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Climate-Resilient Traditional Architecture: A Case of Dharamshala, India

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Abstract

The settlement typology of any region is determined by various climatic, cultural, and topographical dynamics. In mountainous regions, rapid and unregulated urban development often results in the emergence of an organic urban fabric that fails to meet the environmental needs of the area. It is important to thoroughly examine and analyse the traditional wisdom and techniques employed in designing buildings and settlements in mountainous regions. This study focuses on the exploration and understanding of traditional architecture in the hills of Dharamshala, India having composite climatic conditions. It aims at studying the role of traditional buildings, which are made of stone and mud having sloping roofs with bamboo and natural stone slates, in the context of resilience in disaster prone areas. The scope of this research is to establish the effectiveness of traditional building materials in maintaining the indoor comfort temperature in this region. A descriptive-interpretative approach was utilized to comprehensively understand and document the traditional designs and methods. Results show that half of the housing stock is still vernacular in form and traditional houses have 3°C - 4°C lower indoor temperatures in the hot season as compared to outdoor temperatures due to passive construction styles.

Keywords

Traditional architecture; Vernacular architecture; Community resilience; Hill regions; Built form, Resilience

1.Introduction

The increase in climatic disasters in mountainous regions caused by unregulated and spontaneous development has heightened the necessity to enhance the resilience of urban settlements. A critical priority lies in promoting innovation, awareness, and education to nurture a culture centred on safety and resilience within vulnerable urban hill settlements. The hilly region of Dharamshala, India is prone to earthquakes, landslides, and cloudbursts (Himachal Pradesh State Disaster Management Authority [HPSDMA], 2011) . It is essential to integrate an understanding of indigenous and scientific knowledge for developing social-ecological resilience (Bohensky & Maru, 2011). Understanding, managing, and adapting social-ecological system resilience methodologies in the phase of new environmental dilemmas should have wider discussions. Feedback about actions and environmental education must guide change in social-ecological systems (Krasny et al., 2010).

The current situation of rapidly increasing urbanization puts tremendous strain on hill towns with limited development potential. Additionally, this massive growth places a great deal of strain on the environment, infrastructure, and urban form, which also affects every other aspect of community wellbeing (Sharma et al., 2015). In the region, traditional construction techniques are losing their charm with a trend towards modern techniques and building materials (Mahajan et al., 2018). To preserve the economic character of hill towns, which is tourism-based, planning must be resilient and sustainable (Jain et al., 2010). While we embrace newer technologies from across the globe, often we abandon or ignore the wisdom inherent in traditional practices evolving over centuries (Sharma & Sharma, 2013). In terms of settlement planning and design of building units in the context of the extreme cold conditions of the hilly regions of the Himalayas, it is imperative that we identify, document, understand, and adopt the good practices and traditional wisdom (United Nations Office for Disaster Risk Reduction, 2015). This built form is a product of contextual factors like topography and climate (Singh & Sharma, 2019).

The increased natural hazards in the region due to changing climate, which includes landslides, cloudbursts, flash floods, extreme cold temperatures, and deviant rainfall, have impacted built form and livelihood practices (Choudhary, 2016). The purpose of our survey is to provide insight into the way traditional structures and settlements manage to withstand the cold and warm temperatures and seasonal water requirements, as well as the reasons they can withstand the long-term effects of disasters.

The domains of disaster, resilience, and vernacular are knitted together in a built environment. Resilient and vernacular settlements frequently experience considerable damage, but they also exhibit a high level of resilience since the afflicted individuals effectively cope with shocks by utilising their social capital and networks (Shinde, 2016). This study examines both recent and historical settlements in and around the Dharamshala region, focusing on the design of traditional buildings and historic settlements characterized by traditional patterns, constrained materials, and technologies from the past.

Our research delves into disaster preparedness through strategies for climatic resilience planning and design. It aims to aid in identifying suitable methods and actions to enhance the current situation while uncovering traditional approaches from the past that were effective in mitigating the impacts of disasters (Jain et al., 2005). By building resilient communities in hilly areas, this initiative also will direct a planned and methodical approach to reduce damages in the social and environmental sectors.

2.Literature

In India, national disaster management plans increasingly prioritize resilience, emphasizing the importance of communities and individuals in achieving disaster reduction (National Disaster Management Authority, 2016) . Past researchers have provided various definitions for the term “resilience”. Resilience can be defined as the capability of a system, community, or individual to endure, adapt to, and rebound from various challenges or adversities, all while retaining essential functions, structures, and identity. It involves the capacity to withstand stress, recover from setbacks, and potentially even emerge stronger after experiencing difficulties. This concept encapsulates both the ability to withstand the effects of adverse events and the potential for growth and adaptation in their aftermath (Razafindrabe et al., 2009) . According to Patel et al. (2017) , resilience can be defined as the capacity of a community exposed to hazards to withstand, absorb, and recover from their effects efficiently. It also is related to the efficiency needed to return to the desired functional level. Therefore, it is essential for society to enhance its understanding of climate change and its connection to planning patterns to build resilience against future challenges. The urban settlement layout in hilly regions is influenced by factors such as topography, climate, culture, socio-economic conditions, flora and fauna, accessibility, and visual attributes (Sharma et al., 2019). Recent changes in natural processes, combined with the evolution of intricate geo- and socio-ecological systems, have amplified the susceptibility of these areas to disruptive events. In recent times, settlement development patterns have shifted from traditional wisdom and vernacular ways to unplanned and economic-driven patterns (Kumar & Pushplata, 2013). A decline in the influence of factors such as slopes, climate, land use, urban form, energy consumption patterns, historical and religious significance, density distribution, and connectivity on planning decisions has been observed Dharmendra et al., 2016) . Most of the urban developments in India, on a small and medium scale, are driven by economic constraints and large interventions by political agendas. Urbanization and climate change are contributing to more frequent and intense precipitation events, which in turn increase the risk of floods and related damages (Bose et al., 2016).

This situation not only has altered the climatic conditions of the area but also has rendered cities vulnerable to climate-related risks. The exposure of the hill population to various hazards makes these settlements highly vulnerable. A study of the region shows that there is a high vulnerability index (SEEDS, 2009). The vulnerability index is basically a composite of multiple quantitative indicators.

An approach to resilience is enhanced by traditional knowledge, as historical constructions have proven their ability to withstand disasters effectively (Rautela et al., 2008). Vernacular architecture, by virtue of its development, is sustainable and resilient in nature (Rahul & Ahuja, 2014). The aim of this study is to develop effective climatic resilience considerations for framing strategies in the area to mitigate the hazards associated with climate change and enhance community preparedness. The purpose of the case study is to identify the roles and responsibilities of various agencies and stakeholders to comprehend current situations and propose future solutions to build resilience. By building resilient communities in hilly areas, this effort also will direct a planned and methodical approach to reduce losses in the social and environmental sectors.

3. Methods

The scope of this research is to establish the effectiveness of traditional building materials in maintaining the indoor comfort temperature in this region. A variety of evidence, including documentation, material usage, construction techniques, personal interviews, and observations, is utilised in the case study method. This helps to accumulate all the data and provide a wider understanding of the resilient vernacular-built environment (Yin, 2003).

The initial objective is to systematically map and document several climatic variables in the region to establish a basic understanding in context to traditional architecture. The second objective is to examine old house patterns to identify the material and design strategies. The third objective is to determine whether various existing systems and methodologies (both local and worldwide) have managed to mitigate the adverse repercussions of cloudbursts, landslides, and earthquakes. The final objective is to make recommendations of the considerations for context-based planning and design techniques that will lessen the negative effects of catastrophic events in the area under study.

To comprehend and document traditional methods and designs, a descriptive interpretative approach it was utilized, incorporating maps, sketches, plans, sections, and interviews (Sarkar & Bose, 2016). The investigation of the region’s case study involved conducting a primary survey and engaging with diverse stakeholders, a methodology like that utilized by other researchers (Kumar, 2014) .

The study also encompassed a review of available literature and scholarly articles. Secondary data sources were utilized to formulate strategies and action plans. Additionally, survey methods and interviews with various stakeholders proved instrumental in assessing the vulnerability of the area. In total, 100 households were interviewed regarding their understanding, perception, and knowledge of resilience as shown in Figure 1.

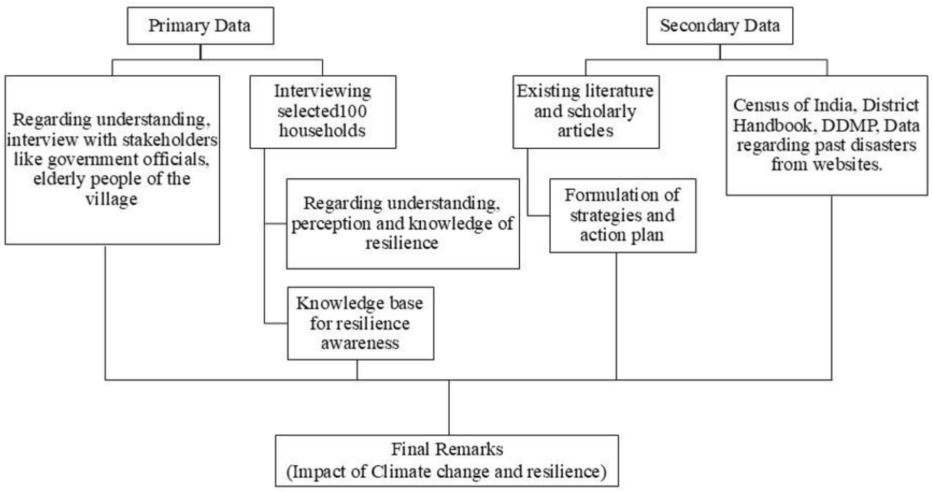

Figure 1. Flow chart showing the descriptive interpretative approach (Source: Author).

To keep the participation of the interviewer anonymous no personal information questions were asked throughout the survey. The survey results helped to document the current knowledge base for resilience awareness. Data analysis from census records, references to state and district-level literature, information gathered from websites, and consultations with stakeholders have contributed to the analysis and final remarks regarding the impacts of climate change and resilience.

3.1 Overview of Study Area

Dharamshala is one of the most climatically vulnerable towns in the region due to its topography and fragile ecosystem. It is one of the most picturesque settings in the hilly state of Himachal Pradesh. It is sheltered by the massive Dhauladhar range of mountains, which accounts for its pleasant weather. The climatic data for the area are shown in Figure 2. In recent years, the hilly region has experienced impacts of climate change. Geologically, the study area is situated within the extensive Alpine-Himalayan seismic belt.

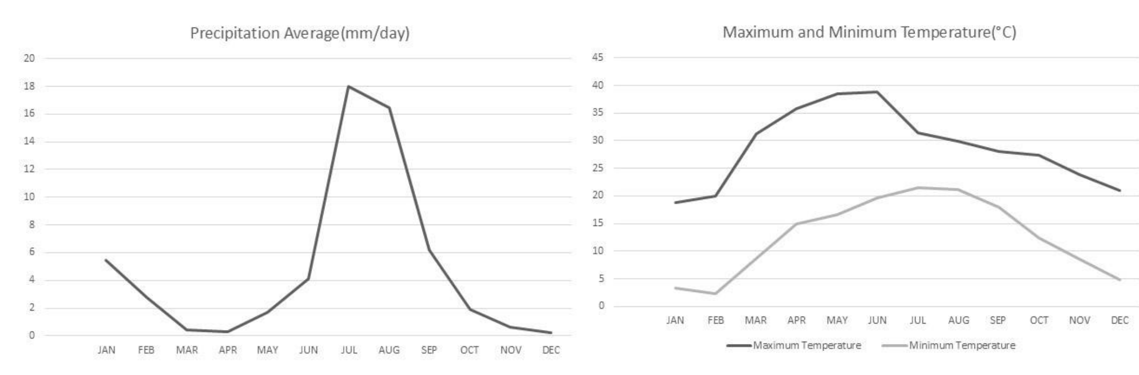

Figure 2. Climatic attributes of the region (Source: NASA Langley Research Center (LaRC, n.d.)).

This area is susceptible to a variety of natural hazards, including earthquakes, landslides, flash floods, storms, and dam failures. The hazards that pose the greatest threat, however, are the landslides and cloudbursts. The town also is a tourist attraction, and it is now the Dalai Lama's exile home. The case study area, Rajana Khas Settlement, is situated 36 km away from Dharamshala. As per 2011 statistics, Rajana Khas is a gram panchayat (cluster of a few villages) with a total geographical area of 194.61 hectares (Office of the Registrar General & Census Commissioner, India, 2011). It has a total population of 2694 people. There are about 590 houses in the study area. The extent of the study area along with the major road network is shown in Figure 3. At first glance, contour-based agriculture and residential development are quite evident from the satellite image. The average altitude of the area is 770m above MSL. The natural water stream acts as a lifeline for this settlement.

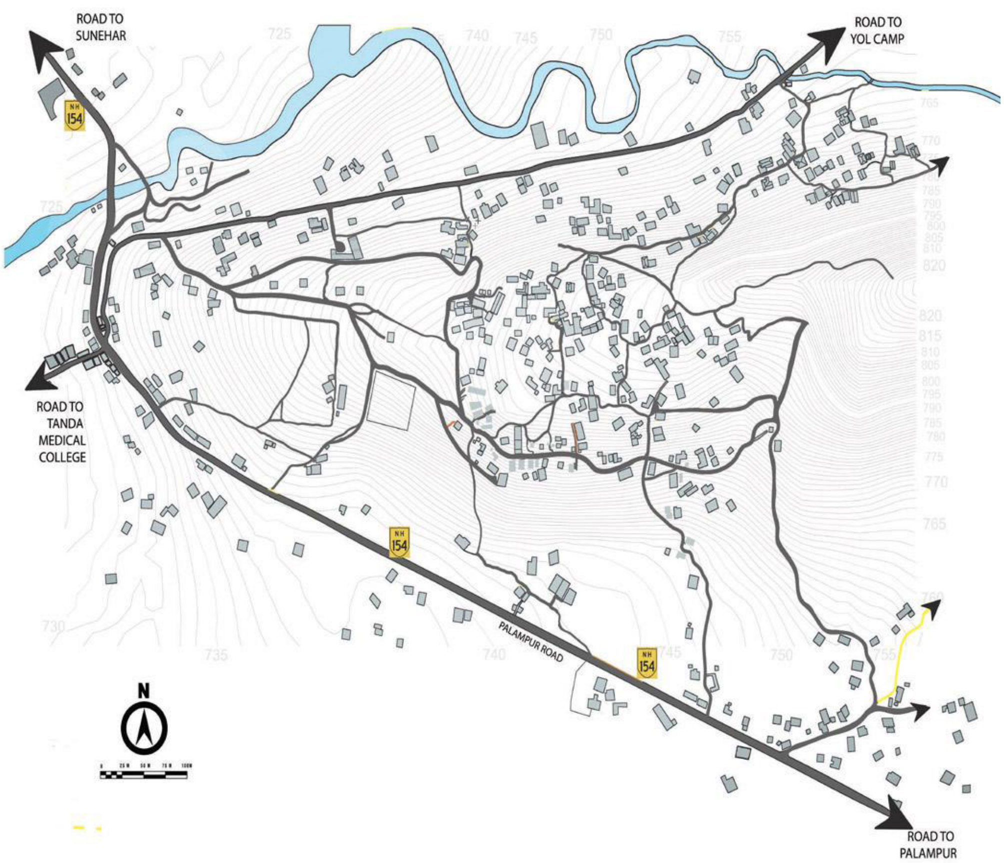

Figure 3. Location with contour map of study area (Source: Author).

4. Case Study Findings

The findings from the case study are examined across three levels or scales of the built environment. The case study has been summarised at the settlement scale (slope, orientation, settlement anatomy, built and open relations), the cluster scale (open space usage, built and open relations, cluster configuration, and spatial arrangement), and the unit scale (plan forms, roof forms, building materials, and construction techniques). The strategy that was created highlights the necessity of building community resilience to lessen and minimise the negative effects of climate change threats. According to the survey, half of the area's residents knew about crisis management plans, but they did not know much about resilience. The community and survey respondents were unaware of several issues with respect to resilience planning.

4.1 Settlement Pattern

It is a remote community with beautiful native buildings situated along a small network of roads. The settlement's design clearly reflects careful consideration of the natural topography. Houses are strategically positioned within the natural environment to minimize the need for extensive cutting and filling. Figure 4 shows that the settlement pattern is organic in nature and most of the internal roads are only pedestrian. Main roads are around the habitable area and that has been derived so that proximity to a perennial water source is maintained. The settlement pattern follows the terrain and moves along the contour and natural drainage pattern. The open spaces are used for agriculture, horticulture, and storing fodder, and the settlements work in harmony with the surrounding open stepped spaces. The green cover analysis shown in Figure 5 indicates that houses are constructed near farmlands and forest areas are protected towards the east end. In this community, the utilisation of natural springs is quite important. The springs are directed between the houses to create waterspouts, check dams, and tiny reservoirs. Additionally, the orientation pattern of clusters and individual houses maximises the amount of sunlight available in the courtyards and inside the houses. The buildings typically are small, two-story structures with plenty of open space around them for natural ventilation, sufficient lighting, and simplicity of access to the nearby agricultural fields.

4.2 Cluster Scale

The region is split up into Mohallas, or caste-based household groups. There are enough open areas around each cluster. Every cluster features a common area for gatherings, a kid-safe play space, a place for processing agricultural products, and several customs like performing local dance, worshiping local deity (Devta). The study was conducted through a physical survey of 100 households in the area. Cluster size varied from ten houses to twenty houses arranged in different manners based on land ownership. Enough space is maintained between the houses to ensure seclusion in this organically designed layout.

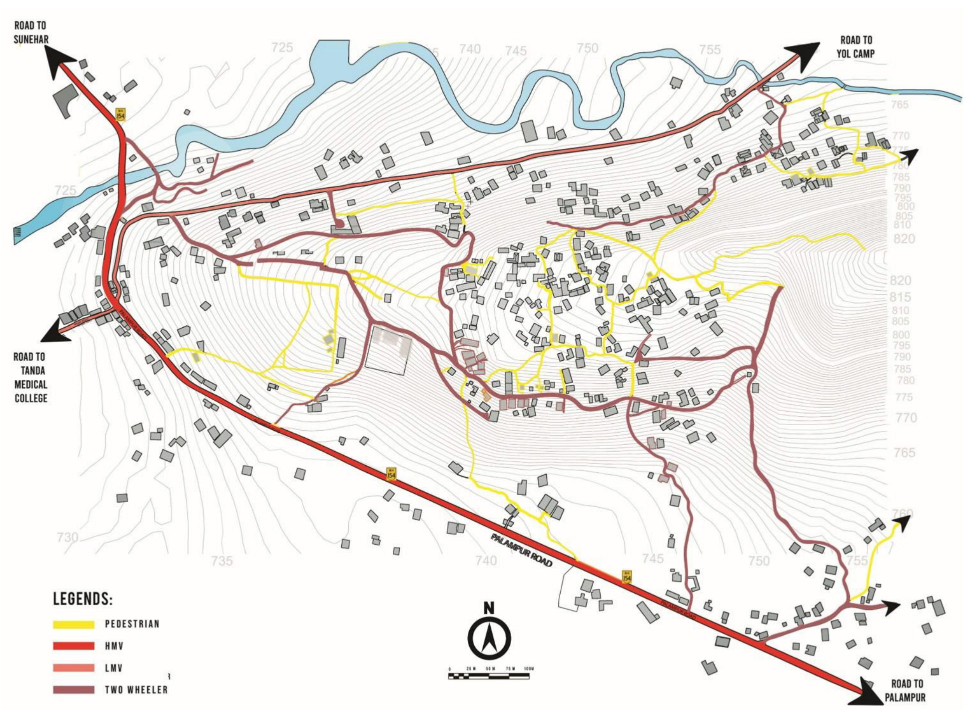

Figure 4. Vehicular and pedestrian accessibility map of study area (Source: Author). HMV. Heavy motor vehicle; LMV.Light motor vehicle

There are clustered open spaces between the houses to provide ample sunlight during the winter, as well as space for public activities. The houses predominantly face the south and south-west for heat gain during the winter. One of the study's key conclusions is that such old settlements still manage to preserve their sense of place.

Figure 5. Green cover analysis map of study area (Source: Author).

Figure 6 shows the physical and qualitative attributes of built form retrieved from the questionnaire survey, depicting that people are shifting towards modern construction methods. Space for community interactions provides strong interrelationships between built, semi-open, and open spaces. Such gently sloping villages use the stream flow to irrigate gardens and the surrounding agricultural fields, as well as to grind wheat flour following traditional methods. The current resilience strategies emphasise the importance of modern communications, historic building forms, and land use practices like planting trees and avoiding streams.

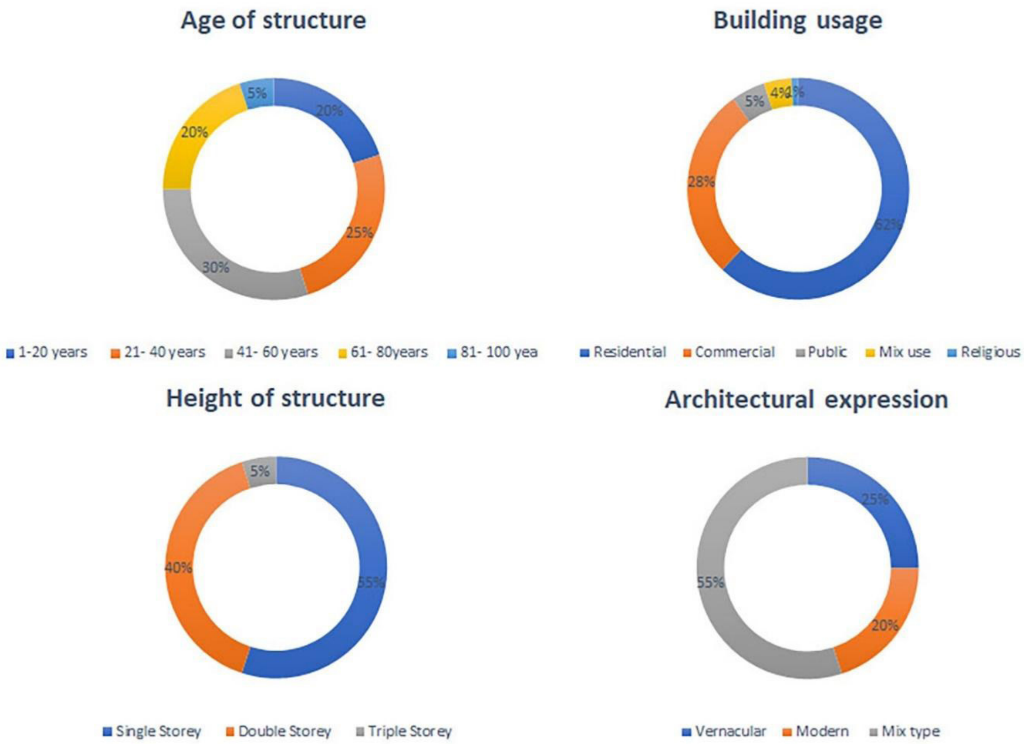

Figure 6. Physical and qualitative attributes analysis of built form (Source: Author).

4.3 Unit Scale

Every house has been developed by carefully selecting its slopes and orientation to maximise stability, maximise day light, and reduce the risk of landslides. The houses have a basic plan that is considered as most suitable for providing resilience to natural risks. Houses are surrounded by a lot of thoughtfully planned open spaces for social interaction, which is important for the community's physical and social sustainability. Because readily available materials like wood, stone, and slate were used in their construction, the buildings are climate-responsive and cozy during severe winters. Figure 7 gives a glimpse of the built form quality, which is predominantly vernacular. The materials used are economical, sustainable, and support the livelihood of the local workforce. Materials used essentially are locally available and local skills are used for construction purposes. The interiors have a basic design, with a focus on heat-retaining walls and roof patterns.

To provide for a living and prevent landslides, every house keeps wide-girth trees on the uphill slope side and plantations or gardens on the descending slope side. Traditional houses are more thermally comfortable than their modern counterparts. Sloping hip roofs made of slate stone allow for easy rainwater drainage. Plinth with stones usually is provided for protection from heavy rains. More openings towards the south side allow winter sun in the interior spaces and protect from harsh sun in the summer season. As a construction technique, sloping and slanting roofs preserve the building's visual identity, as do facades finished with similar materials. Slanting and sloping roofs contribute to the visual aesthetics of the area, while similar finishing materials on facades are a common construction practice. Ground-level treatment of soil and cow dung in most houses helps to deter and prevent crawling insects. Houses typically have an internal staircase to reach the upper floor, which primarily is used for storage and cooking purposes. The veranda on the upper floor acts as a semi-open space.

This research showcases house case study types with varied typologies, like vernacular, modern, and mixed typologies. The comprehensive built-form appraisal is given in Table 1.

The use of local materials and roof styles is common in all cases.

The built-form vocabulary of case examples A, B, C, and D is illustrated through plan forms and sections. Figures 8-11 depict the architectural expressions of cases A, B, C, and D, respectively. The use of local materials with thick walls and slate roofs makes these structures thermally efficient and the simple plan form with wooden jointing at all levels makes them earthquake-resistant. Setting them as per natural constraints makes them sustainable and resilient. Social integration helps build community resilience during challenging times.

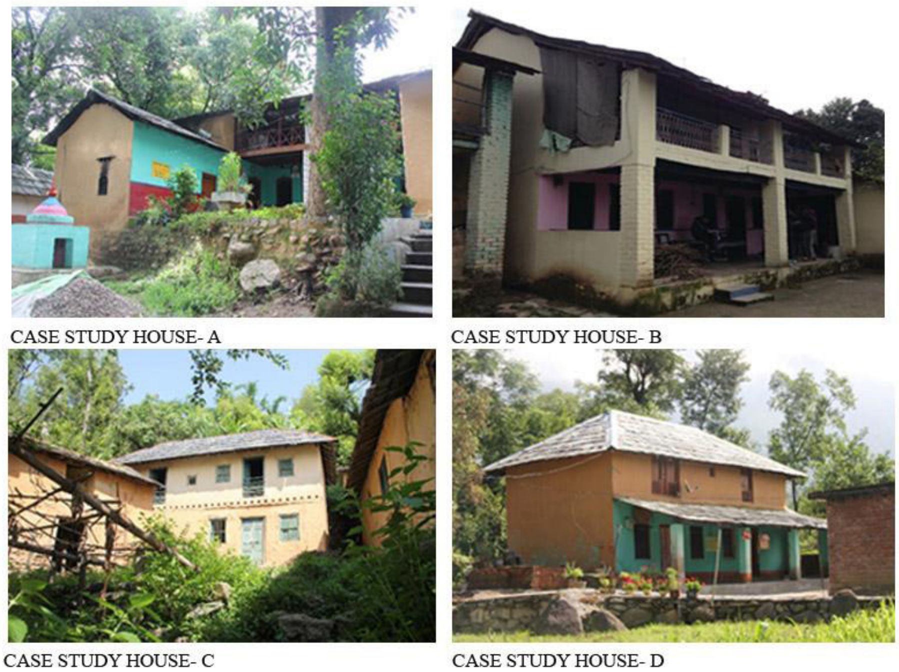

Figure 7. Visual impression of all case examples (Source: Author).

Table 1. Descriptive details of the case examples (Source: Author)

House case study	Age of structure	Architectural style	Family structure	Construction method
House A	70 years old	Traditional style with sloping roof and separate ground floor kitchen unit	Single family, Residential	Traditional knowledge, Sloping roof (slates) and thick stone walls with mud plaster
House B	25 years old	Contemporary style (rural) with hipped roof and three kitchen units	Three families, Residential	Contemporary, Sloping roof (slates) and stone/brick walls with cement plaster
House C	60 years old	Traditional style with hipped roof and no active kitchen unit	Two families, Granary store and cattle shed	Traditional knowledge, Hipped roof (slates) and thick stone walls with mud plaster
House D	40 years old	Traditional style with hipped roof and kitchen (internal) at ground floor	Two families, Residential	Traditional knowledge, Hipped roof (slates) and thick stone walls with mud plaster

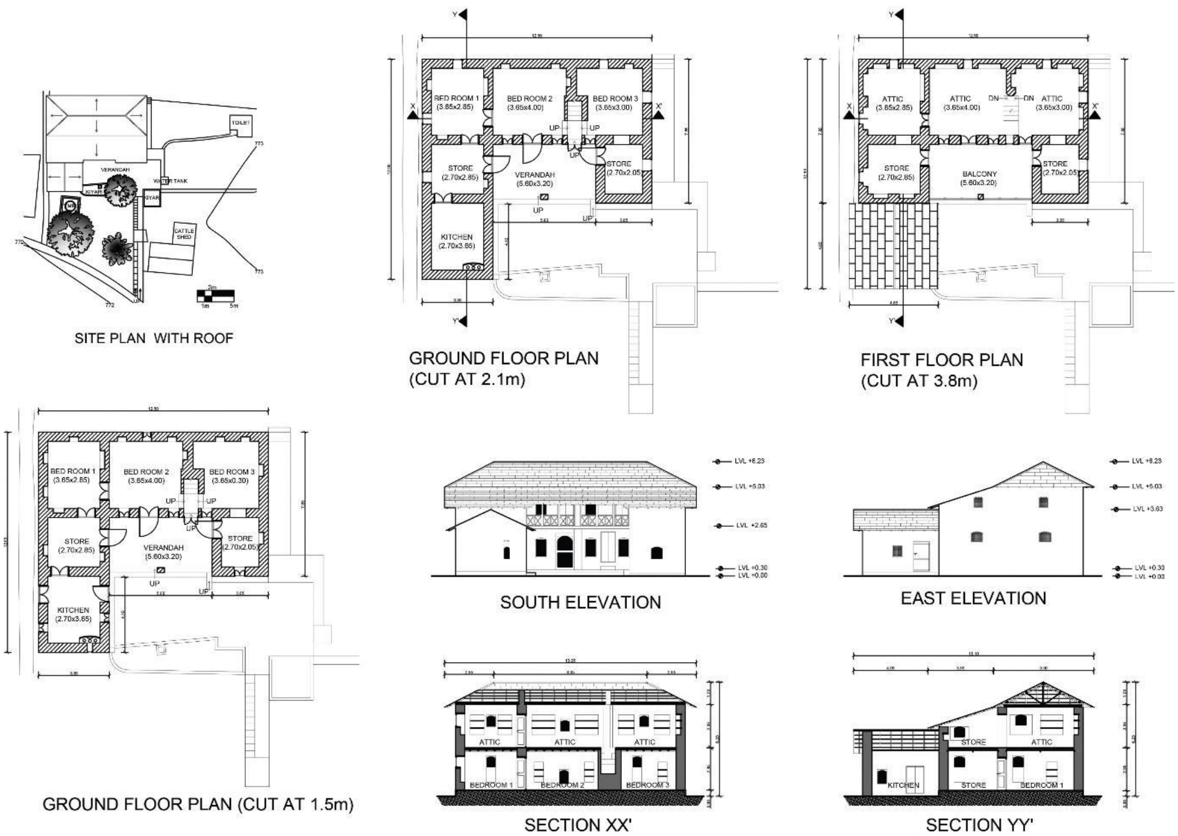

Figure 8. Architectural documentation of case example A (Source: Author).

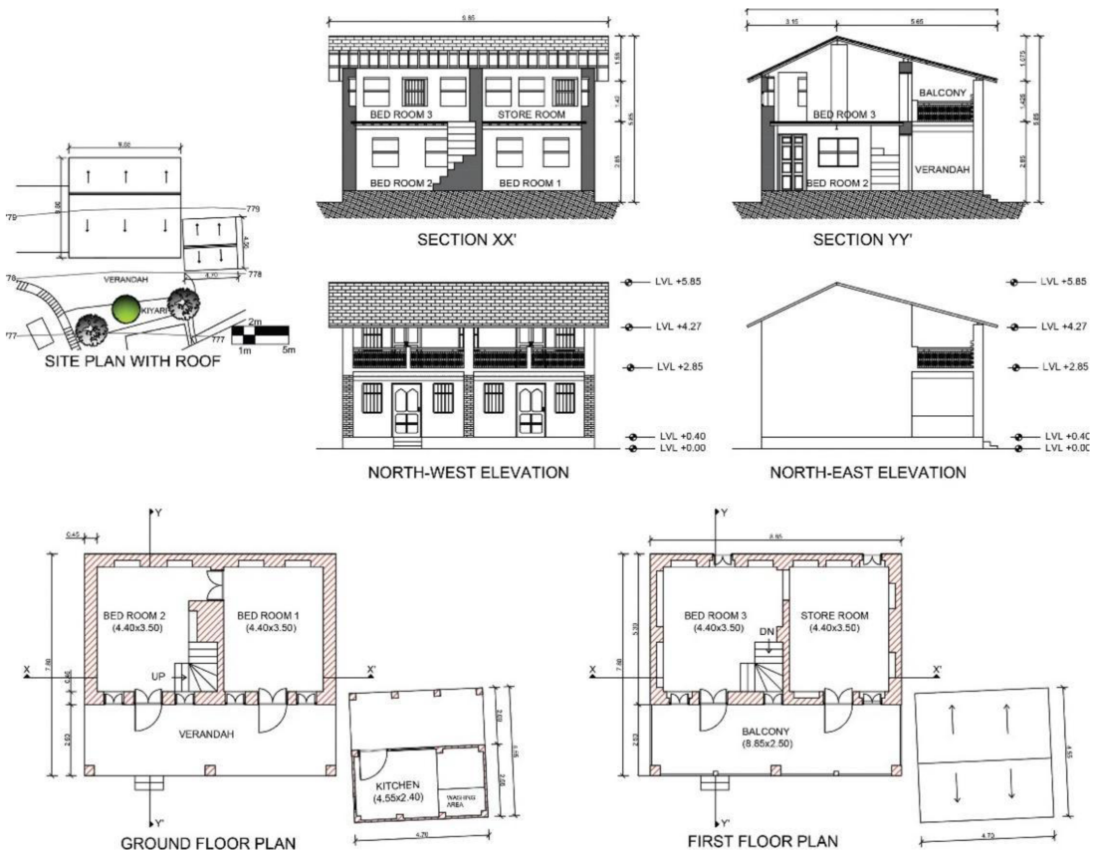

Figure 9. Architectural documentation of case example B (Source: Author).

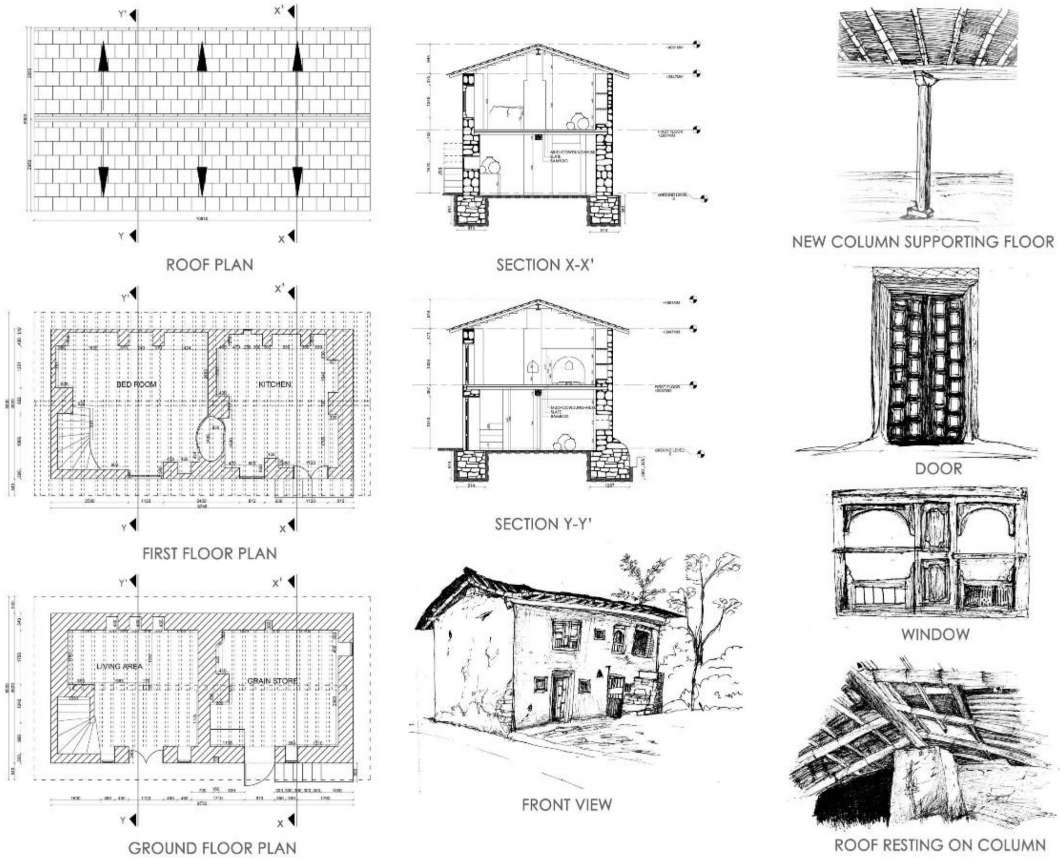

Figure 10. Architectural documentation of case example C (Source: Author).

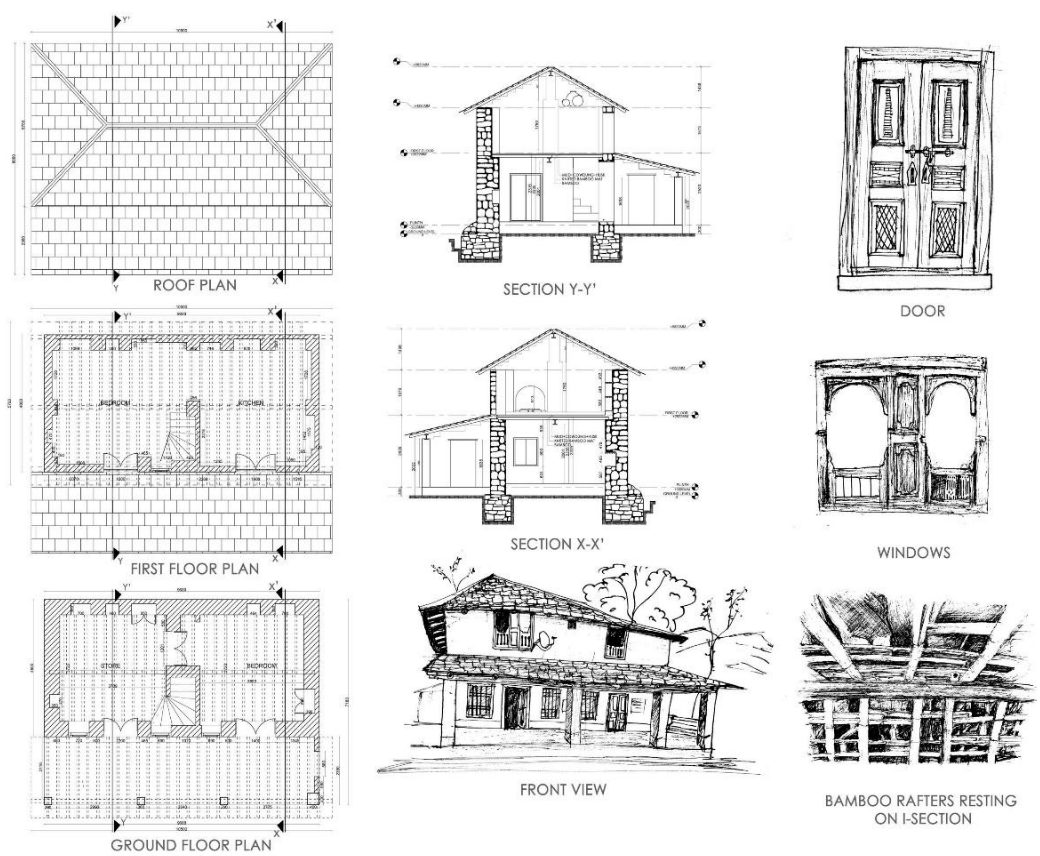

Figure 11. Architectural documentation of case example D (Source: Author).

Vernacular households have shown better resilience to earthquakes, as per historical experience (District Disaster Management Authority Kangra, 2012) . Table 2 elaborates on the relationship between construction components and their usefulness in resilient constructed forms.

Table 2. Resilient built form elements used in case examples (Source: Author)

House case study	Foundation	Wall material	Roof material	Floor and openings	Earthquake resistance feature	Climatic features
House A	Dressed stone	Stone with mud plaster and timber frame	Seasoned timber roof with slates	Wooden mud flooring, Timber	Rectilinear plan and truss with tie beams and bracing	Orientation, thick wall, and low ceiling for heat retention
House B	Brick with cement mortar	Stone and brick with cement plaster and timber frame	Bamboo roof with slates	Wooden mud flooring, Timber	Not safe structure	Orientation and veranda
House C	Random rubble stone	Stone with mud plaster and timber frame	Local wood roof with slates	Slate and mud floors, Timber	Rectilinear plan and truss with tie beams and bracing	Orientation, thick wall
House D	Random rubble stone with lime	Random rubble with mud plaster and timber frame	Local wood roof with slates	Slate and mud floors, Timber	Rectilinear plan	Orientation, thick wall, and verandah

These houses use local materials for construction, thereby reducing costs and supporting rural livelihoods. Such structures are energy efficient and are thermally comfortable as compared to conventional structures (Sharma & Sharma, 2013). Table 3 summarizes a few major advantages of the materials used for construction in the study area. Due to the present scenario, lack of availability, and lost indigenous knowledge, these materials are not in common use. The community is aware of the benefits, but continuous maintenance is one of the major hurdles to the continuity of such a built form.

Table 3. Material suitability analysis (Source: Author)

Material	Advantages	Disadvantages	Common feature
Slate	Resist high heat and temperature, fire resistant, extremely resistant to frost and freezing	Limited availability, needs quality craftsmanship for leak proof setting, prone to wear and tear	The traditional practices such as internal wooden and stone stairs, upper-level veranda, rubble stone with mud mortar and slate roofing with timber and bamboo defines the resilient built form in the region
Stone	Water resistance, retains heat, durable, requires low maintenance and aesthetically appealing	Limited availability, lack of craftsmanship	
Mud	Better insulation as compared to concrete plaster, local material and technology and low-cost construction	Difficult to maintain	
Bamboo	Good tensile strength, easily available, very low lost material and needs no skilled labour	Needs termite and fire protection	
Timber	Good structural member, provides insulation, very good aesthetic value and easy to work with	Very costly, needs termite and fire protection	

5.Results and Outcomes

The study indicated that the region is extremely sensitive climatically and the traditional housing typologies are climatically, economically, and socially sustainable, thereby showing a good level of community resilience. The results show that nearly half of the housing stock is still maintained as traditional housing. The field measurements of hot season inside temperatures are nearly 3°C - 4°C cooler than outdoor temperature among houses built with local materials as shown in Table 4.

Table 4. Indoor and outdoor temperature measurements for Houses A, B, C and D (Source: Author)

House case study house	Date	Time and Temperature Recorded								
	19 - 07 - 2022	06:00			12:00			18:00		
		Indoor Temp.	Outdoor Temp.	Temp. Difference	Indoor Temp.	Outdoor Temp.	Temp. Difference	Indoor Temp.	Outdoor Temp.	Temp. Difference
A		23.36	25.76	2.40	26.41	29.73	3.32	23.98	26.08	2.10
B		23.75	25.76	2.01	26.77	29.73	2.96	25.01	26.08	1.07
C		23.26	25.76	2.50	25.83	29.73	3.90	24.01	26.08	2.07
D		23.11	25.76	2.65	25.72	29.73	3.42	24.02	26.08	2.06

**Temperature values are in °C, Temp. =Temperature, Avg. =Average*

The greatest difference between indoor and outdoor temperature is observed around noon, followed by a moderate difference in the mornings and minimum in the evenings. The varied topography and resulting pressure differences results in better wind flow in the evenings. Similar findings have been reported in the past studies also (Hena et al. 2021). The use of passive construction methods and materials has resulted in better thermal comfort in habitable spaces. Most of the houses face south and east to derive direct sunlight. The sensible placement of the structures as per the contours helps in achieving the land stability and reduces the chances of the landslides in future. Most houses are two stories and have a linear layout with bedrooms on the ground floor, kitchen, and store on the first floor. Survey results showed that 90% of the built form was low-rise, and 50% of houses were more than 50 years old. Materials used essentially are locally available and local skills are used for construction practices. The interiors are of basic design, with a focus on heat-retaining walls and roof patterns. To provide for a living and prevent landslides, every house keeps wide-girth trees on the uphill slope side and plantations or gardens on the descending slope side. Most houses keep a cow/ buffalo shed as an essential component of their design. The settlement uses the adjacent open tiered spaces for fodder storage, horticulture, and farming, working in harmony with them. Utilising natural springs also is very important. Plot and space subdivision within units is a result of shifting family dynamics and the demand for more storage.

Despite using contemporary building methods, people continue to maintain traditional houses for a variety of reasons, including affordability, emotional attachment, and thermal comfort. The decline of vernacular houses can be attributed to several factors, including a lack of labour, high and frequent maintenance costs, fewer stories, and social status. These factors also have caused traditional building methods to change, such as combining contemporary and local materials. The ban on stone quarrying, the high cost of wood, and the lack of trained masons are resulting in higher maintenance costs for the indigenous structures. Because of the different work locations and nuclear family arrangement, people lose their attachment to their hometown and their house. The advent of higher-order assets like refrigerators, televisions, and vehicles has brought the need for more secure and safe private spaces. Developing resilience strategies for such regions requires consideration of all such issues and concerns.

6.Conclusion

This research paper delves into traditional built form practices that are resilient in nature and have withstood numerous disasters. The findings elaborate on the material's suitability analysis which are effective in providing thermal comfort in the structures. The rapid construction practices prevalent today often disregard the findings of this study regarding material suitability, passive construction techniques, and sensible placement of buildings. This disregard leads to future vulnerabilities in hilly regions Transformation is occurring primarily due to lifestyle changes, peer competition, increased income, and social restructuring. Improving climate resilience of a region is directly proportional to the citizen-level awareness, respect towards the local knowledge, and traditional construction practices. Governance and regulation play an important role in keeping the eco-sensitivity of the place intact by implementing strict by-laws regarding development and construction. Disaster-prone areas should be demarcated for the possibilities and impacts related to climatic resilience. Apart from taking these safety measures, it also is important to maintain the study area's aesthetic value because it is a major tourist destination in the Kangra District of Himachal Pradesh. At present the region has quite a significant number of traditional structures, which is one of the reasons for the tourist attraction. Traditional architectural styles should be promoted and shifts to standard conventional construction practices should be limited. Enhancing cooperation and coordination between the locals, decision-makers, and professionals is necessary to improve the climate resilience of hilly areas. Architects and planners play a crucial role in preventing loss of life and property through implementing policy frameworks for mitigation and managing disasters. Including academic experts, non-governmental organisations, and everyday citizens is the best approach to create a community that is climate resilient. This study indicates that future development ought to preserve the integrity of the area and prioritise the eco-sensitivity of the region.

Declaration of Conflicting Interests

'The Author(s) declare(s) that there is no conflict of interest.'

Author Contributions

Conceptualization: P.S., I.S.; Methodology and Survey: G.K., P.S., I.S.; Analysis: G.K., P.S., I.S.; Writing - original draft preparation: G.K.; Writing - review and editing: P.S., I.S.. All authors have read and agreed to the published version of the manuscript.

Data Availability

Data may be obtained from the corresponding author upon reasonable written request, although all required data already are mentioned in the manuscript.

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