ROLE OF TRADITIONAL KNOWLEDGE SYSTEM IN BUILDING RESILIENT BUILT ENVIRONMENT: A STUDY OF GARHWAL REGION, UTTARAKHAND

Ar. Namrata P. Dhobekar
361 BIT, Aurangabad,
Maharashtra, India
ndhobekar@gmail.com

Dr. Janmejoy Gupta
Associate Professor and Dean (Research)
Department of Architecture, School of Planning and Architecture (under GoI, MoE)
Vijayawada, Andhra Pradesh, India
janmejoy71@gmail.com

ABSTRACT

Traditional knowledge systems have evolved from the experiences of communities. They have the mechanism to cater socially and are ecologically responsive and disaster-resilient lifestyles. In mountain ecosystems like Garhwal in Uttarakhand, the natural setting is extreme, livelihood resources are minimal, and are threatened by constant disasters. In such cases, the traditional knowledge system is the key to better living. Hence, it is observed that communities are continuing to practice their traditional wisdom of livelihood, natural resources, health, buildings, and construction. This system contributes to an essential relevance in building resilient communities. The aim is to study and document the traditional knowledge system for Uttarakhand state in the Garhwal region in order to develop an understanding of the various systems and evolve mechanisms to benefit the community. This research allows us to understand that traditions and culture significantly impact lifestyle and built form. The study assesses the geographic profile as well as the socio-economic and built environment study. This study provides awareness of the indigenous community's life and its intangible and tangible heritage. It invites further exploration of the Garhwal culture and its valuable traditional knowledge system.

Keywords: *traditional knowledge system, disaster resilience, socio-economic built environment, sustainability.*

1. Introduction

Uttarakhand is one of the hilly states in the Himalayan belt. It lies in the northern part of India between the latitudes 28° 43' N and 31° 27' N and longitudes 77° 34' E and 81° 02' N **(Govt. of Uttarakhand, 2014).** It is a state with 13 hill districts with two major divisions- Garhwal and Kumaon, based on their cultural differences and historical background. The cultural background of the Garhwal region is more spiritual due to ancient Hindu temples and the holy river Ganga. (ibid). Geographically, the Garhwal region is more fragile, disaster-prone, and sensitive. Moreover, it has extreme weather conditions and dense forests. To cope with these extreme conditions, communities follow traditional practices. The hill state offers unbelievable vignettes in the fields of architecture, water management, ethnomedicine, ethnobotany, metallurgy and agriculture. They show a deep understanding of climate change and risk reduction at the building level and the community level. The communities have transferred knowledge and wisdom from one generation to another through oral and other traditional ways. These practices protect the built environment, maintain the community's social fabric and minimize hazards cost-effectively and sustainably. Today, numerous multi-storied buildings are constructed without considering the geography and climate with modern materials and techniques which damage the fragile environment in and around the hilly settlements and affect social and physical well-being. Traditional practices are beneficial even today and therefore need to be studied and documented.

Methodology

The study was initiated from macro-level planning and gradually moved on to micro-level planning. Macro-level planning includes the process of selecting the site and developing and arranging the built form which will respond to the natural landscape. Micro-level planning includes the selection of materials, disaster resilience, climatic response, structural stability, aesthetical value and use of small spaces for different purposes. This study has been done based on the secondary sources including DMMC reports, research papers and government reports.

2. TRADITIONAL KNOWLEDGE SYSTEMS ABOUT BUILT ENVIRONMENT

2.2 Evolution of Settlement

Uttarakhand has a rich past in architecture. Communities developed their style of architecture using locally available materials. Both Garhwal and Kumaon regions have their own set of traditional wisdom of building construction. The following study covers the evolution, types of settlement and different techniques and the style used in the Garhwal region for construction. The initial settlements came in the higher region of Uttarkashi valley due to the old Indo-Tibetan route (refer Fig. 1). The communities believe that majority of the settlements were not permanent. Nomads used to stay near the forest areas and the availability of water, fodder, and possibilities of agriculture practices were the criteria for site selection. Many temporary settlements turned permanent slowly as the communities started inviting their friends and relatives. These settlements are passed onto generations by oral traditions in the villages during festivals through folktales and folksongs (Routela, 2015).

2.2 Types of Settlements

Due to the difference in geography, different types of settlements have evolved depending upon the location. These settlements can be categorized into four types- valley, hill-top, spur and gap. Local communities have developed their response toward site planning according to the existing conditions. Table no. 1 describes the design techniques that can be used to construct in sloped terrain. Tables 2 and 3 show the site planning approaches and features for every type of settlement respectively (Rawat, 2019).

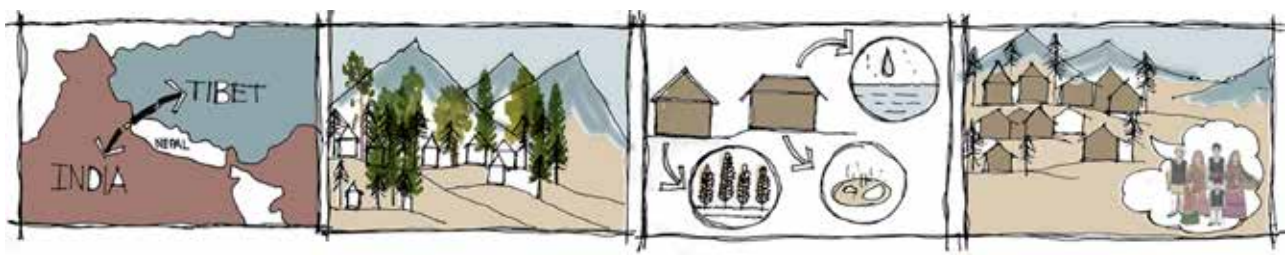


Figure 1: Evolution of settlements
(Source: Author)

3. Styles of Architecture in the Garhwal region

3.1 An Overview

The Garhwal and the Kumaon regions have different local languages, cultures and traditions. Due to these, the building styles have also evolved independently in both regions. Kumaon region comprises the districts of Chamoli, Dehradun, Haridwar, Pauri Garhwal, Rudraprayag, Tehri Garhwal and Uttarkashi. The characteristic features of the traditional architecture found in this region are dictated by the immense availability of stone and timber in the areas. The walls are typically made of stone while the timber is used for structural purposes and the slates are used for roofing. The floors are made of wooden planks or mud, for insulation and occasionally stone slabs are also used. Whereas the Garhwal region comprises the district of Almora, Bageshwar, Champawat, Nainital, Pithoragarh and Udham Singh Nagar. The houses in this region are placed after careful site selection usually en route to the pilgrim centres, near sources of water and in the areas which provide protection from the cold winds in winter. The traditional houses are built along the contours of the hills and are generally two- or three-storeyed, having a rectangular plan. It is observed that buildings in the Kumaon region are more elaborate and detailed than Garhwal architecture (Negi, Jain, & Singh, 2017). The detailed study of Garhwal region architecture is discussed in Table no 4.

3.2 Garhwali Stone Construction

According to Negi, et al (2017), the geometry of these houses rectangular and straightforward, which provides stability and makes it less disaster-prone. Thick masonry walls are made from stone and timber (refer Fig. 2). The sloping roof is constructed with locally available slate tiles. It is covered with mud plaster and placed above the timber beams. This method is also known as dry stone construction as dry masonry due to its limited water source. The dry masonry provides flexibility in horizontal movement. The interlocking between the stone is so efficient that it can prevent the wall from collapsing. Mud and cow dung is used for plastering the walls. The doors and windows are kept small to give insulation. Initially, timber was used for structural members. Today, concrete columns and beams are used in many Garhwali styles of the house due to a lack of timber availability.

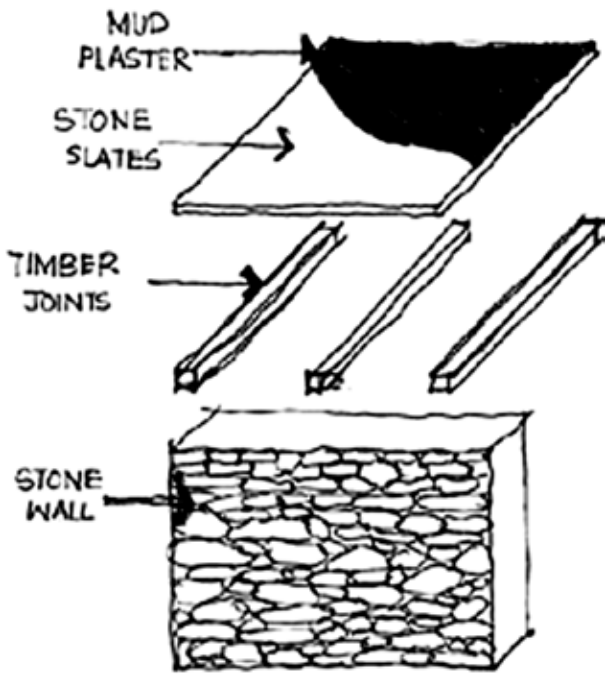


Figure 2: Construction Detail
(Source: S. K. Negi, 2017)

3.3 Koti Banal Style of Construction

Despite being a part of a seismically vulnerable region, Garhwal shows an elaborate earthquake-safe construction style called Koti Banal architecture. The local communities practice this style for the past 1000 years. Koti Banal is a village near Yamuna valley in the Uttarkashi district with its own set of building features (Rautela, Joshi, & Lang, 2008). The salient features of this technique are listed below (Joshi & Chandra, 2008):

1) Raised Platform

The buildings are constructed on a stone-filled reliable platform. Its height varies from 1.8m to 3.6m. Dry stone masonry is used for construction.

2) Simplicity

The structure is constructed on a rectangular plan with a ratio of 1:1.5 (refer Fig. 3). The length and the width vary between 4 to 8 meters. This symmetrical plan provides rigidity and minimizes the torsion. The height of the building is maintained double the length of the shorter side. Mostly it is maintained between 7 to 12 meters.

3) Walls

The thickness of the wall depends on the available size of the wooden log. The wall is constructed with dressed up flat stones and two wooden logs alternative arrangement. A wooden beam is placed in the middle height of the wall to provide better reinforcement.

4) Openings

Most of the houses have a single small entry on the ground floor above the raised platform. Access to the upper floors is provided with the help of wooden ladders. The size of the opening is small, and the height is low. Firm wooden logs are provided for the framing and to compensate for the loss of strength.

3.4 Salient structural features of Koti Banal architecture:

Some of the salient structural features of Koti Banal architecture as stated by Joshi (2008) are as follows:

Figure 3: Rectangular plan
(Source: Author)

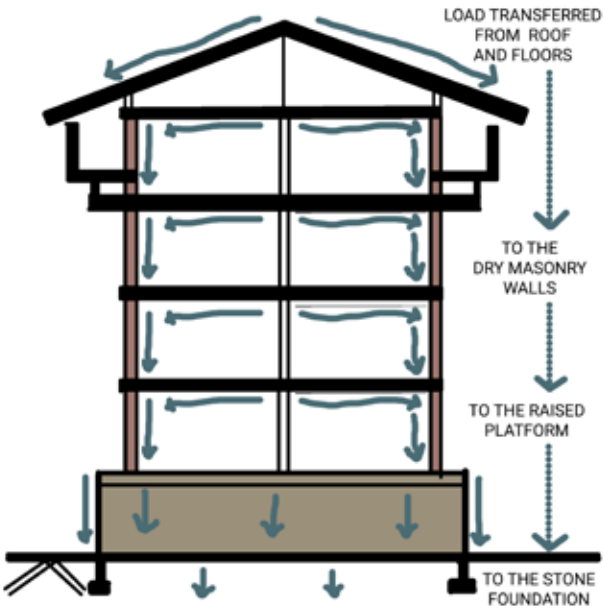


Figure 4: Load transfer mechanism
(Source: Author)

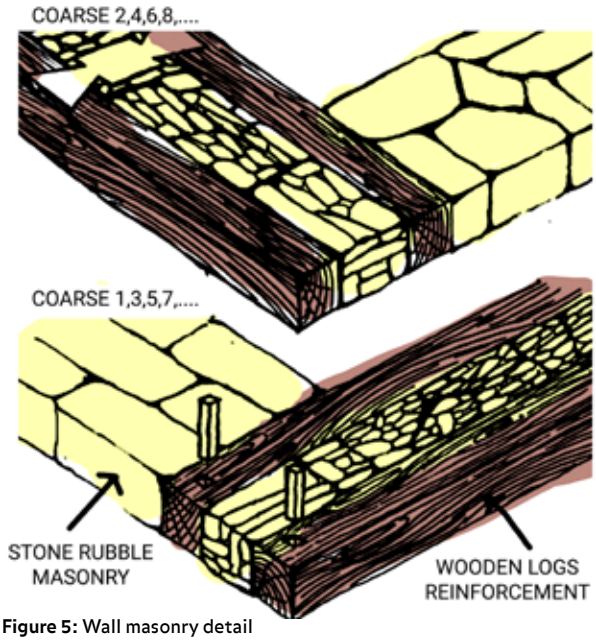


Figure 5: Wall masonry detail
(Source: Author)

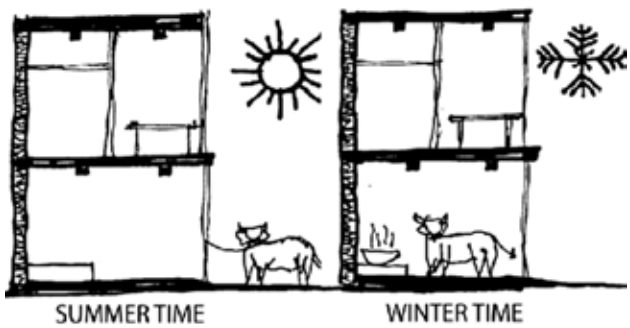


Figure 6: Different Use of ground floor in different season
(Source: Author)

- *Load Resisting System:* The masonry used for construction is dry rubble masonry. And hence it helps in lateral deflection. This avoids damages during earthquakes. The live load and dead load gets distributed from roof to wooden structural logs to the dry masonry walls, and wall transfers the load to the strong stone foundation as shown in Fig. 4.

1) Good aspect ratio (1:1.5) of building: This is in line with building code requirements, which state that the structure should have a simple rectangular plan layout and be symmetrical in terms of mass and rigidity to reduce torsion and stress accumulation.

2) Timber reinforced stone wall with dry masonry: There are two kinds of load sharing mechanisms in the 1.5 feet thick dry masonry walls: i) vertical load is distributed through walls which run in all four directions, and ii) horizontal weight is distributed via intersected timber logs in parallel and perpendicular directions (refer Fig. 5). In the construction of the wall, wooden beams can be seen coming in from the outside. These beams are installed from above which improves the structure's seismic resistance.

3) Massive solid platform: It is located at the structure's base and aids in keeping the structure's centre of gravity and centre of mass close to the ground. During earthquakes, this type of loading reduces the overturning effect of very tall structures. For higher storeys, lighter materials are used for construction.

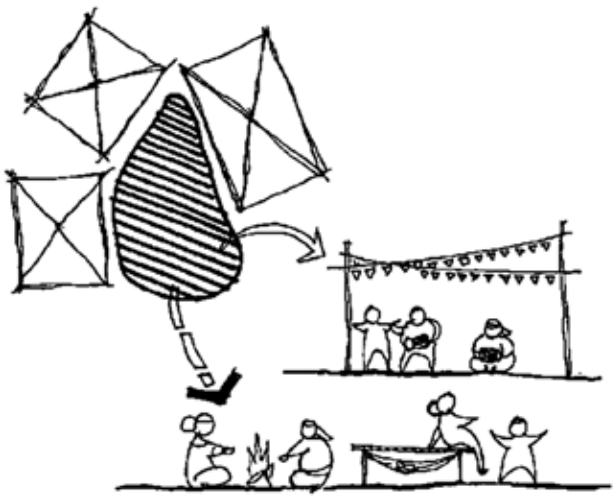


Figure 7: Use of central open space
(Source: Author)

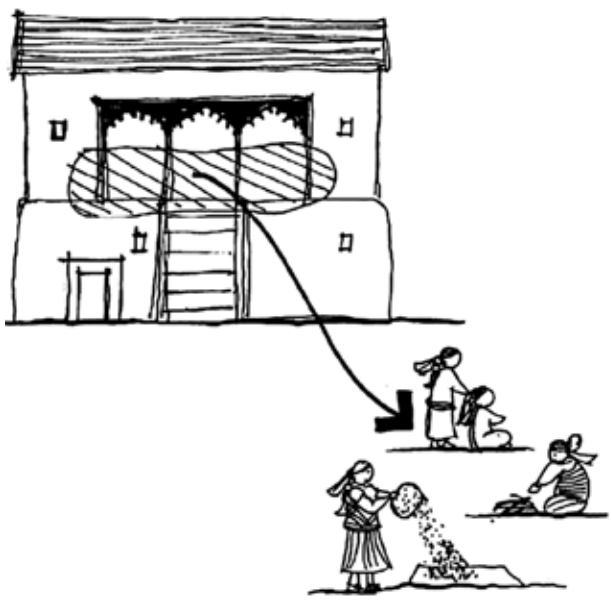


Figure 8: Use of Semi - open space
(Source: Author)

4) Use wooden beams for structural support: The building's beams are usually rectangular and 20 to 30 cm thick. These beams have a width-to-height ratio of 2:3, making them appropriate for use as bending members. These wooden beams have sections that are larger than required for safety. As a result, the construction system satisfies both the rigidity and strength requirements. This aids shock resistance even further. Wood is an elasto-plastic substance that may absorb seismic energy. The wooden components featured in these structures are joined utilizing a combination of housing and nailing techniques. Minimal angular displacement is possible as a result of this.

3.5 Socio-Economic Aspects

Generally, one family occupies one housing unit. Due to the succession of families, nowadays, different floors are allocated for different sons. During the daytime, a maximum of five members are present in the house, and in the evening, 5 to 10 members are present. In most houses, the ground floor is used for cattle, and the upper floors are used as living and kitchen (refer Fig. 6). The use of spaces in the Garhwali houses changes as per weather conditions. On summer days, the cattle are kept outside. However, on winter days, they are kept inside the ground floor space. Usually, the ground floor is used for storage and cattle, but this space is used for cooking to keep the upper floors warm in winter times. Toilets are missing in old houses as cultural ethics do not allow building a toilet inside the house.

On the first floor of a typical Garhwali residence, a semi-open space with columns on the front and a wall on the other three sides is observed. That space traditionally acts as a semi-open front room for daytime activities. In most modern houses, that space is perceived as a balcony (refer Fig. 7).

Traditional houses have three kinds of spaces- open, semi-open and enclosed. Every space has its own set of functions. They may vary according to time and weather conditions—most of the spaces around the house are used by women for household activities. The spaces formed due to a cluster of two-three adjacent houses act as a private shared gathering space as shown in Fig. 8.

Two types of architectural styles are dominant in the Garhwal region: traditional and contemporary. The houses which are built considering indigenous wisdom are older than the modern dwellings. There are similarities and differences between these two styles. Table no. 5 shows a comparative analysis of those styles.

4. Case studies

4.1 Case study 1: Koti Banal Village

Location: Near Barkot, Uttarkashi (Area: 1.1 sq. km.)
Koti Banal village is one of the well-known villages in the district. It has no proper connectivity to the main road. The settlement is connected with different small public spaces formed organically in the checks (refer Fig.9). These public spaces act as gathering spaces for holding different festival activities (refer Fig. 10). The houses are oriented in the north direction (Fig. 11) and hence the open spaces between them get ample sunlight, and daily household activities can be done there. The wooden houses in this village are mostly 2 to 3 storeyed. The ground floor is allocated for cattle and the family occupies the upper floors (Sharma, 2020).

4.2 Case study 2: Sonara Village

Location: Rajgarhi, Uttarkashi.
Sonora is a small village with a total area of 113.7 hectares and a population of 334 people. Stone and wood, load-bearing construction is found in the village. In this typology, the ground floor is constructed using

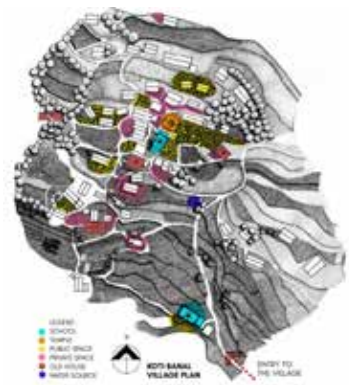


Figure 9: Site plan of Koti-banal village *(Source: Sharma, N., 2020)*

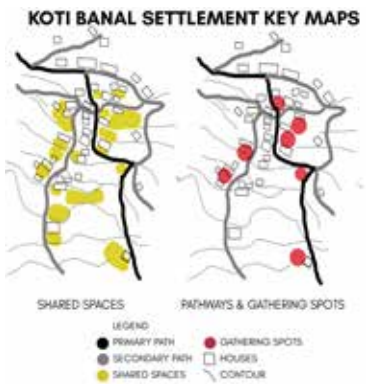


Figure 10: Movement and open space *(Source: Sharma, N., 2020)*

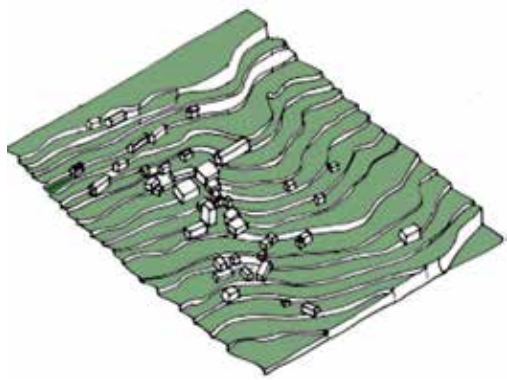


Figure 11: Site contours and settlement *(Source: Sharma, N., 2020)*

Figure 12: Ground Floor plan of house *(Source: Sharma, N., 2020)*

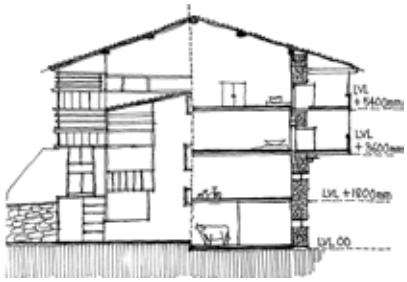


Figure 13: Site plan of Sonara Village *(Source: Sharma, N., 2020)*

Figure 14: Sectional Elevation of House in Sonara village *(Source: Sharma, N., 2020)*

stone (refer Fig. 12), and the thickness of each wall is 500mm. For constructing the first floor, interlocking rods of wood are used with stone to make the upper structure lighter. This technique centralizes the centre of gravity and hence makes the structure earthquake-resilient. Granaries and structural members are made purely with deodar wood only. Random rubble masonry is used in the construction of the wall. This village has rocky terrain, so the houses do not require any foundation underground (refer Fig. 13). The settlement has spread organically in small pockets around the river (as shown in Fig. 14).

4.3 Case study 3: Gona Village

Location: Rajgarhi, Uttarkashi

Gona village has an area of 127.53 hectares with a population of 383. The settlement is spread inorganically around the main pathway (as shown in Fig. 15). Wood and stone are used for construction. In this village, the houses are taller to manage the mass to a small area (as shown in Fig. 16). The ground floor is locally known as goshal or goth, a space dedicated to cattle and storage. This floor has no formal or defined entrance (refer fig. 17). Ventilators are used instead of the window to provide insulation. The flooring is coated with cow dung. Sometimes, this space is also used for cooking. The construction is simple and symmetrical. Strong interlocking wooden members are joined at the corners. The structure has flexibility as it has no mortar. The thickness of the wall decreases on the upper floors. The building rises to 13m over the ground with a pitched roof (Sharma, 2020).

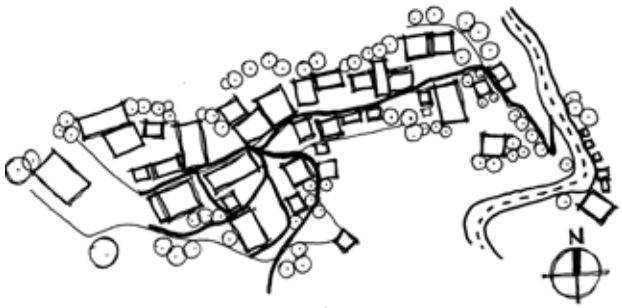


Figure 15: Site plan of settlement of Gona village
(Source: Sharma, N., 2020)

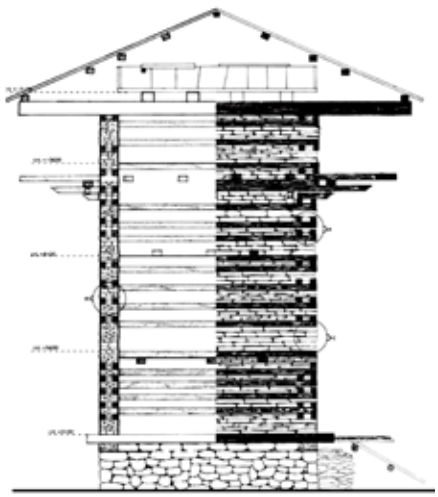


Figure 16: Section and elevation detail
(Source: Sharma, N., 2020)

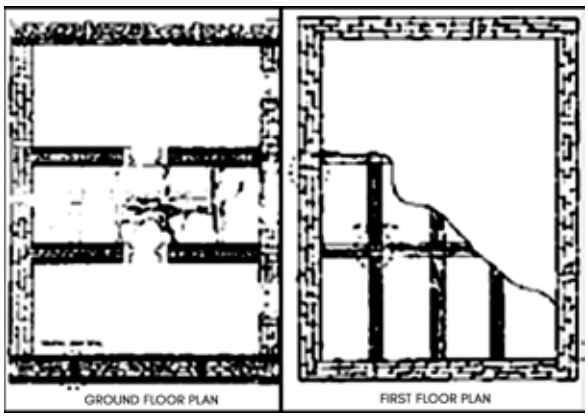


Figure 17: Ground and first floor plan of house
(Source: Sharma, N., 2020)

4.4 Case study 4: Khirsu Village

Khirsu is a small village with a population of approximately 1000, located in Pauri Garhwal district in the Garhwal region. It is placed at an altitude of 1700m. A total of 245 families live here. Farming is the primary source of livelihood. Hence the daily routine activities are either household or agriculture-related. The spaces built based on traditional knowledge are helping them to perform their daily chores. The open spaces get uniform sunlight due to the north orientation of the building. Fig.18 explains the traditional house form and activities around it (Compartment S4, 2020).

5. Conclusion

After this study, a few salient points have been observed :

1) Garhwal region has its own set of cultures, construction styles and geographic conditions. It is more disaster-prone and vulnerable as compared to Kumaon.

2) Traditional knowledge system has helped local communities to cope with adverse situations and maintain livelihoods.

3) Local communities still use the indigenous knowledge passed by their ancestors for farming, construction, site planning and medication.

4) Nowadays, people tend to choose modern materials for construction due to the lack of availability of wood.

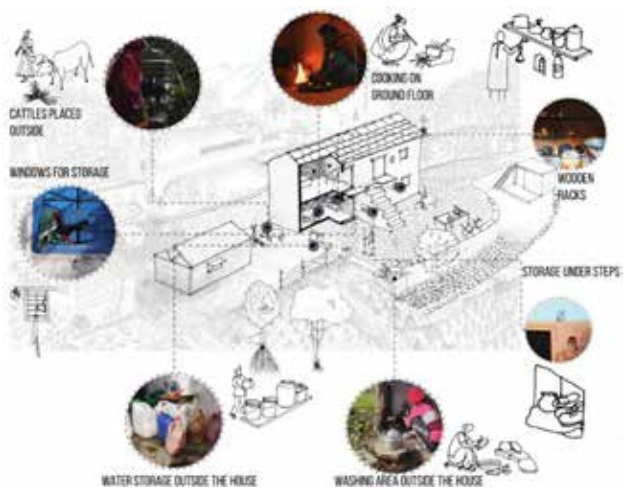


Figure 18: House form and activities around it
(Source: Compartment S4, 2020)

Table 1: **Design Guidelines for a sloping site**
(Source: Author)

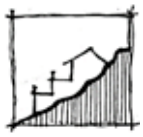
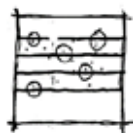
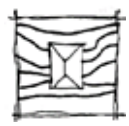
No	DOs		DO NOTs	
1	Structures should minimize the grading and preserve the natural features.		Constructing the building by destroying the natural slop and landscapes	
2	Terraced decks minimize the visual bulk		Overhanging makes building look more massive	
3	Grading angle should be gradually transitioned to the angle of the natural slope		Steeper slopes with an angular profile should be avoided	
4	Trees and shrubs in concave areas are preferred		Avoid uniform coverage of tress	
5	The most significant horizontal direction of the building parallel to the natural contour		Buildings perpendicular to the natural contour	
6	Vertical structures should be below the ridge elevation		Structures with massive form and height destroy the silhouettes of hill	
7	Gable end perpendicular to the direction of the downhill side		Gable ends of the house on the downhill side	
8	The angle of roof slope should be parallel to the slope		The angle of roof opposite in direction with a slope of contour	

Table 2: **Site planning Approach for of different settlement types**
(Source: Author)

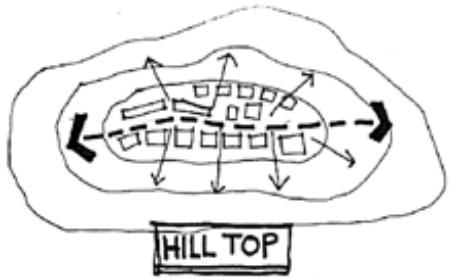
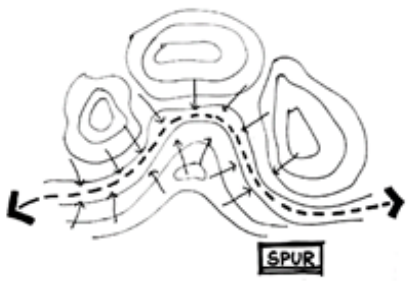
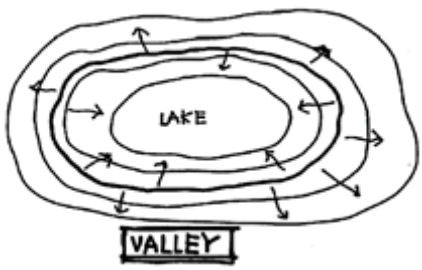
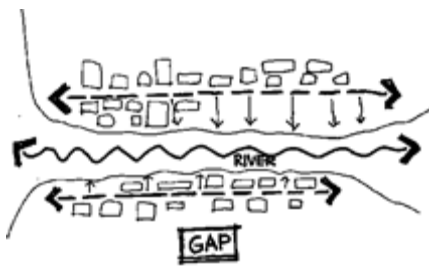
Site Type	Planning Approach	Patterns
Hill Top	They spread along the central functional axis, which is parallel to the contour and ridge. They spread from the central axis outwards	 Hill top settlement pattern
Spur	Spur settlements grow inwards. They spread towards the major axis or major road.	 Spur settlement pattern
Valley	They spread in outwards direction, from major axis towards up and down areas of the valley.	 Valley Settlement pattern
Gap	These settlement types have the least scope for spreading and are divided into 2-3 parts due to river or stream. The structures are built along the liner axis parallel to the edge of the river.	 Gap settlement pattern

Table 3: **Types of settlements**
(Source: Adapted by Author from Rawat, 2019; All images from Google earth, Nov. 2021)

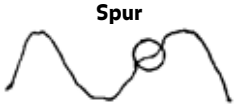
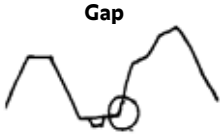
Location	Pros	Cons	
Valley 	Centrality, adequate space for physical expansion, Easy accessibility of water, Ease for transportation and utility services network	Due to the presence of a river system or water body and its catchment	 Thalisain Village in Pauri Garhwal
Hill-top 	Healthy climate, scenic beauty, Strategic position, and free drainage.	Virtual absence of flat land and lack of water supply	 Narendra Nagar in Tehri Garhwal
Spur 	Transition between valley floors and hilltops, Natural defense, panoramic landscapes, moderate climate, and limited loss to the agricultural fields	Restricted accessibility, frequent landslides, and limited scope for expansion	 Pauri town in Pauri Garhwal
Gap 	Coverage of routes, transition points, water availability	limited scope for expansion	 Devaprayag in Tehri Garhwal

Table 4: **Common Characteristics of Traditional Housing**
(Source: Author)

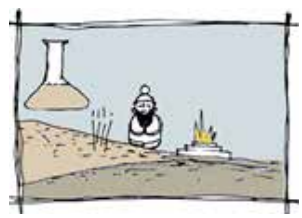
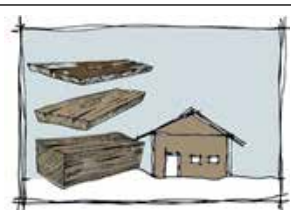
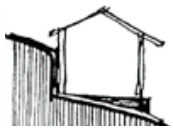
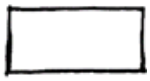
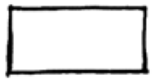
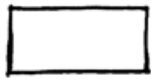
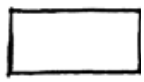
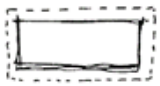
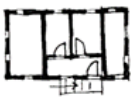
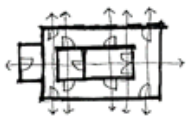
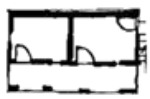
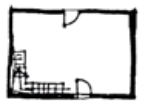
1. Soil Testing: The first step in construction is soil testing in the Garhwal region. The locals examine the soil land and then consult the priest regarding the site's good or bad aspects.	
2. Small Doors and Windows: Old houses have some characteristics which protect them from extreme weather conditions. Most of the houses in the Garhwal region have only one or two small windows.	
3. Extensive use of timber: Timber is found in abundance. Villagers believe that wooden houses are best suited according to the geographical conditions of this place	

Table 5: **Comparative analysis of Traditional and modern villages in Uttarkashi district**
(Source:Adapted by Author from Rawat, 2019)

Aspect	Traditional Architecture		Contemporary Architecture		Inference
House	Panwar Residence in Uttarkashi (1700s)	Residence in Mussoorie (1810)	Pant Residence in Uttarkashi (1998)	Residence in Tilod, Uttarkashi (1995)	
Site *(Image source: Author)*					Traditional houses have stable sites
Plan *(Image source: Author)*					The geometry in traditional is symmetrical and simple in both cases
Projections *(Image source: Author)*					More robust joinery in traditional houses and more articulated.
Openings *(Image source: Rawat, 2019)*					Openings are bigger in modern houses without ornamentation
Material	Stone slate, Wooden Joints, Mud plaster	Stone, Mud for Plaster and cement	Mud and cement and load bearing structure	cement and RCC structure	Strength of traditional houses is more due to stone, mud, timber

5) Modern methods of construction style are neither sustainable nor disaster-resilient. Hence, the wrath of natural hazards has been seen to increase in recent years.

This study shows that the traditional knowledge system was used to develop the built form considering the needs of open, semi-open and closed spaces, and has had a major impact on the built environment. In Uttarakhand, out of two regions, namely Garhwal and Kumaon, although the Garhwal region is more prone to disaster, great variety of knowledge for built environment is observed. And hence, it is essential to study the communities' traditional wisdom as they have a vital significance in different life sectors. This knowledge has shown a deeper understanding of climate, culture, construction, and people. It is gained from experience and constant applications. This knowledge has sustained many settlements and heritage as well as protected lives from disasters. It can be concluded from this study that our traditional wisdom can provide sustainable solutions in the present context. As well as these can be studied further in order to deepen the research. Considering the scope of the traditional knowledge systems in Garhwal region, there is a major scope to find out numerous unidentified styles of construction methods and disaster resilience strategies.

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Ar. Namrata P. Dhobekar graduated in 2021 from the School of Planning and Architecture, Vijaywada. Iie in sustainable built-in environment and styles which incorporate this. These have stemmed from her understanding the need to explore innovative architectural methods. Her architectural research interests.

Dr. Janmejoy Gupta is an architect- urban planner with over 17 years of industrial and teaching experience. His research areas include passive design strategies in buildings and energy efficiency in buildings. He has several quality research publications and book chapters to his credit. He has also authored book on housing, climate and comfort.