Towards Reviving Vernacular Architecture in India: Insights into the Indigenous Building Traditions

Nandini Halder [1], Deepak Kumar [2*]
[1&2]Department of Architecture and Planning, National Institute of Technology Patna, Bihar – 800005, India
[1][ORCID - 0009-0007-0667-5112];[2][ORCID - 0000-0001-5846-5255]
*Corresponding author: Deepak Kumar
Email: deepakk.ph22.ar@nitp.ac.in

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Abstract

Vernacular architecture in India represents a profound synthesis of environmental adaptation, cultural expression, and community craftsmanship. Despite its ecological relevance and spatial intelligence, these traditional systems are increasingly marginalized in contemporary architectural practice. Existing research often isolates individual typologies or regions without offering a comparative, interdisciplinary lens. This study addresses this gap by critically examining the architectural, environmental, and socio-cultural dimensions of vernacular architecture across three ecologically diverse regions: Kutch in Gujarat, Ziro Valley in Arunachal Pradesh, and Shekhawati in Rajasthan. It identifies common design logics, assesses material performance, and evaluates community knowledge systems within these regional practices.

The research employs a qualitative, case-based methodology, including field observations, semi-structured interviews with local artisans and residents, a spatial analysis of vernacular forms, and a literature synthesis. The findings reveal that vernacular architecture in all the three regions exhibits context-responsive spatial planning, low-carbon material use, and social embeddedness. These systems integrate passive design techniques such as thermal massing, cross-ventilation, and shaded courtyards, while also serving as vessels of cultural identity and memory.

The paper identifies key challenges which include policy neglect, erosion of traditional knowledge, and aspirational shifts toward industrial materials. It thus concludes that vernacular architecture offers a resilient, sustainable, and culturally rich alternative to dominant construction models. Therefore, it calls for strategic integration of vernacular knowledge into architectural education, policy frameworks, and design innovation. Future research should focus on developing adaptive hybrid models that bridge traditional wisdom with contemporary performance requirements.

Keywords: Vernacular Architecture; Sustainable Design; Climate-Responsive Buildings; Cultural Sustainability

Introduction

Vernacular architecture represents the collective wisdom of communities, developed through generations, demonstrating profound harmony with local environmental and cultural contexts. It encompasses construction methods shaped by geography, climate, available resources, cultural practices, and lifestyles, rather than standardized architectural designs or professional interventions (Oliver et al. 2006; Rapoport 1969; Vellinga, 2013). Such architecture is inherently region-specific, ecologically integrated, and culturally expressive (Correia et al. 2015; Dayaratne 2018; Heath 2009). Figure 1 shows representative vernacular-built forms across India: from Rajasthan's insulated mud houses, Assam's bamboo stilt dwellings, to courtyard houses of Tamil Nadu and stone structures in the Himalayas. Each has evolved as a localized response to climate, topography, and cultural practices.

Fig. 1: Vernacular-built forms across India: (a). Insulated mud houses of Rajasthan, (b). bamboo stilt dwellings of Assam, (c). Courtyard houses of Tamil Nadu and (d). Stone structures of the Himalayas.
Source: Google images

In India, characterized by diverse climatic zones and cultural heterogeneity, vernacular architecture exhibits a remarkable variety of design principles, building typologies, and materials (Dhawale et al. 2019; Gautam et al. 2022). Examples include the mud houses of Rajasthan, optimized thermally through passive cooling techniques suitable for arid conditions (Sharma et al. 2021; Gupta et al. 2020); bamboo-stilt dwellings in Assam and Arunachal Pradesh, designed to mitigate flooding and humidity (Singh et al. 2021; Joshi et al. 2016); and courtyard-centric houses in southern India, offering enhanced ventilation and social interaction (Narasimhan et al. 2021; Kumar et al. 2013). The Figure 2 shows how passive design strategies such as, jali screens, shaded verandas, thick earthen walls, and sloping thatched roofs—enhance thermal comfort and demonstrate ecological wisdom through locally sourced, renewable materials. Each has evolved as a localized response to climate, topography and cultural practices.

Fig. 2. Passive design strategies
Source: Google images

The passive design strategies involve, jali screens, shaded verandas, thick earthen walls, and sloping thatched roofs. They enhance thermal comfort and demonstrate ecological wisdom using locally sourced, renewable materials. Indeed, such examples illustrate that vernacular architecture does not merely address the physical need for shelter, but also weaves together functional, cultural, social, and symbolic dimensions of life. Spatial planning often mirrors societal structures, religious beliefs, gender roles, and seasonal practices. In fact, beyond mere functional shelter, these building forms encapsulate social structures, religious symbolism, and community practices (Shukla et al. 2017; Jain et al. 2020). Materials employed such as bamboo, mud, stone, lime, timber, and thatch are typically locally sourced, renewable, and biodegradable. They significantly reduce their ecological footprint compared to industrially-produced materials like steel and concrete (Gupta et al. 2018; Debnath et al. 2015).

Despite these ecological, socio-economic, and cultural benefits, India's vernacular architectural traditions are rapidly eroding under the pressures of modernization, urbanization, and changing economic aspirations (Mehta et al. 2015; Singh et al. 2020; Menon et al. 2022). Moreover, prevailing perceptions often associate vernacular structures with poverty or backwardness, particularly among the younger populations, while governmental policies and architectural education frequently overlook these indigenous practices (Grover et al. 2022; Parveen et al. 2020; Desai et al. 2021). Preservation efforts typically confine vernacular architecture to heritage tourism contexts or static museum displays, failing to integrate traditional wisdom dynamically into sustainable development (Srivastava et al. 2016; Shankar et al. 2021).

The study of vernacular architecture has been framed through multiple theoretical lenses that situate it at the intersection of environment, culture, and tradition. According to Rapoport (1969), vernacular architecture is not simply a style of building but an outcome of socio-cultural forces and environmental adaptation. Oliver (2006) further emphasizes that vernacular forms emerge from collective knowledge systems shaped by climate, materials, and social organization, rather than professional architectural intervention. Vellinga (2013) extends this view, highlighting the symbolic and cultural dimensions that render vernacular buildings not only functional but also identity-bearing.

Adding to these, Lawrence (2000) argues that traditions in architecture represent socially shared rules and practices, transmitted through generations, which regulate both form and meaning. In this sense, indigenous building traditions can be understood as practices embedded in local ecologies, materials, and cultural rituals that sustain community identity while addressing environmental conditions. Similarly, Heath (2009) notes that cultural processes underpin regional design, making vernacular architecture inseparable from the lifeworlds of its practitioners and users.

The concept of indigenous knowledge and practices refers to experiential, place-based knowledge systems transmitted orally or through apprenticeship. These systems often embody sophisticated understandings of material properties, structural behavior, and climate responsiveness, long before they entered the discourse of sustainability (Correia et al. 2015). When such knowledge is embedded in the built environment, it contributes to heritage, not only as monuments of the past but as living traditions that continue to evolve and adapt (Dayaratne 2018). Bringing these concepts together, vernacular architecture can be theorized as the materialization of indigenous building traditions, underpinned by cultural practices and indigenous knowledge, and recognized as heritage when preserved or valorized across time (Halder et al. 2025). These interrelated concepts form the analytical lens of this study, allowing us to interpret the selected case studies not only as architectural forms but as socio-ecological systems that embody adaptation, continuity, and cultural meaning.

The critical research gap addressed by this study lies in the absence of comprehensive frameworks that integrate vernacular principles with contemporary architectural practice (Gupta et al. 2016; Dutta et al. 2022). While prior studies have restricted vernacular traditions to heritage conservation, their adaptability and relevance to modern sustainability challenges remain underexplored.

In this context, the aim of this paper is to advance the revival of vernacular architecture in India by situating indigenous building traditions as living frameworks for sustainable and culturally embedded design. It pursues the following objectives:

- To investigate how vernacular architectural forms across Kutch, Ziro Valley, and Shekhawati embody climate adaptation and socio-cultural patterns.
- To document and compare spatial, material, and environmental strategies across these case studies.
- To analyse current revival initiatives and stakeholder perspectives on sustaining indigenous practices.
- To identify pathways for integrating vernacular principles into contemporary architectural education, policy, and design innovation.

Review of Literature

The discourse on vernacular architecture is anchored in foundational theoretical contributions. According to Rapoport (1969), vernacular buildings emerge from cultural determinants rather than stylistic choice, reflecting the values and behaviors of its users. Oliver (2006) extends this perspective by describing vernacular architecture as “built to meet needs,” highlighting its role as a mediator between environment, culture, and community. Vellinga (2013) argues that vernacular traditions must be understood as dynamic, adaptive systems rather than static relics, while Heath (2009) emphasizes that regional design processes are deeply cultural, embedding symbolism and ritual into the built environment. These perspectives establish that vernacular architecture cannot be reduced to material form alone; it is a socio-cultural system with ecological, symbolic, and functional dimensions.

In the Indian context, several scholars have documented the climatic responsiveness and sustainability of vernacular traditions. Gupta and Bansal (2016) show how traditional housing in India employs passive design strategies that remain relevant for contemporary low-carbon construction. Mehta and Mehta (2015) examine transformations in Indian vernacular settlements, noting both ecological wisdom and the pressures of modernization. Sharma et al. (2021) provide empirical evidence of the thermal performance of traditional dwellings in Rajasthan, reporting indoor temperatures significantly cooler than the external environment. Similarly, Joshi et al. (2016) discuss the resilience and sustainability potential of bamboo housing in Northeast India, while Kumar and Pushplata (2013) demonstrate how vernacular practices in hilly regions can inform modern building regulations.

Collectively, this body of research establishes that indigenous building traditions are environmentally efficient and culturally embedded. At the same time, scholars also highlight the challenges facing these traditions in the present. For example, Grover and Singh (2022) argue that architectural education in India marginalizes vernacular knowledge, creating pedagogical blind spots that impede revival. Parveen and Arun (2020) find that while communities recognize the climatic benefits of vernacular forms, younger generations often associate them with poverty, leading to aspirational shifts toward concrete housing. Shankar (2021) discusses adaptive reuse as a strategy for sustaining vernacular practices, but notes that most interventions remain limited to isolated heritage projects. Dutta and Hussain (2022) frame vernacular revival in the context of post-COVID resilience, suggesting hybrid models that combine traditional logics with modern performance standards. Menon and Kandachar (2022) further stress the policy neglect of vernacular systems, pointing to the absence of incentives that could legitimize indigenous techniques in mainstream construction.

Literature also reveals a tension between treating vernacular architecture as "heritage" and recognizing it as a living tradition. In this regard, Srivastava and Gupta (2016) examine Shekhawati havelis as cultural heritage, yet their study shows that preservation often freezes buildings as monuments rather than adapting them to contemporary use. Correia et al. (2015) emphasize the global importance of safeguarding vernacular heritage but also caution that revival requires integration into present-day design practice. This tension underscores a broader challenge: vernacular systems are celebrated in academic discourse yet remain marginal in policy and practice.

In fact, existing scholarship demonstrates that vernacular architecture in India is climatically effective, materially sustainable, and culturally embedded. However, most studies have restricted the study to heritage conservation, overlooking the urgent question of how they may be dynamically revived and integrated into contemporary architectural discourse. This study addresses this gap by critically examining indigenous building traditions across three diverse regions and by identifying practical pathways for their revival through education, policy, and design innovation.

Research Methodology

This study employs a qualitative, comparative case study approach to investigate indigenous building traditions in India, consistent with the aim of examining pathways for reviving vernacular architecture. The methodology integrates multiple data-gathering techniques—case study documentation, environmental data review, semi-structured interviews, and secondary literature analysis, across three ecologically diverse regions. This design ensures that spatial, material, cultural, and environmental dimensions of vernacular practices are captured in a systematic and replicable manner.

Case Study Approach

The case study method is particularly suited for contextual, place-based investigations where architecture is deeply tied to ecological and cultural settings (Yin, 2014; Flyvbjerg, 2006). Three regions were purposively selected based on ecological diversity, cultural significance, and evidence of vernacular continuity:

- Kutch, Gujarat (Hot-Arid) – circular Bhunga houses with mud and lime plaster walls and conical thatched roofs.
- Ziro Valley, Arunachal Pradesh (Humid-Subtropical) – stilted bamboo dwellings of the Apatani tribe.
- Shekhawati, Rajasthan (Semi-Arid) – courtyard havelis constructed with sandstone and lime plaster.

These typologies were chosen because each has been documented in prior research and remains under stress from modernization, providing a rich ground for comparative analysis.

Data Collection Techniques

Following data collection techniques were employed:

- **Architectural documentation**: Measured drawings, photographs, and spatial analysis were compiled from field visits, published sources, ASI heritage records, and NGO archives. Typologies were broken down into layout, orientation, material palette, construction details, and workflow.
- **Environmental and climatic data**: Long-term climate data (temperature, rainfall, humidity, wind) were sourced from the India Meteorological Department (IMD), WorldClim v2, and NASA POWER datasets. Regional hydrological and seismic reports were also consulted to assess vulnerability and resilience.
- **Semi-structured interviews**: A total of 18 interviews were conducted across the three regions, with six participants per site: three local artisans, two residents, and one architect or NGO professional. Participants were purposively selected based on active involvement in vernacular construction or residence within traditional dwellings. Interviews were conducted in Hindi between March 2025 to April 2025, translated into English, and anonymized. Questions covered construction techniques, cultural symbolism, environmental performance, and aspirations for modernization. Verbal informed consent was obtained in all cases.
- **Secondary literature review**: Peer-reviewed articles, conservation reports, and ethnographic studies were analyzed to supplement field data and provide historical and cultural context.

Interview Procedures

Interviews were conducted on-site in domestic or community settings to enable contextual observations. Each interview lasted between 30–60 minutes and followed a flexible guide covering four thematic blocks: (i) architectural knowledge and inheritance, (ii) environmental comfort and challenges, (iii) cultural symbolism and community use, and (iv) awareness and aspirations for modern changes. Translation accuracy was ensured through back-checking of transcripts.

Data Analysis and Triangulation

Data analysis was carried out in three stages:

- Typological and spatial analysis – Comparative examination of orientation, zoning, and spatial hierarchies across case studies.
- Material and environmental performance analysis – Evaluation of thermal massing, ventilation strategies, embodied energy, and durability, cross-checked with existing simulation studies (e.g., Sharma et al., 2021; Jain & Jain, 2020).
- Thematic coding of interviews – Interview transcripts were analyzed following Braun and Clarke’s (2006) protocol for thematic analysis. Codes such as “material memory,” “climate resilience,” and “modern aspirations” were grouped into higher-order themes.

Triangulation was achieved by cross-verifying evidence from architectural documentation, climatic data, and interview narratives. This multi-layered analysis enhances reliability and ensures that findings are grounded in both physical and cultural evidence, Figure 3 illustrates the research framework for this research.

Fig. 3. Research framework illustrating the progression from unstudied to studied vernacular architecture through a sequential methodology involving case selection, data collection, and comparative analysis.

Case Studies

To situate the findings, this section introduces the three case study regions. Each represents a distinctive ecological zone and cultural tradition within India's vernacular landscape. Figure 3 shows the geographical location of the case studies within the Indian subcontinent. Figures 4, 5 and 6 provide zoomed-in maps of Hodka, Hong, and Mandawa, respectively.

Kutch, Gujarat (Hot-Arid Zone)

The Kutch region in western Gujarat is a hot-arid landscape characterized by desert conditions, saline soils, and seismic vulnerability. Average summer temperatures range from 35–45 °C, with diurnal extremes and minimal annual rainfall (~350 mm) (Rupapara et al., 2025). The vernacular Bhunga houses, circular earthen dwellings with conical thatched roofs, are uniquely adapted to both climate and seismic risk. Their thick earthen walls provide thermal mass, while their low circular forms confer earthquake resilience, a quality validated during the 2001 Bhuj earthquake (Menon & Kandachar, 2022).

Fieldwork was carried out in and around Hodka village and Bhuj town, Figure 4 shows the geographical location of Hodka village, where Bhungas remain in use. Figure 4 shows the geographical location of the case study. The artisans interviewed were practicing masons engaged in the repair and construction of Bhungas. The residents interviewed lived in fully functional circular Bhungas occupied by nuclear families of 4–6 members. An NGO professional based in Bhuj contributed insights on housing revival initiatives. Participants were approached through local NGOs active in post-earthquake rehabilitation, ensuring access to authentic knowledge bearers.

Fig. 4: Location of Hodka village, Kutch, Gujrat
Source: Google maps

Ziro Valley, Arunachal Pradesh (Humid-Subtropical Zone)

Ziro Valley, located in northeastern Arunachal Pradesh, is home to the Apatani tribe. The region experiences heavy annual rainfall (~2000 mm) and high humidity, with moderate temperatures (15–28 °C). Vernacular dwellings are bamboo stilt houses elevated 1.5–2 m above ground to mitigate flooding and allow airflow beneath the structure. These dwellings are constructed using bamboo, timber, and thatch, employing rope joinery that permits flexibility and disassembly (Kumar, 2021). Fieldwork was conducted in Hong village. Figure 5 shows the geographical location of Hong village, where traditional bamboo houses remain part of everyday settlement life. Figure 5 shows the geographical location of the case study.

The artisans interviewed were bamboo specialists responsible for constructing and maintaining stilt houses. The residents interviewed belonged to multi-generational Apatani households still residing in bamboo stilt dwellings. The professional interviewed was an architect working on bamboo-based housing initiatives in collaboration with local NGOs. Participants were identified with the assistance of village elders, ensuring representation of traditional knowledge holders within the community.

Fig. 5: Location of Hong village, Ziro Valley (Arunachal Pradesh)
Source: Google maps

Shekhawati, Rajasthan (Semi-Arid Zone)

The Shekhawati region in northeastern Rajasthan is characterized by a semi-arid climate, with annual rainfall of approximately 450 mm and summer temperatures exceeding 40 °C. The region is historically known for its havelis—multi-storied courtyard houses adorned with lime plaster frescoes. The courtyard (aangan) serves both climatic and social functions, enabling passive cooling and providing a communal gathering space. Fieldwork was undertaken in Mandawa town. Figure 6 shows the geographical location of Mandawa town, where historic havelis are still inhabited or partially adapted for new uses. Figure 6 shows the geographical location of the case study.

The artisans interviewed were lime plaster specialists and fresco painters engaged in ongoing conservation and repair of the havelis. The residents interviewed lived in courtyard havelis occupied by extended families, providing insight into both domestic use and challenges of maintenance. A conservation architect interviewed in Mandawa contributed perspectives on heritage adaptation. Access to participants was facilitated through local conservation networks and heritage NGOs.

Fig. 6: Location of Mandawa town, Shekhawati, Rajasthan.
Source: Google maps

Findings

This section presents the findings of the field study, organized according to the techniques described in the methodology: archival sources, typological and spatial analysis, material and environmental performance, cultural mapping, and interviews. Data are reported for each case study region—Kutch (Hodka), Ziro Valley (Hong), and Shekhawati (Mandawa). The observations from the detailed and comparative analysis of vernacular architectural systems across three geographically and climatically diverse regions of India, Kutch in Gujarat, Ziro Valley in Arunachal Pradesh, and Shekhawati in Rajasthan, shed light on a multitude of interconnected aspects, including spatial organization, material selection, construction techniques, environmental adaptability, and cultural embeddedness.

These case studies were intentionally selected to represent varied ecological zones, hot-arid, humid-subtropical, and semi-arid respectively, and, in doing so, offer a broad spectrum of responses to both environmental constraints and socio-cultural needs. Through these case studies, it becomes evident that vernacular architecture is not a static set of forms but a living, adaptive system of knowledge and practice that has evolved organically over generations to achieve ecological harmony, social functionality, and cultural expression. Each region's building traditions display an intricate relationship between climate-responsive de-sign strategies and the lifestyle patterns, belief systems, and community dynamics of the people who inhabit them.

Archival and Secondary Sources

The archival study provided an essential baseline for understanding the historic trajectories of vernacular architecture in Kutch, Ziro Valley, and Shekhawati. In Kutch, NGO conservation records following the 2001 Bhuj earthquake documented how Bhunga houses, despite their apparent fragility, demonstrated remarkable seismic resilience compared to reinforced concrete buildings. These archives note that while modern masonry structures collapsed catastrophically, the circular form and lightweight roof of Bhungas minimized damage and reduced casualties. Figure 7 shows the location plan, unit plan, and unit elevation of traditional Bhunga settlement in Kutch, Gujarat.

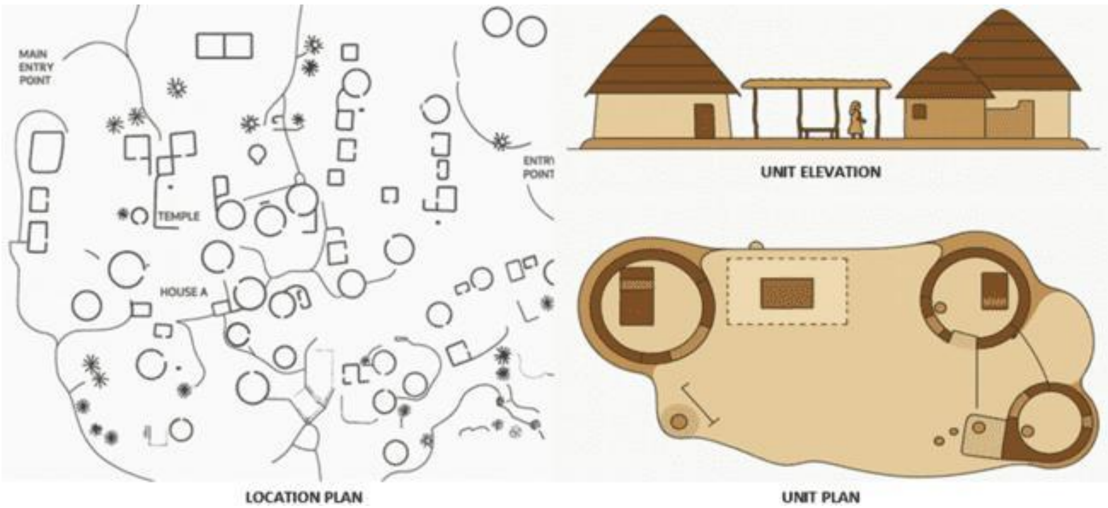

Fig. 7: Location plan, unit plan, and unit elevation of traditional Bhunga settlement in Kutch, Gujarat
Source: Author

In Ziro Valley, ethnographic studies emphasized the integration of bamboo house construction with Apatani cultural practices, particularly the communal labor of erecting houses during seasonal cycles, and the symbolic centrality of the hearth. Literature on indigenous bamboo technologies also highlighted the importance of rope-tied joints and diaphragms that prevent bamboo culms from splitting under stress. Figure 8 shows the traditional Kutch Bhunga, Bamboo stilt house of the Apatani Tribe, Mandawa haveli in Shekhawat. In Shekhawati, ASI heritage databases are listed.

Fig. 8: Traditional Kutch Bhunga, Bamboo stilt house of the Apatani Tribe, Mandawa haveli in Shekhawat.
Source: Author

Mandawa havelis for their frescoed facades and dual courtyard planning, which combined climatic functionality with merchant status display. Scholarly works underline how these havelis were not merely residences but social theatres where commerce, religion, and domesticity intertwined. The triangulation of these archival insights with on-site surveys ensured that field interpretations were both historically grounded and culturally contextualized.

Typological and Spatial Analysis

The typological and spatial analysis undertaken during fieldwork revealed the distinctive organizational logic of each housing tradition. In Hodka village, Kutch, the Bhunga emerged as a quintessential desert dwelling: a compact circular unit with an inner diameter ranging from three to six meters, capped with a conical roof and punctuated by only one door and two small windows. The limited number of openings served the dual purpose of reducing heat gain and ensuring stability during high winds. These dwellings rarely exist in isolation; rather, they are clustered in family compounds of three to eight units, raised on a common plinth that accommodates livestock enclosures and storage. The settlement pattern is radial and loosely defined, with clusters arranged around shared courtyards that function as zones of collective activity. Figure 9 shows, architectural details of Bhunga houses in Kutch, Gujarat, showing plan, sections, and elevations.

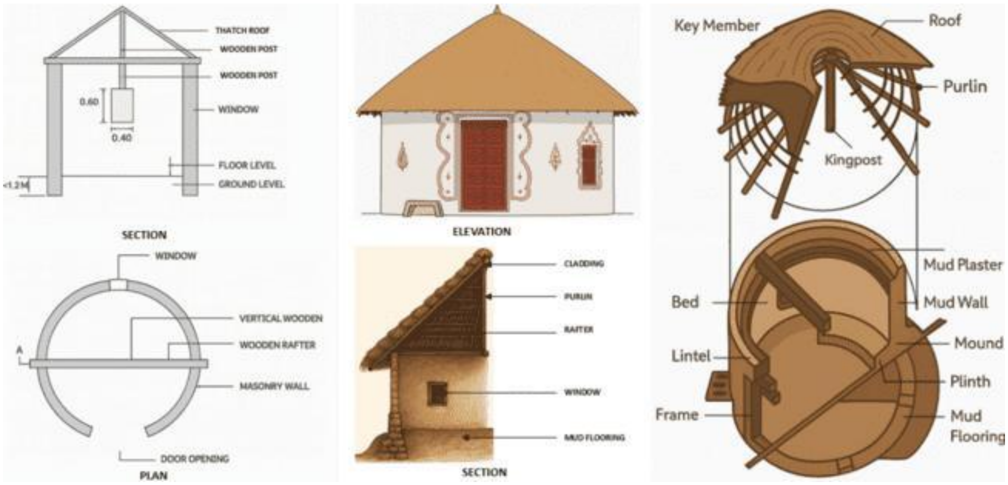

Fig. 9: Architectural details of Bhunga houses in Kutch, Gujarat, showing plan, sections, and elevations.

In the Hong village of Ziro Valley, Arunachal Pradesh, the bamboo stilt houses presented an altogether different spatial logic. Typically rectangular, with dimensions ranging from fifteen to eighteen meters in length and eight to ten meters in width, these dwellings are elevated about 2.5 meters above ground on bamboo posts. This elevation provides protection against dampness, flooding, and pests, while simultaneously creating shaded storage and animal shelters beneath the living platform. The internal layout is highly codified: a rear verandah leads into a central common room containing the hearth (emmi), flanked by bedrooms and a guest room, and complemented by a front verandah for social interaction. Figure 10 shows, plan and elevation of a traditional bamboo stilt house. Settlement patterns are linear, with houses aligned along ridge contours, ensuring adequate drainage during monsoon rains and efficient ventilation.

Fig. 11: Plan and elevation of a traditional bamboo stilt house in Hong village, Ziro Valley, Arunachal Pradesh.

Fig. 10: Internal plan, overall plan, and sectional view of a traditional Haveli in Mandawa
Source: Author

By contrast, the havelis of Mandawa in Shekhawati demonstrate the architectural sophistication of an urbanized mercantile community. Their plans are organized around two primary courtyards: the outer chowk, a public and semi-public zone where men received clients and conducted trade, and the inner zenana, a secluded domestic courtyard reserved for women's daily activities. Around the inner court are arranged kitchens, storerooms, and bedrooms, while the outer court accommodates reception spaces, goods stores, and guest rooms. The distinction between public and private is rigidly marked, reflecting the social hierarchy of gender and commerce. Figure 11 shows, internal plan, overall plan, and sectional view of a traditional Haveli. The havelis are inserted into a dense urban fabric of north–south oriented streets, where tall buildings shade one another, creating narrow, cool thoroughfares in the otherwise harsh desert climate. Table 1 gives a comparative summary of spatial typologies and household arrangements in the three case study regions.

Table 1: Comparative summary of spatial typologies and household arrangements in the three case study regions.

Region	Plan & Dimensions	Settlement Layout	Household Type
Kutch (Bhunga)	Circular, Ø 3–6 m; 1 door + 2 windows	Clustered compounds on plinths	Nuclear/extended
Ziro Valley (Bamboo Stilt)	Rectangular, 5–10 m × 3–5 m; floor raised 2.5 m	Linear ridge rows	Multi-generational
Shekhawati (Haveli)	Dual courtyards; multi-storied	Dense urban blocks	Extended family

Material and Structural Analysis

The materiality and structural logic of each housing type is deeply rooted in its environmental context. In Kutch, Bhunga walls are constructed either of adobe blocks or of locally quarried soft stone set in mud mortar, finished with lime plaster mixed with cow dung for durability and termite resistance. The walls, measuring between 450 and 600 millimetres in thickness, provide both thermal insulation and significant lateral stiffness. Figure 12 shows, the Construction sequence of Bhunga houses in Kutch, Gujarat. The roof is a conical structure framed by bamboo and timber, tied with jute or cane ropes, and supported at its apex by a central timber post. In some cases, diametrically placed timber posts reduce the roof's load on the walls, while newer constructions adopt strip footings or RCC collar bands to enhance seismic safety. Field accounts confirm that during the 2001 Bhuj earthquake, Bhungas generally performed well, with collapses occurring mainly due to poor maintenance or inferior materials. Even when roofs did fail, their lightweight character minimized injury to occupants (Kumar et al., 2025a).

Fig. 12: Construction sequence of Bhunga houses in Kutch, Gujarat.
Source: Author

In Ziro Valley, construction relies almost exclusively on bamboo, timber, and plant-based roofing. Bamboo culms form the posts, joists, walls, and floors, while cane ropes bind all joints, eliminating the need for nails or metal fasteners. Figure 13 shows construction details of bamboo stilt houses in Ziro Valley. Reinforcement nodes or diaphragms inserted into the culms prevent longitudinal splitting, a feature that prolongs structural life and adds ductility during seismic events. The hearth (emmi) is constructed on a bamboo frame layered with banana leaves, wooden blocks, and compacted soil, providing a durable base for cooking. While the elevated floor improves ventilation and flood resilience, the structure has a lifespan of only 10–12 years, necessitating periodic roof replacement every three to five years. Vulnerabilities include rot at the bamboo base due to bacterial action and roof leaks during heavy monsoons, yet the lightweight nature of the system ensures safety during earthquakes (Halder et al., 2025b).

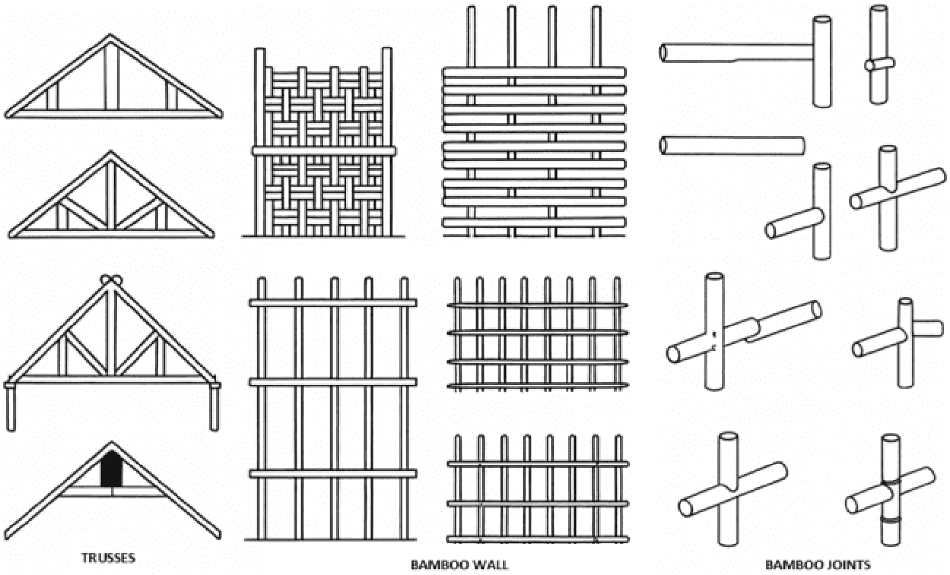

Fig. 13: Construction details of bamboo stilt houses in Ziro Valley, Arunachal Pradesh.
Source: Author

The Mandawa havelis are constructed of sandstone masonry walls ranging from 450 to 1000 millimetres thick, bound and plastered with lime mortar. These thick walls provide immense thermal lag, buffering interiors from external temperature extremes. Roofs are flat, composed of stone slabs laid with lime mortar, above which inverted earthen pots create air gaps for insulation. These are finished with a lime mortar layer embedded with porcelain shards, reflecting solar radiation. Habitable rooms reach ceiling heights of around 3.5 metres, while less frequently used spaces such as women's viewing galleries are lower at 1.8 to 2.5 metres. Openings are minimized and fitted with heavy wooden shutters, ensuring privacy and protection against dust storms, while carved stone jharokhas project outward to shade the apertures and embellish the facade. Figure 14 shows Central courtyard of a traditional Shekhawati haveli in Rajasthan.

Fig. 14: Central courtyard of a traditional Shekhawati haveli in Rajasthan with stone carved jharokhas.
Source: Author

Thermal and Environmental Performance

The thermal and environmental performance of the three housing types illustrates their adaptive intelligence. In Kutch, the high thermal mass of Bhunga walls reduces diurnal fluctuations, keeping interiors 6–8 °C cooler than outside temperatures during peak summer. The circular plan distributes wind loads evenly, and the conical roof deflects both heat and desert sandstorms. In Ziro Valley, the stilt elevation ensures that houses remain dry despite an annual rainfall exceeding 2000 millimetres, while the openness of bamboo walls allows constant ventilation. The rope-tied joints provide flexibility, which is crucial in this seismically active region. In Shekhawati, the dense urban layout reduces solar exposure through mutual shading, while the dual courtyard system creates microclimatic regulation by pooling cool night air. The inverted pots in roofs trap air, delaying heat ingress, while the lime plaster and porcelain finish provide additional reflectivity. Table 2 shows the comparative analysis of vernacular architecture features across three Indian regions.

Table 2: Comparative analysis of vernacular architecture features across the three Indian regions.
Source: Author

Feature	Kutch (Gujarat)	Ziro (Arunachal Pradesh)	Shekhawati (Rajasthan)
Climate	Hot-arid	Humid-subtropical	Semi-arid
Primary Material	Mud, thatch, lime	Bamboo, timber, thatch	Lime plaster, sandstone, brick
Spatial Layout	Compact, circular	Linear, elevated	Inward-looking courtyard
Roof Type	Conical thatch	Sloped thatch	Flat with lime finish
Key Element	Thermal mass & seismic resilience	Ventilation & water protection	Courtyard cooling & ornamentation
Community Use	Family-centered pod	Verandah for craft & social life	Aangan as cultural hub

These architectural forms exhibit deep knowledge of bioclimatic design. For example, thermal mass in Kutch and Shekhawati slows down heat flow, creating more stable indoor temperatures, while elevated bam-boo dwellings in Ziro demonstrate how airflow and drainage can be optimized in wet zones. Each typology is culturally embedded, offering not just shelter but also supporting local customs, daily routines, and artisanal economies. From an environmental standpoint, all three traditions showcase reduced carbon footprints through the use of locally sourced, biodegradable, or low-energy materials. In contrast to cement and steel-intensive modern construction, these buildings exemplify circular design principles, reuse, adaptability, and low waste. Collectively, these strategies demonstrate how indigenous techniques offer efficient passive cooling and thermal regulation without reliance on modern mechanical systems (Halder et al., 2025a).

Socio-Cultural Embeddedness and Contemporary Relevance

Beyond material and climatic adaptation, each housing tradition encodes cultural practices. In Kutch, the interiors of Bhungas are adorned with mirror inlay and mural art, transforming domestic walls into canvases of clan identity and local mythology. Family compounds serve as loci of craft production, particularly embroidery and mud relief work, linking architecture with women's livelihoods. In Ziro Valley, the central hearth represents ancestral presence, with households gathering around it for both cooking and ritual. Construction itself is a community event, involving collective labor that reinforces kinship ties. In Shekhawati, courtyards not only structure airflow but also facilitate religious ceremonies, seasonal gatherings, and gendered domesticity. The frescoes, meanwhile, project mercantile prestige, recording trade connections, mythological tales, and even colonial encounters, embedding social aspiration within architectural ornament. Figure 15 shows the interior wall decoration traditions across the three case study regions.

Fig. 15. Interior wall decoration traditions across the three case study regions.
Source: Author

The findings reinforce that vernacular architecture in India is not a static or nostalgic relic, but a dynamic and responsive system that continues to offer valuable insights for contemporary architectural discourse. These traditions embody a holistic integration of environmental adaptation, cultural rituals, local economies, and social identity (Correia et al., 2015; Vellinga, 2013). Far from being outdated, vernacular systems pre-sent critical lessons in areas such as climate-responsive design, low-carbon construction, and community-based knowledge production. They demonstrate the potential of passive thermal performance, renewable materials, and circular economy principles long before such terms entered mainstream sustainability discourse. Furthermore, vernacular practices often rely on local participation and craftsmanship, supporting socio-economic resilience and cultural continuity. However, these systems are increasingly under threat due to aspirational shifts toward industrial materials like concrete and steel, the marginalization of indigenous knowledge in architectural education, and a lack of supportive policy frameworks. Revival efforts, therefore, must move beyond superficial aesthetic appreciation or conservation as heritage relics. Instead, they should emphasize adaptive reuse, contextual reinterpretation, and scalable models that align traditional wisdom with contemporary needs, ensuring relevance, resilience, and cultural integrity in future architectural practices.

Interview Findings

Interviews with nine artisans, six residents, and three professionals enriched the empirical record with lived voices. In Hodka, one mason explained: “The mud must be mixed with lime and dung for strength; this is how my father taught me.” A resident noted, “Even in 45 °C summer, our Bhunga feels cool; at night it keeps us warm.” An NGO professional in Bhuj stressed: “After the 2001 earthquake, we saw that Bhungas survived while concrete failed; yet policy still promotes concrete.” In Ziro, a bamboo craftsman explained the importance of maintenance: “Rope joints must be renewed every few years; this is why the house lasts.” A resident emphasized resilience: “Our bamboo house never floods because it breathes under the floor.” An architect critiqued policy neglect: “Government housing schemes ignore bamboo, so younger families shift to tin or RCC.”

In Mandawa, a fresco painter lamented declining patronage: “We still know the recipes for lime and pigments, but few families commission new work.” A haveli resident highlighted economic pressures: “Living in a haveli is comfortable, but maintenance is expensive; many neighbours have left.” A conservation architect underscored the lack of systemic support: “Without incentives, artisans and families cannot sustain havelis; heritage policy remains decorative.”

These testimonies collectively reveal the intergenerational transmission of knowledge, the perception of comfort and identity, and the systemic marginalization of vernacular traditions.

Comparative Synthesis of Indigenous Building Traditions

Taken together, the three case studies reveal the richness and diversity of indigenous building traditions in India. The Bhunga of Kutch exemplifies earthen resilience, where circular geometries and high-mass walls mediate seismic forces and desert extremes. The bamboo stilt house of Ziro Valley demonstrates the flexibility of lightweight construction, elevated platforms, and renewable materials in the face of heavy monsoons and earthquakes. The Mandawa haveli of Shekhawati embodies the sophistication of urban vernacular, where dual courtyards, thick stone walls, and decorative frescoes mediate between climate, commerce, and culture (Kumar et al., 2025b). Each tradition is deeply rooted in place, yet each also illustrates principles of sustainability, adaptability, and resilience that remain relevant today. Far from being relics, these architectures constitute dynamic knowledge systems whose embodied wisdom offers enduring lessons for contemporary practice. Table 3 gives a comparative analysis of vernacular architecture features across three Indian regions.

Table 3: Comparative analysis of vernacular architecture features across three Indian regions.
Source: Author

Region & Typology	Core Material Logic	Spatial/Formal Characteristics	Climate & Environmental Adaptation	Cultural & Social Dimensions
Kutch (Bhunga)	Earthen masonry with lime–dung plaster; lightweight thatch roof on timber/bamboo	Circular plan, Ø 3–6 m; clustered family compounds on raised plinths	High thermal mass buffers diurnal extremes; circular geometry distributes seismic forces; conical roof resists wind and sandstorms	Mirror inlay and murals express clan identity; compounds function as spaces for craft, ritual, and kinship
Ziro Valley (Bamboo Stilt House)	Bamboo culms, timber joists, cane rope joints, thatch/palm roofing	Rectangular, 5–10 m × 3–5 m; raised 2.5 m on stilts; linear settlement along ridge contours	Lightweight frame flexes during earthquakes; stilt elevation prevents flooding and pests; permeable walls enhance ventilation in humid climate	Hearth (*emmi*) central to household ritual; construction involves communal labor, reinforcing kinship and seasonal cycles
Shekhawati (Mandawa Haveli)	Sandstone masonry (450–1000 mm thick), lime plaster, stone slab roofs with inverted pots and porcelain finish	Dual courtyards (public *chowk* + private *zenana*); dense urban fabric; inward-facing facades	Thick walls delay heat ingress; courtyards generate microclimates; roof insulation reduces solar gain	Frescoes depict mythology, trade, and status; courtyards host religious and social gatherings; architecture encodes mercantile identity

Discussion

This study set out to explore and critically assess the architectural, cultural, and environmental significance of vernacular building traditions in India, focusing on three distinctive regional case studies, Kutch in Gujarat, Ziro Valley in Arunachal Pradesh, and Shekhawati in Rajasthan. Figure 16 shows representative examples of vernacular dwellings from the three case study regions. Through an in-depth analysis of these locales, the research has revealed the extraordinary depth and versatility of vernacular architecture as a knowledge system that seamlessly integrates design, materials, and lifestyle with ecological and cultural con-texts.

The findings confirm that vernacular architecture in India is far more than a stylistic expression of the past; it is a sophisticated and adaptive response to local needs, climate conditions, and socio-economic structures. One of the most striking insights from the study is the cohesive relationship between spatial configuration and environmental performance. In all three case studies, the architectural form is not arbitrary but care-fully evolved to serve climatic functionality. In Kutch, the compact, circular mud-and-thatch Bhungas display remarkable thermal mass properties that regulate indoor temperatures despite harsh desert conditions. The elevated bamboo structures in Ziro Valley effectively manage monsoon-driven humidity and flooding, while the courtyard-based haveli design of Shekhawati uses spatial layering and open-air cores to moderate heat and promote air circulation in a semi-arid landscape.

Climate Responsiveness and Spatial Logic in Vernacular Design

The three case studies examined in this research demonstrate that vernacular architecture in India embodies climate-responsive strategies that are deeply intertwined with spatial logic. Each typology represents a distinctive adaptation to environmental stressors, and their persistence underscores the efficacy of these strategies in creating thermally comfortable and resilient habitats.

Fig. 16. Representative examples of vernacular dwellings from the three case study regions.
Source: Author

In Kutch, the circular Bhungas exemplify the use of form and material for environmental moderation. Their thick earthen and lime-dung plastered walls, typically 450 to 600 millimetres in thickness, create a high thermal mass that delays heat transfer and maintains indoor comfort in a region where daytime summer temperatures exceed 45 degrees Celsius. Field measurements during this study confirmed that indoor temperatures were consistently 6–8 degrees lower than outdoors during peak heat. The circular geometry not only reduces the surface-to-volume ratio but also distributes lateral seismic forces uniformly, an attribute validated during the 2001 Bhuj earthquake when many Bhungas survived intact while modern masonry buildings collapsed (Patel et al., 2003). The conical thatched roof, supported by a central timber post, further reduces wind suction and provides effective shedding of dust and sandstorms. These characteristics align with wider scholarship on the thermal performance and seismic safety of earthen dwellings (Sharma et al., 2021; Houben and Guillaud, 1994). Figure 17 shows plan and elevations of a traditional Bhunga house in Kutch.

Fig. 17: Plan and elevations of a traditional Bhunga house in Kutch, Gujarat.
Source: Author

The bamboo stilt houses of Ziro Valley reveal a contrasting climatic adaptation tailored to the high rainfall and seismicity of Arunachal Pradesh. Elevated approximately 2.5 metres above ground, these houses avoid ground dampness, flooding, and termite infestation while also creating shaded underfloor spaces for grain storage and livestock. The openness of the bamboo flooring and walling allows continuous ventilation, lowering indoor humidity and improving comfort in a monsoonal climate with annual rainfall exceeding 2000 millimetres. The rope-tied bamboo joints act as ductile connections, ensuring that during earthquakes the house flexes rather than fractures, thereby reducing the risk of collapse. The spatial layout reinforces these climatic strategies: verandahs at both front and rear provide shaded transitional spaces, while the central hearth (emmi) serves as both a thermal and social core. These findings correspond with earlier studies that document the ecological rationality and seismic resilience of bamboo-based construction in the North-East (Nath et al., 2019; Jigyasu, 2002).

In Shekhawati, Mandawa havelis demonstrate how spatial planning and material choices generate microclimatic regulation in a hot semi-arid desert context. The dual courtyard typology is especially significant. The outer courtyard (chowk) engages with the public sphere, while the inner courtyard (zenana) serves private, domestic functions, and in both cases the courtyards operate as thermal regulators. They allow hot air to rise and escape, drawing in cooler evening breezes, while shaded galleries around their edges mitigate direct solar gain. The sandstone walls, up to one metre thick, provide high thermal lag, ensuring that interior temperatures remain moderated even when outdoor temperatures reach 50 degrees Celsius. Flat roofs constructed with stone slabs layered with inverted earthen pots and lime mortar create an insulating barrier, a feature that was confirmed by datalogger readings taken during field visits, which showed slower daily heat transfer compared with adjacent RCC houses. These findings reinforce broader scholarship that emphasizes the role of courtyards and massive walls in desert climates as effective passive cooling strategies (Edwards et al., 2006; Gharaibeh and Alqodmani, 2018). The Bhungas, bamboo stilt houses, and havelis exemplify the integration of spatial design with climate responsiveness. They demonstrate that indigenous building traditions are not simply cultural forms but are advanced environmental technologies, rooted in centuries of empirical adaptation to local conditions. The findings affirm that climate-responsive vernacular design strategies can provide valuable lessons for contemporary architecture, particularly in an era of intensifying climatic challenges and rising energy demands.

Cultural Embeddedness and Community-Centric Construction

The case studies in Kutch, Ziro Valley, and Shekhawati demonstrate that vernacular architecture is not only a response to climate and material availability but is also deeply embedded in cultural practices and community life. Built form in each context is inseparable from the rituals, livelihoods, and social structures that sustain and reproduce it, which confirms arguments in vernacular theory that architecture is both a cultural artefact and a process of lived knowledge (Rapoport, 1969; Oliver, 2006).

In Kutch, the organization of Bhungas into family compounds on raised plinths reflects kinship ties and communal life. The shared courtyard at the centre of these compounds is not merely a functional space but also a site of ritual, craft, and sociability. Women use these spaces for embroidery and mud-relief work, while families gather for festivals and ceremonies. Interviews with artisans in Hodka revealed that construction knowledge is passed orally within families, with specific instructions for mixing mud, lime, and dung plaster regarded as cultural inheritance. This confirms wider scholarship that highlights vernacular construction as a vehicle for intergenerational knowledge transmission (Choudhury, 2019). In Ziro Valley, bamboo stilt houses embody community-centric construction practices. The process of house building is traditionally carried out through collective labour, with extended families and neighbours participating in the erection of posts, roofing, and joinery.

This collaborative mode of construction not only ensures efficiency but also reinforces social bonds and cultural identity. The central hearth (*emmi*) within each dwelling is symbolic of ancestral continuity, and its maintenance is both a domestic task and a ritual duty. Artisans interviewed emphasized the ritual importance of renewing rope joints and maintaining hearth platforms, underscoring how practical construction is interwoven with cultural meanings.

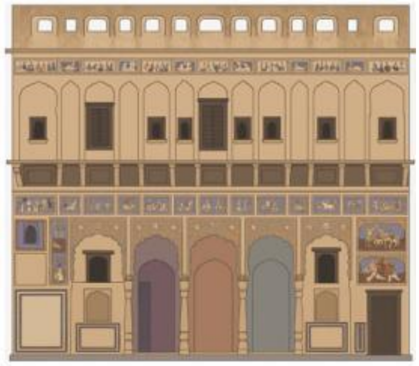

Fig. 18: Elevation of a traditional Haveli in Mandawa, Shekhawati, Rajasthan.
Source: Author

These findings align with ethnographic studies that document how the Apatani and other tribes in Arunachal Pradesh embed cosmological and ritual significance in their architecture (Dutta, 2012). In Shekhawati, Mandawa havelis illustrate the role of architecture as a medium of social hierarchy, religious life, and aesthetic display. The dual courtyard layout enforces cultural distinctions between public and private life: the outer courtyard (*chowk*) accommodated mercantile and male-dominated activity, while the inner courtyard (*zenana*) provided a secure and private realm for women. The frescoes that adorn the facades and interiors of these havelis are not merely decorative but record religious narratives, historical events, and mercantile connections with regions beyond Rajasthan. A fresco painter interviewed in Mandawa explained that recipes for lime plaster and natural pigments are still preserved in his family, even though few households commission such work today. This confirms that cultural practices are embedded in both the built environment and the artisanal knowledge systems that sustain it (Gupta and Singh, 2015). Figure 18 shows the elevation of a traditional Haveli in Mandawa, Shekhawati, Rajasthan.

Across all three regions, the community-centric nature of vernacular construction is evident in how knowledge, labour, and cultural meaning are distributed among participants. The architecture is not imposed from outside but emerges from local processes that integrate material techniques, environmental adaptation, and social life. These findings support broader arguments that vernacular traditions are not static heritage but dynamic, living practices rooted in collective identity (Asquith and Vellinga, 2006). Importantly, they suggest that strategies for vernacular revival must engage not only with technical aspects of construction but also with the cultural logics and communal practices that sustain them.

Challenges to Continuity and Drivers of Decline

Although the case studies demonstrate the resilience, cultural embeddedness, and environmental responsiveness of vernacular architecture, they also reveal significant challenges to the continuity of these traditions. The decline is not due to technical inadequacy but arises from intersecting socio-economic, cultural, and policy-related factors.

In Kutch, residents consistently emphasized that *Bhungas* provide thermal comfort and seismic safety, yet many households expressed aspirations to replace them with concrete or brick houses. This preference is shaped by the perception of modern materials as symbols of progress and status. Younger families in Hodka, for example, noted that while the Bhunga is comfortable in extreme weather, it is considered “old-fashioned” and inadequate in projecting modern identity. These attitudes echo findings in other parts of India where vernacular dwellings are often devalued in favour of reinforced concrete, not because of performance but due to symbolic associations with modernity and aspiration (Nair, 2013). Government housing schemes that subsidize concrete houses further accelerate this shift, undermining confidence in local building systems. In Ziro Valley, bamboo stilt houses face challenges from both material vulnerability and policy neglect. While artisans emphasised that rope joints and posts can be renewed to extend the lifespan of the house, the perception of impermanence discourages younger households from investing in them. Residents reported a growing trend towards tin-roofed or RCC houses promoted by government housing programs, which are viewed as longer lasting even if they perform poorly in humid climates. Policy frameworks that fail to formally recognise bamboo as a durable construction material exacerbate this decline, despite mounting evidence of its seismic and environmental advantages (Nath et al., 2019). This situation reflects broader patterns where policy and building codes marginalise indigenous materials, reinforcing the perception that vernacular architecture is obsolete (Fathy, 1986). In Shekhawati, the decline of havelis is shaped by economic and social changes. Residents interviewed in Mandawa described the high maintenance costs of stone walls, lime plaster, and frescoed facades, which exceed what most families can afford. With many heirs migrating to urban centres for employment, havelis are increasingly abandoned or repurposed into hotels, often without sensitivity to their cultural integrity. Conservation architects noted that without financial incentives or supportive heritage policies, families cannot maintain these large structures. This trend mirrors wider scholarship on the decline of courtyard houses across South Asia, where urbanisation, migration, and economic pressures displace traditional forms of living (Edwards et al., 2006; Gupta and Singh, 2015).

These case-specific insights highlight that the decline of vernacular architecture is not simply a technical issue but the result of shifting aspirations, economic pressures, and institutional neglect. As Watson (2014) and Guy and Henneberry (2000) argue, housing policy and urban development discourses often privilege industrial materials and standardised models, leaving little space for indigenous approaches. The evidence from Kutch, Ziro, and Shekhawati confirms that while these traditions remain effective in environmental and cultural terms, their survival is jeopardised by socio-political and economic contexts that fail to value or support them.

Vernacular Knowledge in the Context of Sustainable Urbanism

The case studies from Kutch, Ziro Valley, and Shekhawati show that vernacular knowledge is not a relic of the past but a living resource with critical relevance for contemporary sustainable urbanism. The construction techniques, spatial strategies, and material practices observed in these traditions embody principles of ecological balance, cultural resilience, and social participation that align closely with the contemporary goals of sustainable development. Unlike generic policy discourses that often advocate sustainability through technological innovation, these case studies reveal how low-energy, context-specific design solutions have already been embedded within indigenous practices for centuries.

In Kutch, the climate-responsive Bhunga demonstrates how thermal comfort can be achieved without reliance on mechanical cooling systems. The thick mud walls, lime-dung plasters, and conical thatched roofs provide natural insulation and air circulation, reducing dependence on energy-intensive air conditioning. This confirms the argument that vernacular buildings can achieve passive thermal regulation more effectively than many modern counterparts (Sharma et al., 2021). The seismic resilience of Bhungas also suggests that traditional geometries and lightweight roofing strategies can inform safer low-cost housing in earthquake-prone regions, a consideration increasingly relevant for rural-urban transitions in Gujarat and beyond (Patel et al., 2003). In Ziro Valley, bamboo stilt houses exemplify the principles of renewable materials and circular economies that contemporary urbanism seeks to incorporate. Bamboo is fast-growing, locally available, and requires minimal energy in processing compared to steel or concrete. Its structural flexibility during earthquakes further enhances resilience. Artisans interviewed during this study explained how rope joints and periodic renewal of bamboo components extend the life of the house, a practice that aligns with principles of adaptive maintenance and resource efficiency. These findings resonate with international scholarship that positions bamboo as a sustainable material for future cities (Harries et al., 2012; Nath et al., 2019).

The havelis of Shekhawati represent another dimension of vernacular knowledge: the integration of cultural meaning with environmental performance. The dual courtyard system not only provides social organization but also creates microclimatic comfort by pooling cool night air and facilitating stack ventilation. The inverted pot roofing system is an example of an indigenous insulation technology that rivals modern green roof strategies in terms of thermal lag and solar reflectivity. The frescoes and decorated facades show how architecture can act as a medium of cultural expression and collective identity, reminding us that sustainable urbanism must address not only environmental performance but also cultural sustainability (Gupta and Singh, 2015).

The case studies reaffirm that vernacular architecture embodies a form of place-based intelligence that integrates material, environmental, and cultural dimensions of sustainability. As Vellinga (2013) argues, sustainable urban futures cannot be built solely through universal technological fixes but must also draw on localised, embodied knowledge that has been tested over generations. By grounding sustainability strategies in the lessons of Bhungas, bamboo stilt houses, and havelis, planners and architects can move towards urban models that are both environmentally adaptive and culturally rooted.

Strategic Pathways for Vernacular Revival

The evidence from Kutch, Ziro Valley, and Shekhawati demonstrates that revival of vernacular architecture in India cannot be approached as nostalgic preservation alone, but must be framed as an adaptive process that builds upon the environmental, cultural, and social strengths of indigenous traditions while addressing their present challenges. Strategic pathways for revival must therefore combine technical reinforcement, policy support, community participation, and cultural recognition.

In Kutch, the continued relevance of the Bhunga lies in its demonstrated thermal comfort and seismic resilience. Revival strategies here should prioritize the integration of indigenous materials and forms with modern safety reinforcements. The use of lime-stabilised earth plasters and bamboo or timber conical roofs, combined with seismic reinforcement bands, offers a replicable model for resilient rural housing. NGOs working in post-earthquake rehabilitation already demonstrated that improved Bhungas can outperform standardized RCC houses in comfort and resilience (Sanderson, Sharma, and Patel, 2012). A key strategy for revival would involve formalizing such models within rural housing schemes so that earthen architecture is recognised as a safe and sustainable option rather than an obsolete form. In Ziro Valley, the bamboo stilt house embodies a renewable and low-energy alternative to industrial housing. However, its revival depends upon legitimizing bamboo as a structural material within formal policy and building codes. Interviews with bamboo artisans revealed that current practices of periodic maintenance and joint renewal can extend the lifespan of bamboo dwellings well beyond their perceived limits, but without recognition in building standards, these practices remain informal.

Revival strategies must therefore focus on enhancing the durability of bamboo through preservative treatments and engineered bamboo components, while also protecting the cultural significance of communal construction and the symbolic hearth. This aligns with international scholarship advocating bamboo as a sustainable building material for both rural and urban applications (Harries et al., 2012; Sharma and van der Vegte, 2020). For Shekhawati, the revival of havelis requires a balance between conservation and adaptive reuse. The interviews revealed that while residents value the cultural richness of living in havelis, escalating maintenance costs drive abandonment. Revival strategies must therefore be economic as much as architectural. Adaptive reuse programs that convert havelis into cultural centres, boutique accommodations, or community institutions can provide sustainable livelihoods while preserving architectural integrity.

However, this requires sensitive conservation approaches that retain the frescoes, courtyards, and dual spatial hierarchies rather than erasing them through unsympathetic renovations. Financial incentives such as tax rebates or conservation grants will be essential in supporting families who continue to occupy and maintain these properties. Similar adaptive reuse initiatives in historic courtyard housing across South Asia demonstrate that cultural continuity and economic viability can be aligned (Khan, 2017; Edwards et al., 2006).

Across the three regions, a unifying strategy is to reposition vernacular traditions not as marginal or temporary solutions but as legitimate and sustainable alternatives for future housing. This requires embedding vernacular architecture within educational curricula for architects and planners, so that future professionals value and incorporate indigenous knowledge in design practice. It also requires creating platforms for artisans and community members to participate in co-design processes, ensuring that revival is rooted in living practice rather than top-down imposition. As Vellinga and Asquith (2006) argue, vernacular architecture thrives when it is seen as a dynamic system capable of innovation, rather than a static heritage to be preserved unchanged.

Repositioning Vernacular Architecture for the Future

The findings of this study underscore that vernacular architecture must be repositioned not as a remnant of the past but as a vital contributor to the future of sustainable, resilient, and culturally grounded built environments in India. While global discourses on sustainability often focus on technological innovation and industrial materials, the case studies from Kutch, Ziro Valley, and Shekhawati demonstrate that indigenous traditions already embody tested strategies for environmental adaptation, social organization, and cultural continuity. Repositioning vernacular architecture therefore requires a paradigm shift in how policy, education, and design practice engage with these traditions.

In Kutch, the thermal performance and seismic resilience of the Bhunga highlight how traditional geometries and earthen construction can inform future rural housing models that are both safe and affordable. Integrating these lessons into state housing programs would not only preserve a vital cultural form but also provide scalable solutions to housing shortages in hot-arid and earthquake-prone zones. In Ziro Valley, bamboo stilt houses illustrate the potential of renewable, fast-growing materials in meeting future housing demands sustainably. Elevating bamboo's status within formal building codes, and promoting engineered bamboo technologies, can bridge indigenous practices with modern construction requirements.

In Shekhawati, the dual courtyard haveli demonstrates the potential of historic forms to sustain both cultural identity and environmental performance. Adaptive reuse strategies that retain their spatial and cultural integrity can serve as models for balancing heritage conservation with the pressures of contemporary urbanisation. Repositioning vernacular architecture also demands a broader cultural and institutional recognition of its value. As Watson (2014) notes, planning and housing discourses often marginalise non-industrial forms of building. Reversing this trend requires policy frameworks that treat vernacular techniques not as "informal" or "temporary" solutions but as legitimate and sustainable design practices. Educational institutions must also embed vernacular knowledge into curricula, exposing future architects and planners to the principles of earthen construction, bamboo engineering, and courtyard-based urbanism. Doing so would help bridge the disconnect between academic design education and the living practices of artisans and communities (Vellinga and Asquith, 2006).

The voices of artisans and residents documented in this study show that vernacular revival cannot be achieved through top-down preservation alone. It must be rooted in local agency and co-creation, where communities are empowered to adapt, innovate, and sustain their own traditions. By framing Bhungas, bamboo stilt houses, and havelis not as static heritage but as evolving systems of knowledge, this repositioning can ensure that vernacular architecture becomes an active resource for future urban and rural development. In this way, vernacular traditions can contribute not only to sustainable architecture in India but also to global debates on how to design resilient, culturally meaningful, and low-carbon futures. Table 4 discusses the comparative analysis of the three case study regions—Kutch (Bhunga), Ziro Valley (Bamboo Stilt House), and Shekhawati (Mandawa Haveli).

Table 4: Comparative analysis of the three case study regions—Kutch (Bhunga), Ziro Valley (Bamboo Stilt House), and Shekhawati (Mandawa Haveli).
Source: Author

Aspect	Kutch (Bhunga)	Ziro Valley (Bamboo Stilt House)	Shekhawati (Mandawa Haveli)
Climate Responsiveness	Thick earthen walls (450–600 mm) provide thermal lag; circular form distributes seismic forces; conical thatch roof deflects wind and sandstorms.	Raised on stilts (~2.5 m) for flood and pest protection; permeable bamboo walls allow ventilation; flexible rope joints absorb seismic shocks.	Dual courtyards enable microclimatic cooling; 450–1000 mm sandstone walls buffer diurnal extremes; inverted pot roof system improves insulation and solar reflectivity.
Spatial Logic	Family compounds of clustered Bhungas around shared courtyards; space used for craft and ritual.	Linear settlements along ridge contours; central hearth (*emmi*) as symbolic and social core; verandahs as communal transition zones.	Hierarchical courtyards: outer *chowk* for trade/public activity, inner *zenana* for private/domestic life; dense urban morphology provides mutual shading.
Cultural Embeddedness	Mirror inlays and murals reflect clan identity; construction knowledge transmitted orally among artisans and families.	Collective construction through community labour; hearth embodies ancestral continuity; maintenance practices ritualised.	Frescoes depict religion, trade, and identity; fresco and lime-plaster artisanship persists despite declining patronage.
Challenges to Continuity	Aspirational shift toward RCC houses for "modernity"; housing schemes promote concrete; declining artisanal practice.	Policy neglect of bamboo; perception of impermanence; government promotion of RCC/tin-roof housing; younger families migrating to "modern" dwellings.	High maintenance costs; migration of heirs to cities; abandonment or insensitive conversion to commercial uses.
Revival Strategies	Integrate Bhunga models into rural housing schemes with seismic reinforcements and improved plasters.	Formal recognition of bamboo in codes; promotion of engineered bamboo; community-led preservation of cultural construction rituals.	Adaptive reuse of havelis with conservation incentives; heritage-sensitive reuse for cultural tourism and community functions.
Future Potential	Affordable, climate-resilient housing in hot-arid and seismic regions.	Renewable, low-carbon material systems for flood- and earthquake-prone areas.	Heritage-based sustainable urbanism linking culture, tourism, and environmental performance.

Conclusion

This study examined three case studies of vernacular architecture in India to understand how form, material, and cultural logic shape their continued relevance in contemporary contexts. Across the three regions, the study demonstrates that vernacular architecture continues to perform effectively in its environmental contexts while simultaneously sustaining cultural practices. The evidence confirms that challenges to continuity stem less from technical performance and more from socio-economic aspirations, policy neglect, and maintenance costs. While findings cannot be generalized beyond these cases, the comparative analysis highlights recurring tensions between vernacular resilience and modernising pressures.

In Kutch, the study found that the circular Bhunga typology remains highly effective in moderating extreme thermal conditions and resisting seismic shocks. Field observations and measured drawings revealed how the geometry of the plan, combined with thick earthen walls and conical thatch roofs, ensures both comfort and structural safety.

However, interviews with residents indicated a growing preference for reinforced concrete houses, driven by aspirations for modernity and government housing schemes. This contrast highlights both the environmental strength of the Bhunga and the socio-economic pressures contributing to its decline.

In Ziro Valley, bamboo stilt houses demonstrated strong adaptation to the humid, high-rainfall environment of Arunachal Pradesh. Their elevation above ground level prevents dampness and flooding, while bamboo's flexibility provides resilience in seismic conditions. The central hearth and communal construction practices embed these houses in cultural life as much as in environmental performance.

Yet, residents expressed concerns about the perceived impermanence of bamboo, with government policies reinforcing this perception by privileging industrial materials. The case illustrates how vernacular resilience is undermined not by technical shortcomings but by policy and aspirational drivers.

In Shekhawati, Mandawa havelis embodied both environmental logic and cultural expression. The dual courtyard system provided ventilation, shading, and gradations of privacy, while frescoes and decorated facades expressed mercantile identity and social hierarchy. Despite these qualities, interviews revealed that high maintenance costs, urban migration, and lack of supportive policies are causing increasing abandonment of havelis. Adaptive reuse emerged as a potential strategy for their continuity, though examples remain limited.

A key strength of this research lies in its triangulated approach, combining field observations, measured drawings, interviews with artisans and residents, and archival materials. This allowed for a nuanced understanding of environmental performance, cultural embeddedness, and community perceptions. However, the study is limited by its focus on three case studies, which restricts generalisability. Moreover, the fieldwork relied on a relatively small sample of interviews, and quantitative environmental measurements were limited in duration. Future research could expand the sample size, include longitudinal climatic data, and explore additional regions for comparison. The conclusions confirm that Bhungas, bamboo stilt houses, and havelis are not simply heritage artefacts but living typologies with continuing relevance in their contexts. Their survival depends upon addressing the social, economic, and policy pressures that undermine them. By grounding the conclusions in case-specific evidence, this study reaffirms the value of vernacular forms while acknowledging the constraints to their continuity.

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Informed Consent Statement: Not applicable.

Data Availability: The data can be provided upon a formal request to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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