustainability. This approach aligns with the goal of fostering sustainable communities in Afghanistan's urban mountainous regions.

Skylar [106] emphasizes integrating sustainability into design principles by prioritizing economic viability, ecological integrity, social equity, cultural diversity, and interdependence. This holistic approach ensures projects are financially feasible, preserve natural systems, respect human rights, embrace cultural influences, and recognize interconnectedness. By balancing social, cultural, economic, and environmental dimensions, sustainable design fosters a durable and harmonious future [106]. The author incorporated these principles into their model during the design phase.

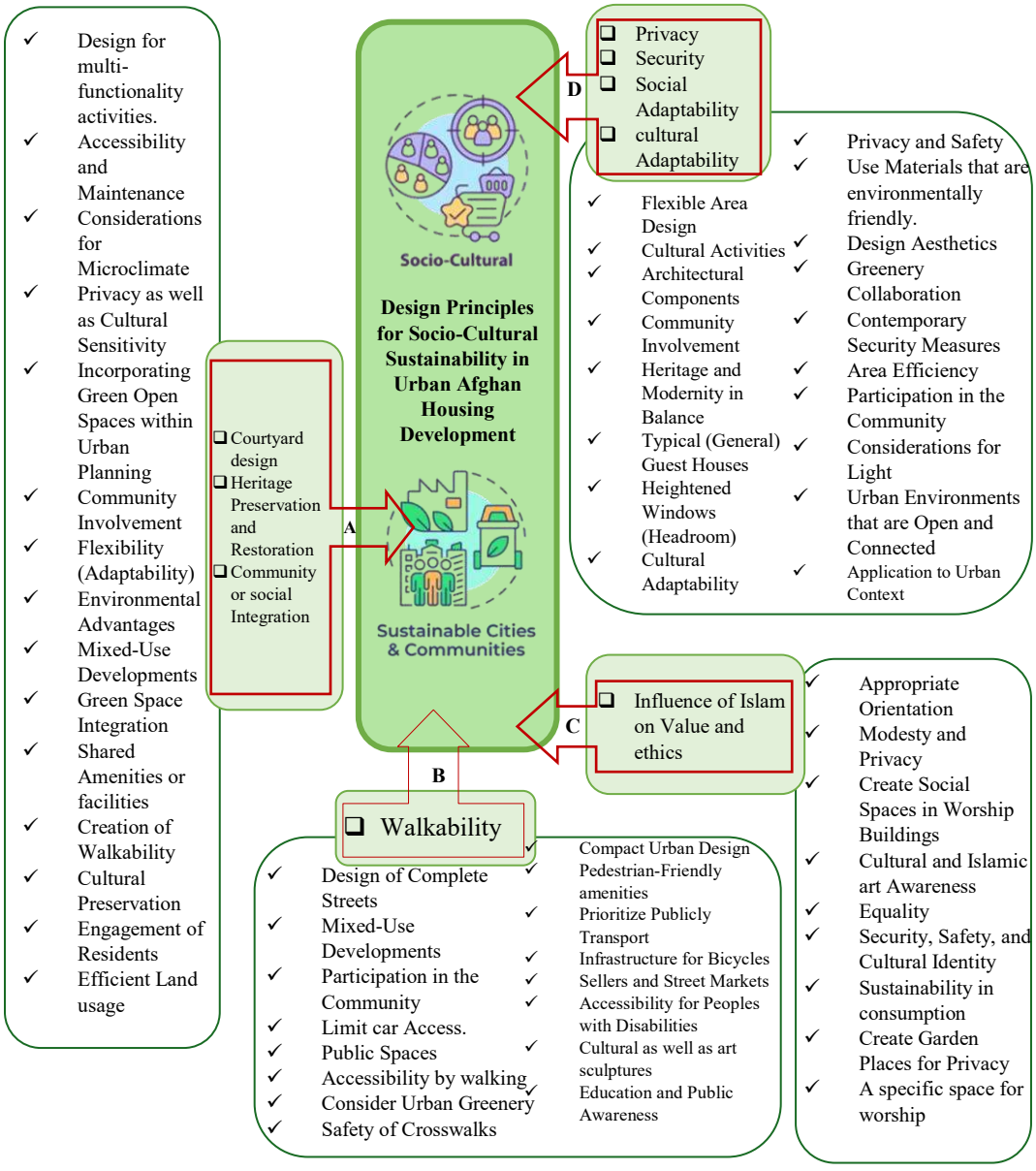


Fig. 10. presents a framework of 58 design principles for sustainable housing growth in urban Afghanistan, as identified by interviewees, aimed at achieving socio-cultural sustainability.

The socio-cultural environment of housing in Afghanistan is significantly influenced by factors such as ethnicity, religion, family structure, gender roles, social gatherings, privacy, safety, and urbanization. These elements shape housing design, spatial organization, material selection, and functionality, as well as residents' social interactions and daily activities. For instance, many homes feature segregated spaces for men and women, or for guests and family members, to comply with Islamic principles of privacy

and modesty. Additionally, houses often incorporate courtyards, gardens, or terraces, which serve multiple purposes, including natural ventilation, cooling, aesthetic enhancement, and the cultivation of vegetables for daily needs (based on literature and site observations).

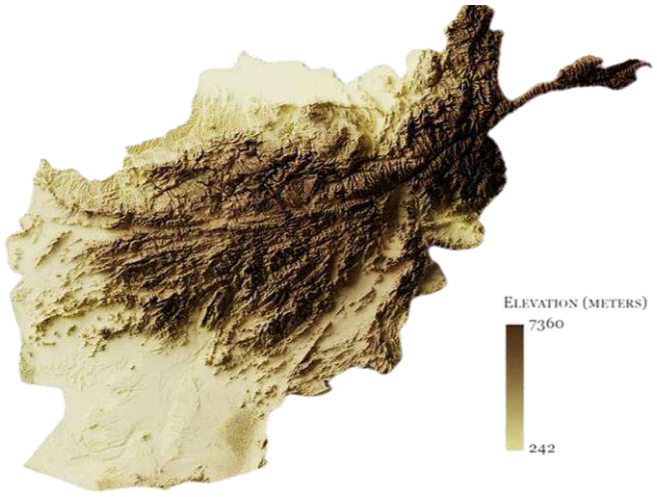


Fig. 11. represents the relief map topography of Afghanistan [105].

6.4. Typical floor Plan layout for the Proposed housing

Blended families are common, but this plan targets nuclear families, primarily consisting of parents and their children, which are prevalent in urban areas and among younger generations influenced by modern lifestyles [107]. In Afghanistan, nuclear families are among the most common, though ongoing conflict and instability have hindered reliable national census data. The first official demographic census for Kabul, conducted by Dr. Mohammad Sharif Noori in 1968, revealed that most families had 6-9 members, while Soliman Osman-khil, another professor at Kabul Polytechnic University, recommended 3-5 rooms for 5-8 people [108]. By 2010, the average family size in Afghanistan was estimated at 7-8 members [109], [110]. Accordingly, this project designs a house plan for a nuclear family of 7 (Fig. 12).

Therefore, in the proposed prototype, the residential complex comprises two blocks, A and B, each with 24 vertically stacked units, totaling 48 houses. Each block functions like a duplex, with 12 dwellings on each side of a central elevator well, creating a mirrored design for side-by-side homes (Fig. 12). This mirror house concept is implemented because the main entryway for each house is located at the stairs and elevator. The design is influenced by Afghan vernacular architecture, particularly terraced housing, to promote socio-cultural sustainability. The upper house utilizes the lower house's roof as a courtyard, facilitating dense development, land conservation, and providing a social gathering space. Each family also has a private garden "Bagh" for social activities, recreation, and gardening (Fig. 12, caption 16).

Each house unit covers 243 m² (0.06 acres or 2.43 “Biswa”, where 1 Biswa = 100 m²), with 90 m² (52%) allocated to living spaces, 81 m² (48%) to the courtyard, and 72 m² to gardening and leisure. According to the Afghanistan Building Code (ABC), each level has a standard height of 3 meters, suitable for both summer and winter climates. For further details on unit specifications, refer to Table 2.

Table 2. Indicate the specifications for each typical housing unit.

Use Purposes	**Element Name**	**Length (m)**	**Width (m)**	**Area (m^2)**	**Area (Biswa)**	**Area (Acre)**	**Total area (m^2)**
Living	Residential area (rooms)	10	9	90	0.9	0.022	171
	Courtyard	9	9	81	0.81	0.020	
Entertainment	Garden	9	8	72	0.72	0.018	72
Connectivity	stairs	14.5	1.65	23.92	0.239	0.006	60.17
	Elevator (for 28-30 persons)	3.6, elevator-well 14.5	2.5	36.25	0.362	0.009	

Table 2 indicates that each family’s residence comprises a total area of 243 m², with 171 m² allocated for living space and 72 m² for social gatherings and entertainment. A 60.17 m² area serves as a connecting pathway between houses on the same level. Fig. 12 illustrates the design elements, including straight-run stairs (1) representing walkability and connectivity, and an angled elevator (3) designed to assist disabled and elderly individuals, as well as transport large equipment. According to [111], the elevator measures 3.6m in length and 2.5m in width, with a capacity to lift 4000 lb (1815 kg), equivalent to 28-30 people simultaneously.

Each house features a private entrance (2) connected to both the elevator (3) and stair landing (1). Upon entry, users access the guest hallway (5), locally termed "Dallan" or "Gholay," leading to the guest chamber "Hujra" or "Milmastoon" (7), which ensures privacy by separating family members from guests. The guest chamber includes a personal toilet (9). From the hallway (5), residents can access the central corridor (6), which connects to various spaces, including two master bedrooms (8). The north-facing bedroom is ideal for summer naps, while the south-facing bedroom is suited for winter warmth, reducing internal migration within the house. These rooms can also accommodate children. Each bedroom includes an inner bathroom (10) and an exit door (17) leading to an open-to-sky garden ("Bagh"), used for gardening, recreation, or family gatherings.

The central corridor (6) further connects to additional spaces, such as the general restroom (9), kitchen (11), dining area (12), living room or sun place "Petawi-zay" (14), and prayer area (13). The living room (14) is fully glazed to maximize daylight and solar heat during winter, with direct access to an open-to-sky terrace (15), offering panoramic views. The prayer area (13) is strategically positioned to align with the qibla direction, adhering to Islamic and Afghan cultural practices, ensuring users do not pass in front of worshippers or face the qibla while sleeping. Similar considerations apply to the placement of toilets

(9) and restrooms (9), which include small windows to vent odors while maintaining privacy. Bedroom windows face the garden, promoting ventilation and fresh air. Showers (10) in bedrooms (8) are designed to prevent unpleasant odors, enhancing comfort and functionality.

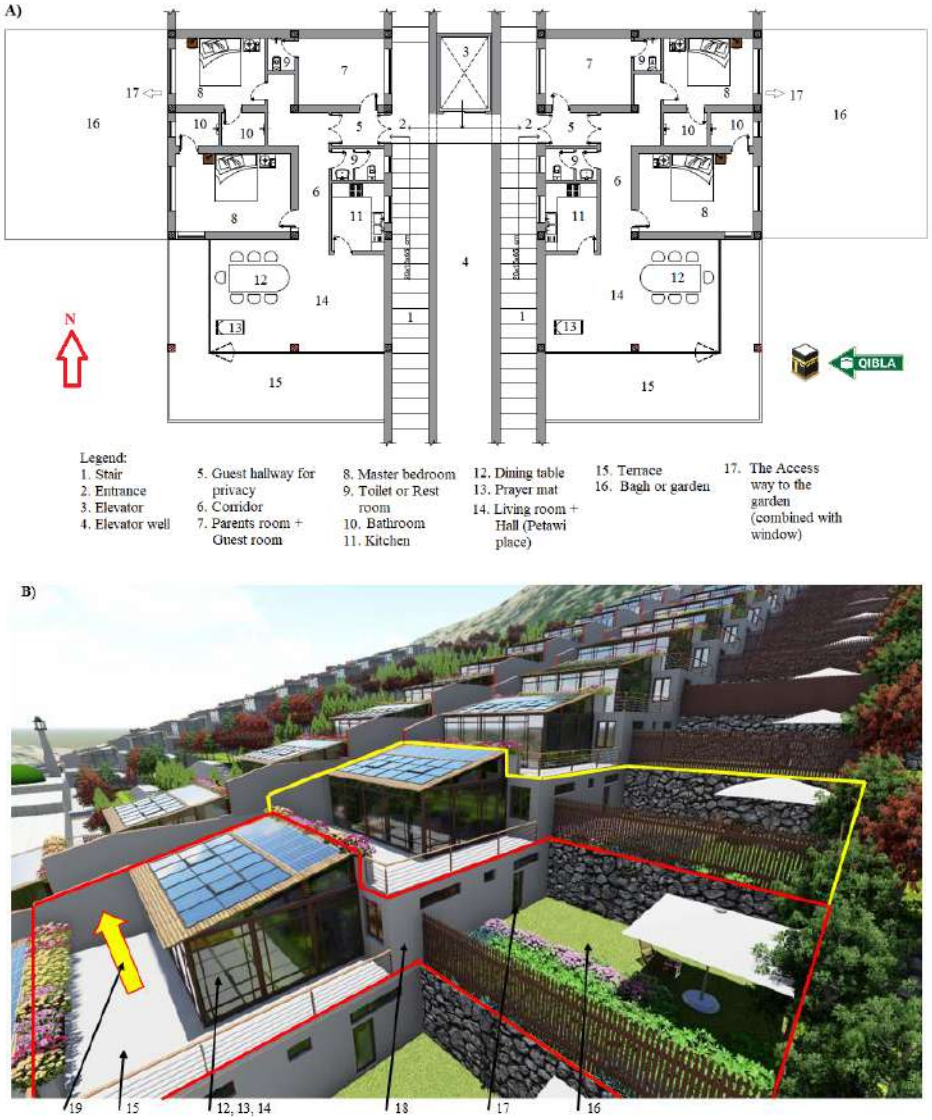


Fig. 12. The figure illustrates a typical floor plan and a 3D bird's-eye view of the 48 housing units within society. Part (A) depicts the floor plan of a representative unit, while Part (B) offers a 3D visualization of the housing units. The red and yellow lines demarcate the lower and upper unit placements, respectively. The accompanying legends detail the specifications of each space, including 18) residential areas (rooms) and 19) the Qibla direction.



Fig.13. The proposed 3D model illustrates the comprehensive layout of the society, integrating structural organization, pathways, and communal spaces.

The Fig. 13 key components include: community gardens or parks (1, 16), private gardens (17), residential blocks A and B (2, 3), a rainwater collection pond (4), commercial facilities such as supermarkets and stores (5), dedicated biking paths (6), a central mosque "Jami Masjid Sharif " (7), a communal guest house and meeting space for community leaders or “Jargas” location for consultancy (8), pedestrian-friendly infrastructure, including sidewalks made of local mountain stone and permeable pavements (11, 15), safe crosswalks or zebra crossings (14), vehicle routes and garage access points (10, 12, 13), and the main entrance to the community garden (9). This design emphasizes sustainability, safety, and community interaction.

One key principle is the design of multi-functional spaces. Courtyards and private gardens serve multiple purposes, such as family gatherings, children’s play areas, and vegetable cultivation (Fig. 12, legend 15, 16). Accessibility and maintenance are also prioritized, with courtyards and gardens designed for easy access and rotation, as indicated by red vectors in Fig. 14. Similarly, the community guest house (Fig.13, legend 8) functions as

a venue for social, cultural, and ceremonial activities, including weddings and mourning events. Microclimate considerations are addressed using vegetation, trees, and irrigation systems, which provide shade, cooling, and flood protection by channeling snow and rainwater into community ponds (Fig13, legend 1, 4).



Fig. 14. illustrates the multi-functional activity area, encompassing the courtyard and private family garden, moreover, highlighting the integration of green open spaces into urban planning.

Fig. 14 illustrates the spatial organization and functional elements of the design. On the left, the yellow square lines on the glass roofs indicate the positions of the wind catcher "Badger" openings, which facilitate ventilation while creating a sunlit space for family gatherings, and ensuring privacy. The red vectors denote the accessibility and maintenance routes for these areas. On the right, the main gate to the community gardens is depicted, with the community guest house adjacent to it. Below the guest house, supermarkets and shopping halls are designated for females to preserve privacy. To the left of the main gate, the mosque is situated, with corresponding male-only supermarkets and shopping halls beneath it, ensuring gender segregation. The high main gate of the community garden connects to the public, enabling access for individuals from nearby towns to utilize the park.

Furthermore, privacy and cultural sensitivity are ensured through features like separate guest rooms near entrances and windows facing courtyards, which respect cultural norms and enhance social harmony (Fig. 12). Additional privacy measures include high boundary walls, screening with colored glass, and tree walls (Fig. 15). Green open spaces

are integrated into urban planning to promote social and health benefits, with community parks accessible to both residents and visitors, fostering economic opportunities (Fig. 13, legend 1, 16). Community involvement is emphasized, with residents participating in the design and maintenance of these spaces, fostering a sense of ownership and responsibility. Flexibility and adaptability are central to the design, with features like movable walls and modular structures allowing spaces to evolve with changing cultural and lifestyle needs (Fig.15, legend 2). Environmental benefits are achieved through permeable pavements, green spaces, and stormwater management, which improve air quality, biodiversity, and microclimate conditions (Fig. 13, legend 1, 4, 16). Mixed-use developments combine residential, commercial, and communal spaces, encouraging social interaction and reducing the need for long-distance travel (Figs. 13 and 14).



Fig. 15. Highlights measures for privacy and cultural sensitivity.

Fig. 15 illustrates several elements designed to ensure privacy and facilitate cultural and social activities: 1) a solid high wall, 2) a social gathering or sun space "Petawi", screened by colorized glass to block external views, 3) a private family garden for gatherings, 4) trees strategically placed for privacy, 5) a cloth canopy or umbrella providing shade in summer and overhead privacy, and 6) a fence wall constructed from local wooden boards at headroom height to enclose the family garden. These features collectively emphasize privacy while accommodating cultural practices and social interactions in an Afghan society.

Walkability is promoted through pedestrian-friendly infrastructure, including green spaces, permeable pavements, and well-marked crosswalks (Fig. 13, legend 14). Cultural preservation is addressed through communal guest houses and gardens that host cultural events, such as Jargas (consultative gatherings) and wedding ceremonies, while respecting Islamic practices (Fig. 14). Resident engagement is encouraged through

participatory planning, ensuring that community upgrades reflect local preferences and cultural values.



Fig. 16. illustrates the design of pedestrian-friendly infrastructure, integrating facilities for both walking and cycling.

According to Fig. 16, the layout includes: 1) dedicated sidewalks for walking and running, 2) seating areas for public rest, 3) secure bicycle racks, and 4) cycling lane indicators to guide cyclists. This design promotes a cohesive and accessible urban environment for pedestrians and cyclists alike in the community.

Efficient land use is achieved by developing mountainous areas for residential purposes while preserving flat lands for agriculture and commerce. Compact urban designs minimize distances between essential services, promoting walkability and reducing sprawl. Shared amenities, such as community centers and grocery stores, are easily accessible, reducing reliance on vehicles and lowering carbon emissions (Figs. 12-15).

Safety and security are enhanced through measures like limiting car access, using cul-de-sac road designs (Fig. 13, legend 10, 12, 13), and incorporating modern security features such as video cameras and privacy glass. Cultural and Islamic art elements, such as prayer mats and Quranic verses, are integrated into home designs to reinforce cultural identity and religious practices (Fig. 18). Gender-segregated spaces, like divided parks and shops, ensure privacy and inclusivity while respecting cultural norms (Fig. 14).

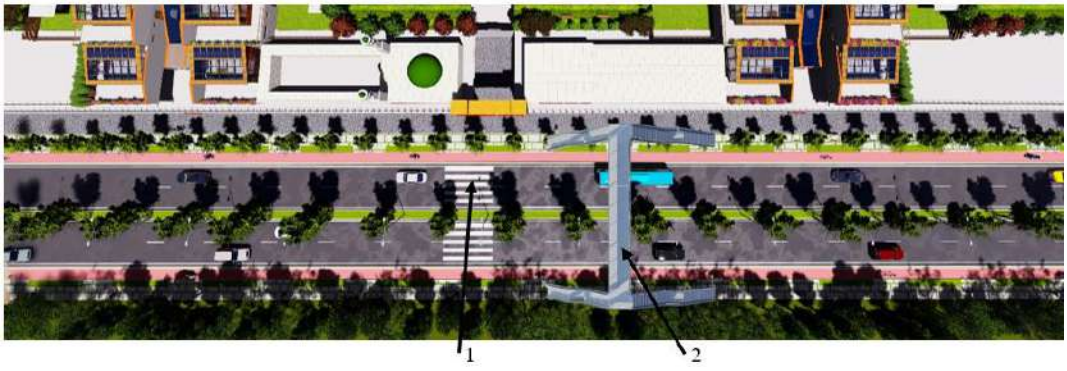


Fig. 17. illustrates the design of crosswalk security and proposes future enhancements for elevated pedestrian crossings on bridges.

The design emphasizes 2 key aspects in Fig. 17: 1) the implementation of crosswalks or zebra lines to ensure pedestrian safety when transitioning from one side to the other, and 2) potential upgrades, such as elevated public crossings or pedestrian bridges, aimed at safeguarding pedestrians by reducing or halting vehicular traffic.



Fig. 18. highlights the integration of cultural and Islamic art within the interior of a room, particularly in the worship area.

In Fig. 18 the key elements include: 1) a terrace area in the courtyard outside the room, 2) a designated prayer space with a prayer mat, 3) a Mehrab on the wall indicating the qibla direction, 4) Islamic art on the wall reinforcing the qibla direction, 5) a living space for residents, 6) a dining area accommodating a family of seven, 7) framed Quranic verses or Ayat displayed on the walls, 8) a doorway leading to the outdoor terrace, and 9) roof glasses providing visual comfort, allowing natural light and outdoor visibility while mitigating heat in the living area.

Sustainability is emphasized through environmentally friendly construction materials, such as locally sourced stone and wood, and the reuse of excavated soil for filling (as illustrated in Fig. 15). Solar panels (see Fig. 15) and rainwater harvesting systems (Fig. 13, legend 4) further enhance environmental sustainability.

Design aesthetics balance traditional and modern elements, with high walls and panoramic elevators providing both security and visual appeal (Figs. 13, 15, 18). Moreover, the balance between heritage and modernity is carefully examined in the gate design, as illustrated in Fig. 19. For instance, the high towers of the Afghan vernacular architecture main gate (Fig. 6, Castle or Fort “Qala” House type) are reinterpreted in the society’s main gate (1), preserving architectural heritage while symbolizing the dignity

of the community garden. The design incorporates windows above headroom height (2), a cultural feature of Afghan vernacular architecture, to address privacy concerns in modern contexts. Additionally, the house entry gate integrates traditional concepts, such as colorized glass (3) for security checks, separate knocking mechanisms for male (6) and female (4) visitors, and modern alarms for male (8) and female (7) callers. A small opening (5) for providing food to beggars is also included, reflecting the preservation of heritage values.

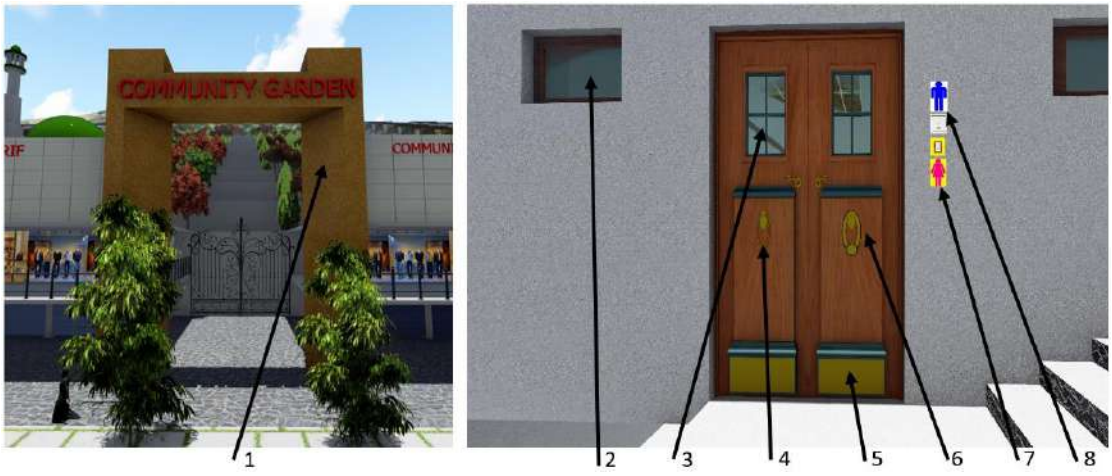


Fig. 19. displays the balance of heritage and modernity in both the community garden gate and the private house entrance gate.

Community involvement remains a cornerstone of the design process, ensuring that cultural integrity is preserved and residents feel a sense of ownership. Open and connected urban environments foster social cohesion, with public spaces, greenery, and pedestrian-friendly infrastructure promoting interaction and integration. By incorporating these design principles (Fig. 10), the proposed urban housing model for Afghanistan aims to achieve socio-cultural sustainability while addressing environmental, economic, and cultural challenges.

7. Conclusions

The people of Afghanistan construct their traditional homes by considering their region's specific climate, site characteristics, social and cultural customs, and economic resources. Vernacular architecture effectively meets their daily needs and addresses local challenges. However, Afghanistan's cultural identity is eroding due to urbanization, modernization, and the return of 8 million refugees and disaster victims [112]-[114], which exacerbates housing challenges and threatens the country's architectural heritage rooted in vernacular traditions. This research emphasizes the need for sustainable urban housing solutions to mitigate urbanization risks and offers design guidelines based on vernacular architecture's potential to contribute to socio-cultural sustainability. Using methods such as literature review, site observations, interviews, photography, and

drawings, the study constructs a framework for socio-cultural sustainable urban housing in Afghanistan.

The literature review identifies 2 main types of low-rise houses in Afghanistan: those with courtyards and those without. Courtyard houses are particularly favored in both rural and urban areas. Afghanistan's 8 provincial zones feature 9 distinct vernacular house types: 1) Castle or Fort "Kala/Qala" House, 2) Single Family House "villa-like", 3) Pitch Roofed "Hip Roof" House, 4) Terraced House, 5) Winterized Houses "Tawkhana's house", 6) Dome Roofed House "Gumbazi House", 7) Nomadic Tent Houses "Kochi or Khaimah House", 8) Huts Form House "Chapari House", and 9) Cave Dwellers Houses. These vernacular forms offer valuable lessons for modern residential development, particularly in achieving social and cultural sustainability. Social sustainability attributes include privacy, security, dense neighborhoods, social bonding, walkability, family gatherings, and entertainment. Cultural sustainability principles encompass religion, behavior, and values.

Interviewees proposed 9 attributes for modern urban housing to enhance socio-cultural sustainability, categorized into social (6 attributes) and cultural (3 attributes) dimensions. Social sustainability includes social adaptability, privacy, security, courtyard design, walkability promotion, and community integration. Cultural sustainability involves cultural adaptability, heritage preservation, and the influence of Islam on values and ethics. A comparison of literature and interview findings reveals that while 9 socio-cultural sustainability indicators align, cultural adaptation emerged as an additional criterion from interviews. The research underscores the gradual loss of Afghanistan's urban cultural identity, recommending cultural adaptation measures to preserve local heritage and boost tourism.

Interviewees suggested 58 design principles (Fig. 10) for achieving socio-cultural sustainability in urban housing, which were rigorously applied in a prototype model. Incorporating vernacular principles into urban planning is crucial for creating sustainable, cohesive environments.

The study promotes socio-cultural sustainable urban housing practices in Afghanistan, offering policy guidance and practical tools for municipalities. By adopting vernacular architecture principles, Afghan urban housing can preserve architectural heritage, attract tourists, and foster resilient communities. Future research should focus on the real-world implementation of socio-cultural design principles and explore policy proposals for sustainable housing solutions. This includes conducting life cycle assessments to compare vernacular and conventional building methods, alongside evaluations of energy efficiency and economic viability. Such a holistic approach can inform policy and foster community participation, ensuring culturally sensitive, environmentally responsible, and economically feasible housing options for Afghans.

8. Recommendations

The study recommends using the 58 design principles to house 8 million refugees and disaster victims, preserving ecological identity, minimizing environmental impact, and promoting tourism. Modular construction is suggested for cost-effectiveness and efficiency. A comprehensive strategy is proposed to protect Afghan vernacular

architecture, including heritage policies, public awareness campaigns, adaptive reuse of historic buildings, and integrating vernacular principles into urban planning. Community involvement, capacity building, and sustainable tourism practices are essential for successful implementation. Prioritizing social and cultural factors in housing design, such as public engagement and disaster readiness, can address Afghan communities' needs while minimizing environmental harm. International aid, resource distribution, and continuous social impact assessments are critical for long-term viability.

9. Limitations

The study's limitations include its focus on 4 of Afghanistan's 8 zones, which may not fully represent the country's diversity. Practical challenges such as accessibility, security, cultural sensitivities, and language barriers also constrained the research.

10. Ethics Statement and Competing Interests

In accordance with institutional ethical guidelines, the authors confirm that formal ethical approval was not required for this study. This exemption was granted as all participant data were anonymized before analysis, ensuring the protection of privacy and confidentiality. Additionally, the author declares no competing financial interests or personal relationships that could have influenced the research.

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