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SOCIO-CULTURAL SUSTAINABILITY OF AL AIN'S MUD VERNACULAR ARCHITECTURE–UAE

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ABSTRACT

This paper explores the socio-cultural dimension of sustainability in Al Ain's mud vernacular architecture, highlighting how indigenous knowledge, oral traditions, and community practices have ensured resilience over the last century. While conservation policies often prioritize physical preservation, this study emphasizes the importance of safeguarding intangible heritage and its contribution to the Sustainable Development Goals (SDGs). A mixed-method approach combined literature review, field observations, semi-structured interviews with restoration experts and a master builder, and a public survey of 161 respondents. The VerSus framework was applied to analyze five socio-cultural principles: the protection of cultural landscapes, the transmission of construction cultures, creative innovation, the recognition of intangible values, and the promotion of social cohesion. The study demonstrates that socio-cultural sustainability is a cornerstone of Al Ain's vernacular resilience. Traditional construction knowledge, social cooperation, and cultural values shaped adaptive architecture and aligned with global sustainability priorities. The findings are strongly relevant to the SDGs related to heritage protection, inclusive urban development, knowledge transfer, and community cohesion. This paper advances scholarship by framing socio-cultural sustainability as a transferable model for heritage management that bridges the tangible and intangible dimensions. By situating Al Ain's mud architecture within the SDG agenda, this analysis highlights the global relevance of indigenous practices to contemporary sustainability challenges.

KEYWORDS: Built heritage management, Sustainable development goals, Intangible heritage, Community resilience, Traditional knowledge transfer, Mud Vernacular Architecture.

1. INTRODUCTION

Sustainability is a multidimensional concept encompassing environmental, economic, and socio-cultural aspects. Socio-cultural sustainability, in particular, emphasizes how traditions, practices, and collective identities shape human adaptation to changing conditions. Socio-cultural sustainability is within this domain, and intangible heritage—such as traditional knowledge systems, social values, and cultural expressions—emerges as a vital resource for sustaining local resilience across generations (Qtaishat et al., 2020). The interplay of culture and social elements is especially evident in vernacular architecture, where building forms are not merely functional responses to environmental conditions but also living expressions of social organization, cultural values, and collective memory. The resilience of vernacular communities is influenced by socio-cultural factors, particularly by the intangible traditional wisdom for adapting to change. Socio-cultural sustainability thus offers critical insights into the continuity of built heritage, particularly in contexts where architecture is the outcome of accumulated community wisdom rather than imported models (Rosaleny Gamón, 2020).

The historical settlement system in Al Ain City in the UAE is directly linked to the abundance of fresh groundwater in its oases. This led to the widespread use of mud as a primary building material, shaping a distinctive architectural identity. Mud architecture in Al Ain showcases the expertise and skill of its builders, using mud brick structures and other local materials as culturally significant components. This legacy includes various typologies such as forts, defensive towers, fortified dwellings, mosques, and souqs, many of which are preserved today. The city's development relied on a delicate balance between desert, oases, and mountains—a "mosaic" of interdependent ecozones that shaped landscape and architecture. As the birthplace and residence of Sheikh Zayed bin Sultan Al Nahyan, the Founding Father of the United Arab Emirates, Al Ain also carries profound symbolic and cultural significance in the nation's modern history (Caratelli et al., 2019)

While Al Ain's tangible heritage has received significant attention in conservation, the socio-cultural dimension of its vernacular architecture—rooted in orally transmitted knowledge and community practices—requires further exploration. This neglect stems mainly from the difficulty of documenting and transmitting intangible heritage. Traditional builders' knowledge, skills, and intuition were historically passed orally across generations. However, the gradual loss of these master builders and their modes of transmission has made the socio-cultural dimension more challenging to study through conventional methods. This article examines the socio-cultural dimension of sustainability in the vernacular architecture of Al Ain, with particular emphasis on how community-driven practices ensured the architecture's adaptability and resilience and sustained its relevance across generations to the present day. The article's scope extends to analyzing how intangible heritage—traditional construction knowledge, cultural practices, and collective social values—contributed to the continuity and sustainability of Al Ain's mud urban architecture. A further element supporting this objective is the political will of the United Arab Emirates, as evidenced by its strong commitment to conserving heritage in all its forms and to encouraging sustainable practices that safeguard both tangible and intangible traditions.

2. METHODOLOGY

The study used a mixed-method approach, combining qualitative and quantitative techniques. The qualitative work included a literature review, site visits in May–June and November 2023 to document mud structures in Al Ain's major oases, and semi-structured interviews with government restoration experts and a master builder. These interviews explored preservation practices, traditional construction skills, and community participation. The quantitative work consisted of an online survey with 161 respondents. It assessed public awareness, perceptions of traditional mud architecture, and views on heritage conservation responsibilities. The qualitative data from site visits and interviews were analyzed thematically. This involved identifying recurring themes related to preservation practices and traditional building techniques. Field observations were cross-referenced with interview findings to validate interpretations.

3. VERNACULAR ARCHITECTURAL HERITAGE AND INTERNATIONAL CHARTERS

Vernacular architectural heritage refers to traditional buildings and settlements that have developed spontaneously through communities' continuous adaptation to their local environment, using indigenous materials, construction techniques, and place-based knowledge. It embodies a community's social memory, identity, and values, while harmonizing with climate, topography, and available resources. As a cultural and historical asset, it reflects the diversity of human expression across

regions and time, serving utilitarian, aesthetic, and symbolic functions rooted in lived experience and collective tradition (ICOMOS, 1999; Akyıldız, 2020).

The characteristics shared by all regions and cultures in traditional or vernacular architecture include the following: the utilization of locally sourced materials in various combinations according to socioeconomic status and cultural factors; and the necessity of constructing structures to mitigate the effects of climate change and other environmental hazards, enhancing the overall physical and spiritual well of people, and creating social unity (Dipasquale, 2020).

International organizations have acknowledged vernacular architecture as a cultural asset of significant value that extends beyond monuments. The Venice Charter, ratified by ICOMOS in 1965, emphasized the importance of traditional architecture in relation to monumental architecture to establish its cultural value within the broader framework of historical heritage. A wide range of cultural and natural assets was recognized as heritage with the adoption of the Convention on the Protection of World Cultural and Natural Heritage by UNESCO in 1972. Inherited from previous generations, preserved in the present, and passed on to future ones. In 1975, the European Charter of Architectural Heritage underscored the need to preserve traditional architecture, minor structures, and local knowledge, which together form a living legacy essential to building resilient and sustainable futures. The recognition of cultural landscapes as World Heritage in 1992 under the World Heritage Convention highlighted the interconnection between human activity and the natural environment. The Nara Document on Authenticity (1994) further acknowledged the need to evaluate heritage assets within specific contexts, as cultural values vary significantly across regions. The Charter on the Built Vernacular Heritage, ratified in 1999, specifically addressed the significance of vernacular architecture. It emphasized the importance of preserving and promoting vernacular heritage by recognizing its cultural, historical, and social values. The document outlined guiding principles for conservation, emphasizing the importance of understanding cultural contexts, supporting community engagement in decision-making, and valuing local knowledge and skills.

4. SUSTAINABILITY DIMENSIONS OF VERNACULAR ARCHITECTURE

Recent studies have emphasized the sustainability of vernacular architecture, a cultural asset of great significance due to its ecological compatibility and environmental efficiency (Hu, 2023; Yıldırım, 2024; Mannonov et al., 2025). These studies evaluate the environmental sustainability of specific vernacular traditions, analyze thermal performance, and investigate their relationships with local climatic and geographic factors. However, understanding the relationship between vernacular architecture and sustainability requires consideration of social, economic, and cultural factors (López Sabater et al., 2022). Multiple factors, including climate change, depletion of natural resources, rising energy demand, population growth, social conflicts, migration, globalization, and technological advancement, influence the sustainability of vernacular architecture. Despite the cultural value of vernacular architecture, it is often overlooked, as modern priorities focus on practicality, cost, and maintenance rather than on environmental or cultural significance. The decline of vernacular practices is frequently attributed to modernization and Western influence; however, a deeper understanding of users' needs and preferences is necessary. It is crucial to consider current environmental, social, cultural, and economic conditions to adapt vernacular architecture for today's context and ensure its future sustainability (Heath, 2009).

The VerSus project, "Lessons from Vernacular Heritage to Sustainable Architecture", which received funding from the European Culture 2007-2013 program, aimed to formalize sustainability principles in vernacular heritage and devise novel techniques for sustainable construction. The study, conducted by five university research groups, translated 15 sustainability principles into five categories across the following domains: environmental, socio-economic, and socio-cultural.

Environmental sustainability concerns the capacity of human settlements to coexist harmoniously with natural surroundings and to contribute to the restoration and renewal of the land actively. Socio-economic sustainability seeks to generate and sustain the highest possible value for societal well-being. Socio-cultural sustainability is concerned with preserving cultural diversity, local knowledge, and social cohesion through adopting vernacular solutions (Correia et al., 2014). Studying vernacular architecture can aid in the preservation of current buildings and the reimagining of future constructions. Recognizing the suitability of technology, resources, and forms is vital, but also considering the shortcomings arising from cultural and economic shifts is crucial. This knowledge can be

acquired through empirical investigation and user experiences. Vernacular traditions constantly evolve, resulting in stability and change and fostering creativity and innovation. The resilience of vernacular communities is influenced by socio-cultural factors, particularly by the intangible traditional wisdom for adapting to change. This knowledge is primarily passed down orally through storytelling, songs, and proverbs. This understanding facilitates the restoration of communities' ecological systems and fosters a future that is both sustainable and resilient (Guillaud, 2014).

4.1. Socio-Cultural Sustainability Parameters of Vernacular Architecture

The importance of sociocultural sustainability is particularly evident in vernacular architecture. The collective experience and knowledge have shaped the architecture of each place and society passed down through generations, resulting in a sustainable response. While there is sufficient literature on sustainability in vernacular architecture, it often emphasizes environmental or socioeconomic aspects, overlooking socio-cultural sustainability. Socio-cultural sustainability refers to the capacity to ensure and strengthen the sense of belonging, cultural diversity, local knowledge and expertise, individual and community well-being, recognition of cultural values, both tangible and intangible, and social cohesion. It aims to collect the positive social and cultural effects that may be seen in local solutions (Correia et al., 2014). The socio-cultural aspects of resilience in vernacular communities encompass intangible traditional knowledge about adapting to change. This includes beliefs, social behaviors, knowledge, cultural practices, and social cohesion. These factors contribute to understanding community dynamics and to sharing local knowledge on how to address disruptions. Intangible traditional knowledge about adapting to change is primarily transmitted orally. Communities relied on stories, songs, and proverbs to preserve their collective memory. The intergenerational transfer of knowledge enables societies to restore their living systems during disruptions (Correia et al., 2014).

Vernacular architecture represents both tangible and intangible traits that demonstrate humanity's capacity to adapt to its living environments and its profound reverence for nature, regardless of the unique characteristics of its surroundings. The connection between nature and culture, the local society's identity, the capacity to create optimal living circumstances to the greatest extent feasible, and knowledge and expertise are closely intertwined (Rosaleny Gamón, 2020). According to Guillaud (2014), the parameters that tackling the socio-cultural issues within the context of vernacular heritage are

- Protection of the cultural landscape: Vernacular heritage is a component of cultural landscapes that have been influenced by human activity, particularly by peasants or artisans, before the industrial period, which had a significant impact on history. The cultural landscapes, including forests, diverse woodlands, wildlife, and well-designed agricultural spaces such as broad valleys and walled fields, contribute significantly to the heritage value of the flora. Water has significant cultural importance. It is often tamed by constructing canals and ponds in interior areas, or by creating salt marshes, dikes, and ports along the coastline. Vernacular architecture and cultural landscapes are interconnected spaces that bridge the gap between nature and culture. It is imperative to preserve and transmit these spaces to future generations.
- Transmission of old traditions in vernacular construction: Vernacular architecture is a tangible representation of the expertise and skills of artisans or anonymous builders who constructed it. The remnants of vernacular building cultures persist in the landscape through the visual elements of materials, such as earth, stone, wood, and plants. Additionally, roofs, building structures, decorative details, and the interconnections between buildings and their surroundings (such as paths, ponds, and streams) help preserve these cultural traces. These aspects exemplify humanity's ability to adapt to a location, fulfill its requirements, and address a region's social and cultural identity.
- Enhancement of innovative and creative solutions: Vernacular architecture showcases an impressive level of communal intelligence and a steady accumulation of construction experiments that have transformed into experience. This social and cultural history demonstrates notable ingenuity in resource adaptation and prudent use. It manifests in many practical, imaginative, and visually pleasing ways, such as colored coatings, decorative elements, and landscaping. These manifestations of ingenuity ought to serve as a source of inspiration for the future.
- Recognition of intangible values: The social

and cultural aspects of vernacular architecture are also evident in the architectural style, which conveys the intangible values of the individuals who constructed and lived in the buildings. This collective memory is manifested through a strong emotional connection to a place, as evidenced by diverse expressions of sacredness (religious and non-religious, including myths and legends), symbolic forms, and the identity associated with the architectural systems.

- Encouragement of social cohesion: Vernacular human settlements, such as cities and villages, represent more than just building architecture; they also show the inhabitants' ability and willingness to share and live together, as well as to preserve social cohesiveness to live as peacefully as possible despite conflicts of interest. Squares and covered markets, facades decorated with different elements and colors, arches that provide shared shade, and other communal gathering places are all evidence of this.

4.2. Sustainability of Mud Vernacular Architecture

The term mud architecture falls under the broader category of vernacular architecture. Architects and researchers worldwide have explored this concept through various interpretations and expressions. It refers to architecture rooted in local building traditions and shaped by design solutions that respond to individual and communal needs. Mud architecture is closely tied to specific geographic regions and cultural contexts, drawing upon knowledge and practices accumulated, refined, and passed down through generations (De Filippi & Balbo, 2005; Tarrad, 2020).

Historical sources indicate that mud was the first material used in the construction field, along with other materials such as stone, wood, and palm trees. Researchers believe that a spiritual dimension connects humanity to mud, the primary material of his creation, thereby further encouraging its adoption as a key component of his architecture.

Since mud achieves a great deal of compatibility and harmony between man and his biological environment, this compatibility and harmony have further helped in the continuation of mud architecture throughout various eras. It is a primary and fundamental concept of sustainability because of its compatibility with the surrounding nature and is a symbol of each place's distinctive architectural identity. This concept relates to various environmental, economic, and social dimensions (Alsuliman and Suliman, 2016).

5. STUDYING THE CASE OF AL AIN, UAE

5.1. Historical Background

The city, once known as Al-Buraimi Oasis or Tawwam, was a favored destination for tribal groups migrating from Yemen to settle in Oman. Among them was the Al Dhaheri tribe, who led a nomadic life centered around their camels. The cluster of seven principal villages surrounding the oases developed into an important trading center that connected the east and west coasts with the country's interior, as well as the deserts to the south and west and the mountains to the east and north. Owing to Al Ain's strategic position, the city served as a vital crossroads on the route to Oman's interior and as a gathering place for numerous Bedouin tribes. By the early nineteenth century, many tribes had established themselves in the oasis, developing farms and semi-permanent settlements (Plate 1). The existence of the 'falaj' irrigation system, consisting of underground channels that carry water from mountain sources to oases, enabled groundwater to be transported from mountain sources to oases, supporting the growth of farming, permanent settlements, and more organized social structures. Therefore, dates and other agricultural products formed the backbone of trade, sustaining a resident population of several thousand people. The economy was further supported by specialized markets, including a notable camel market, as well as homes, mosques, forts, and falaj watchtowers that structured daily life. The community surrounded forts, the place of governance. The palace of His Highness Sheikh Zayed was established on the edge of the Al Ain oasis, the largest in the region, underscoring its political and cultural importance (Al Dhaheri, 2021).

Plate 1: Traditional mud house, located in Qattara oasis in Al Ain, reflects daily life in earlier times (Al Balushi, n.d.).

Before the advent of oil wealth and the onset of modern development, Al Ain functioned as a vital regional center in the Emirates. Its prosperity was rooted in extensive oases of date gardens and

associated agriculture, sustained by permanent groundwater supplies. Despite camel journeys from Abu Dhabi taking up to five days, families regularly traveled to Al Ain during the summer months to escape the oppressive coastal heat and humidity and oversee the annual harvest between June and September. From its earliest history, Al Ain also held significance as a regional administrative hub (Iddison, 2002).

5.2. Spatial Organization of Al Ain Mud Urban Architecture

The historic earthen architecture in Al Ain includes forts, mosques, watchtowers, and fortified houses, built to protect residents, livestock, and agricultural produce. Their building technique is characterized by thick mud walls with minimal openings for light and ventilation, roofs constructed from palm logs and palm matting, and mud plaster applied to floors and walls (Abu Dhabi Culture, 2024).

Communities along the aflaj developed a social and spatial order centered on this vital water source (Plate 2). Protecting and maintaining the falaj was essential, prompting the construction of forts and other defensive structures along its channels. The main fortress, often built at the water's emergence point, oversaw the settlement and the network of channels extending to the mountains. Along the falaj, water usage zones were organized sequentially according to the priority and significance of the function. Water use followed a fair hierarchy from the source to the palm groves. The emergence point supplied drinking water, with a mosque and an ablution area nearby. Downstream zones included a women's bathing area, a basin for washing the deceased, spaces for watering animals, and a public basin for communal access. The final stage was agricultural irrigation, in which conduits and palm trunks distributed water through the groves to ensure uniform, time-regulated irrigation (Al Dhaheri, 2021).

Plate 2: Distribution of Traditional Buildings of Al Ain around oases (Iddison, 2002).

The water distribution hierarchy shaped the oasis system, which was organized into three concentric zones. At the core of the oasis system lies the palm garden oasis—a sunken basin divided into numerous small plots, where date palms grow above layers of fruit trees and vegetables. Water for each oasis was supplied by aflaj, underground channels that tapped into groundwater at the base of the mountains and often conveyed it over long distances (Plate 3). Upon reaching the oasis, water was distributed through a complex network of surface channels governed by traditional water rights. Encircling the core, a second agricultural zone comprised extensive fields irrigated by wells, seasonal rainfall, and associated

settlements. The outer zone contained seasonal vegetation used for grazing camels and goats.

Plate 3: Settlement formation centered on the emergence point of the falaj system (Department of Culture and Tourism–Abu Dhabi, 2019).

6. DISCUSSION AND FINDINGS

The discussion of Al Ain's mud vernacular urban architecture demonstrates that its sustainability cannot be reduced to environmental or material considerations alone; instead, it emerges from the interplay of economic, social, political, and cultural dynamics that historically shaped the community's built environment. This study highlights how the socio-cultural dimension constitutes the cornerstone of Al Ain's resilience and identity by situating these findings within the VerSus framework (Correia et al., 2014) and aligning them with the Sustainable Development Goals (SDGs).

6.1. Socio-cultural Dimension of Al Ain Vernacular Urban Architecture

Socio-cultural sustainability emphasizes how traditions, practices, and collective identities enable human adaptation to changing conditions, with intangible heritage crucial for local resilience. The mud building of Al Ain was shaped by the Bedouin way of life and influenced by Islamic principles, and is an essential component of the Emirate's culture. Mud architecture is a dynamic product of people's lived experiences, in which political governance provided security, economic livelihoods dictated adaptable building types and material use, and environmental conditions necessitated ingenious climatic design (Abed and Hellyer, 2001). Together, these factors formed an enduring adaptation model, embedding collective identity and ensuring community resilience by transforming the built heritage into a living expression of socio-cultural sustainability.

6.1.1. Political Aspect

The architecture of traditional communities in Al Ain was not merely a response to climate or resources but also a reflection of economic livelihoods, social structures, and political organization (Caratelli et al., 2019). Forts, castles, and watchtowers were more than defensive structures; they were visible markers of tribal authority and symbols of protection provided by ruling sheikhs. These structures safeguarded critical resources such as water, farmland, and trade routes, while simultaneously acting as gathering places for assemblies and festivities (Plate 4) (Nafee et al., 2018). One or more forts safeguarded each community, while falaj watchtowers were strategically positioned to oversee the underground water channels that supplied the oases. Mosques, often sponsored by influential families, illustrate how religious devotion was interwoven with political legitimacy and communal cohesion (Iddison, 2002; Al Dhaheri, 2021). Such patronage demonstrated religious devotion and reinforced the socio-political influence of leading households within the community.

Plate 4: Al Jahili Fort was built to protect date palm farmers (Horan, 1962).

6.1.2. Economic Foundations Aspect

The agrarian economy, centered on date palm cultivation, profoundly influenced settlement patterns, building technologies, and material practices. Dates were consumed locally and exported to coastal settlements in exchange for fish, pearls, and other goods, creating interdependent economic networks. Seasonal migration shaped housing typologies, ranging from permanent courtyard houses to portable ʿarīsh shelters and goat-hair tents. This mobility reflected the balance between nomadic pastoralism and settled agriculture (Iddison, 2002). Material use—mud, palm products, stone, and lime-based mortars—was directly tied to economic activities, ensuring cost efficiency and resilience. Specialized professions such as the 'Arif' (falaj overseer), charcoal producers, and female-led livestock farming illustrate how livelihoods were directly linked to construction and daily subsistence (Alsharhan and Rizk, 2020). These practices supported the transfer of knowledge systems that sustained construction cultures across generations.

6.1.3. Environmental Adaptations Aspect

The environmental conditions of Al Ain played a fundamental role in shaping traditional architecture, as communities adapted to the desert's challenges and opportunities. The natural environment directly influenced the choice of building materials. Mud was the most abundant and widely used resource, valued for its thermal properties that moderated interior conditions by maintaining coolness in summer and warmth in winter. Through interviews with master builders in Al Ain, this study collected detailed information on traditional construction techniques. Mud bricks (libin) were typically made from wadi soils, mixed by foot, fermented, and sun-dried, while mud mortar (salhat midra) ensured structural cohesion. Palm tree products were a vital local resource that were used for both lightweight and heavyweight construction.

Trunks were used for beams and rafters, leaves and ribs (zor) for woven mats (da'an), and fibers (lif) for insulation. These organic elements shaped architectural proportions, as the span of palm trunks determined the width of rooms, generally limited to three or four meters (Plate 5). Stone was occasionally used, particularly in the foundations of mud walls (Plate 6) or for defensive structures in highland and coastal plains, while lime-based (juss) was applied as plaster to finish walls and crenellations with a polished appearance.

For more significant and durable buildings, sarooj, a water-resistant clay mortar, provided essential strength and protection.

(a)

(b)

Plate 5: (a) woven mats (da'an) and split palm logs to construct the roof. Photo by authors, (b) Husn Al Jahili interior Roof. Photo by authors.

Plate 6: Mud Wall Stone Foundation. Photo by authors.

Beyond material use, architectural design reflected ingenious adaptations to the desert climate. Thick mud walls minimized heat transfer and offered substantial thermal insulation, while the limited size of exterior openings reduced solar gain yet allowed for ventilation, daylight, and visual connection to the outside (Plate 7) (Abu Dhabi Culture, 2024). Courtyards acted as climatic regulators, while clusters of buildings and shaded alleyways reduced solar gain and enhanced comfort. Rainwater spouts (mizrab) [Plate 8] and elevated housing safeguarded structures from seasonal floods, thereby ensuring durability (Iddison, 2002). These adaptations reveal a sophisticated environmental consciousness embedded in vernacular practices long before "sustainability" became a formalized discourse.

Plate 7: limited small openings for light and air. Photo by authors.

Plate 8: Water Runner "Mizrab". Photo by authors.

6.2. Socio-Cultural Sustainability of Al Ain Mud Vernacular Architecture

The desert architecture of Al Ain, influenced by indigenous and traditional wisdom, has played a vital role in meeting the community's housing needs for generations. This knowledge encompasses a range of information, including methods of construction, cultural ideas, and societal behaviors, across multiple levels of organization, from urban-scale settlements to households. Vernacular architecture incorporates sustainable design principles by using local materials and technologies derived from natural and cultural environments, resulting in its gradual evolution over time. This section aims to analyze the underlying principles of sustainability in traditional building systems in Al Ain. These principles have the potential to foster innovation in restoration projects and conservation management systems, ultimately improving the sustainability and resilience of the community. Understanding the sustainability principles embedded in the vernacular architecture of Al Ain is crucial for formulating resilient planning strategies and for analyzing, selecting, evaluating, and validating the intangible heritage associated with traditional architectural building systems.

The treatment of the oases has been sustainable by necessity, as they, for much of Al Ain's history, provided much-needed water, shelter, nourishment, and commerce (Abu Dhabi Culture and Heritage, 2010). Urban spaces and dwellings reflect the values, attitudes, ways of life, practical skills, and wisdom of their communities. The settlement forms reflect the local identity, shaping people's choices, behaviors, and overall well-being. Summarized in Plate 9, the expression of socio-cultural sustainability in Al Ain architecture is reflected through the following principles derived from the VerSus project mentioned previously

- Protection of the cultural landscape: Al Ain's settlement developed close to oases and aflaj irrigation systems, reflecting wise water management and integrating natural and cultural resources. The primary urban centers and settlements were situated near date plantations, encompassing the Souq marketplace and fortified structures that protected the oasis and its by-products. The houses were dispersed around the date gardens, positioned at an elevated level above the gardens to safeguard against frequent flooding. These components not only demonstrate humanity's capacity to adapt to the environment to satisfy its needs but also foster a sense of inclusion, connecting residents with their surroundings.
- Transmission of old tradition in vernacular construction: The architectural design of Al Ain city is a testament to the expertise and skill

of the artisans and constructors responsible for its construction. These builders deeply understood soil types, mixing ratios, and seasonal timing, enabling them to adapt construction methods to local climate conditions without modern equipment. Historically, skills and knowledge were passed down orally from family to apprentice, reinforced by community-led maintenance of homes and surrounding public spaces.

- Enhancement of innovative and creative solutions: Ingenuity in the design of mud buildings is demonstrated by the ability to utilize and adapt to resources that are readily accessible effectively. Innovative solutions arise from synthesizing accumulated knowledge, acquired through experiential learning and continuous trial-and-error processes. In Al Ain, the use of indigenous materials, such as palm trunks and leaves, for diverse building applications demonstrates inventive solutions tailored to the local context. In addition to the strategic use of mud bricks, palm wood, and gypsum plastering, it not only fulfills practical needs but also enhances the visual appeal of the buildings.
- Recognition of intangible values: Privacy, spatial hierarchy, and symbolic meanings were embedded in settlement patterns and domestic architecture, guided by Islamic cultural principles. This is achieved by incorporating private spatial elements, such as courtyards, a curved entrance passageway from the street, strategically placed transitional spaces and internal circulation, well-planned openings to ensure privacy from neighbors and passers-by, and a clear distinction between public and private spaces.
- Encouragement of social cohesion: Public spaces such as forts, mosques, and Souqs functioned as hubs for tribal gatherings, religious rituals, and markets that strengthen community cohesion and cultural identity. Community cooperation, exemplified by the fazaa' system (panic system for mutual aid), played a vital role in construction, maintenance, and irrigation, reinforcing social solidarity and shared responsibility.

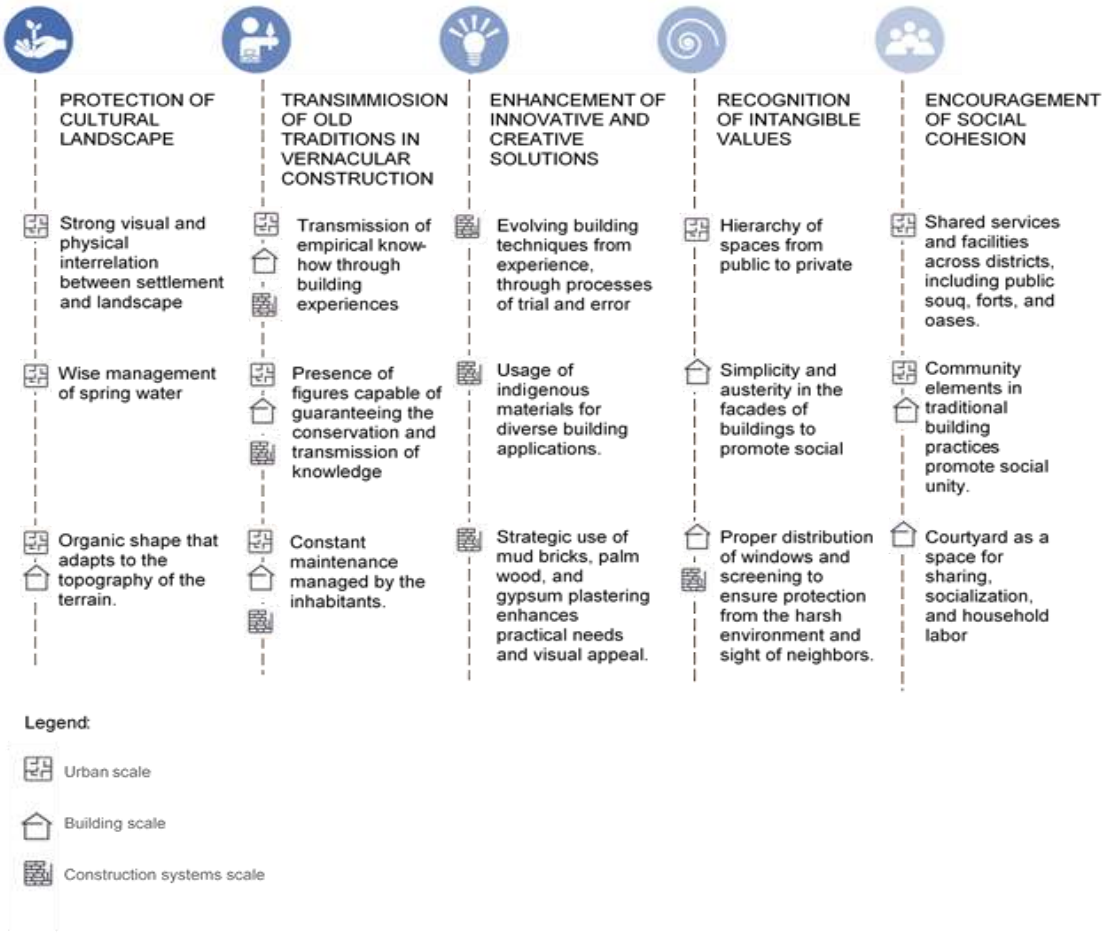

Plate 9: Socio-Cultural Sustainable Local Practices of Al Ain's Mud Architecture. By Authors.

6.3. Linking Findings to the Global SDGs Agenda

When contextualized within the SDGs, the case of Al Ain demonstrates that vernacular mud architecture is not merely a relic of the past but a living repository of socio-cultural sustainability principles that remain relevant to contemporary challenges. Traditional practices—ranging from the protection of cultural landscapes and the transfer of construction knowledge to the fostering of creativity, recognition of intangible values, and encouragement of social cohesion—reflect a holistic response to the environmental and social conditions of the desert. When examined through the lens of the 2030 Sustainable Development Goals (SDGs), these practices resonate strongly with global priorities: safeguarding heritage (SDG 11.4), promoting education and knowledge transfer (SDG 4.7), advancing innovation through resource efficiency (SDG 9 and 12), enabling inclusive urban development (SDG 11.3), and strengthening social cohesion (SDG 16). By aligning the socio-cultural dimensions of Al Ain's traditional architecture with the SDGs, this study underscores the potential of indigenous knowledge systems to enrich heritage conservation and meaningfully contribute to the global sustainability agenda.

7. CONCLUSION

Despite substantial efforts to conserve Al Ain's tangible heritage, the socio-cultural dimension of its vernacular architecture remains underexplored. The erosion of orally transmitted knowledge and traditional practices poses a critical challenge, underscoring the urgent need to recognize intangible heritage as integral to sustainability. This study examined Al Ain's mud vernacular architecture as a product of local experience, shaped by traditions and community practices rather than imported models. It underscores the significance of community agency in shaping vernacular architecture. Al Ain's mud vernacular architecture socio-cultural dimension emerges as a key indicator of sustainability, reflecting the deep interconnection between people, place, and built form.

The article makes a threefold contribution. Theoretically, it advances architectural and heritage scholarship by positioning community knowledge as central to sustainability discourses and linking material traditions with intangible cultural practices. From a policy perspective, it supports participatory frameworks that view communities as beneficiaries and partners in heritage protection, thereby providing a rationale for inclusive planning and conservation policies. In practice, it offers architects, planners, and heritage managers practical insights into how local building knowledge and cultural practices can inform sustainable design, strengthen conservation initiatives, and generate affordable, context-sensitive solutions.

Together, these contributions reinforce the vital role of communities as custodians and transmitters of architectural heritage, bridging the gap between theory, governance, and practice. Future research should extend this approach to comparative studies across the Gulf, enabling a deeper understanding of shared and distinct socio-cultural sustainability strategies in vernacular architecture.

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