Indian Journal of Traditional Knowledge
Vol 23(11), November 2024, pp 1103-1114
DOI: 10.56042/ijtk.v23i11.15021

Coping with disasters: The potential of traditional settlements of hill community of Uttarakhand

Nayana Rastogi Singh
Department of Architecture, School of Planning and Architecture Bhopal, Neelband Road, Bhauri, Bhopal 462 030, India
E-mail: nayana@spabhopal.ac.in

Received 12 August 2022; revised 22 January 2024; accepted 22 October 2024

Traditional settlements of the hill region are the outcome of multiple practices developed by generations from an advanced understanding of the natural settings. Over time, the hill communities know about the multiple challenges and risks that exist in the hill regions which compelled them to take preventive and mitigative measures to safeguard themselves. This paper highlights the potential of various practices exist in the traditional settlements of Uttarakhand's hill region that enabled the communities to survive the impact of multiple disasters over the years. Extensive field studies were carried out in the Bhagirathi valley's traditional settlements, to investigate the living traditional practices. The methods of data collection include observation, informative interviews, and discussion with the local populace. The study has a qualitative approach that has been interpretative and partly comparative, which demonstrates that the hill community has a settlement layout based on the understanding of natural geographical setting, and the socio-economic factor that limited their boundaries based on their belief system. It is also argued that ecological, political, and temporal factors have a significant bearing on the built expression and provide an identity to the hill community. Based on the study, the paper concludes that traditional knowledge gathered not only needs to be recognised, conserved and documented but also needs to be studied thoroughly to throw light upon the coping strategies, leading to reduced disaster risks in modern architectural practices.

Keywords: Coping strategies, Disaster risk reduction, Hill community, Traditional settlement, Uttarakhand

IPC Code: Int Cl.[24]: E04H 9/16

Globally, disasters are rising in frequency and magnitude, affecting people physically, socially, economically, and ecologically. New pedagogy emphasizes pre-disaster actions including prevention, mitigation, and preparedness. Disaster risk reduction is an approach to reduce the impact of disaster by avoiding the hazards, reducing the vulnerability, and increasing the capacity of the community[1]. Disaster risk stresses reducing the impacts of disaster by reducing the level of vulnerability through measure as mitigation, preparedness and keeping exposure from the hazards as far as possible[2]. These strategies need to be integrated with the policy, practices, and planning of various professionals to achieve three major identified goals *i.e.,* the Sendai Framework for Disaster Risk Reduction (SFDRR), Sustainable Development Goals (SGDs), and the Paris Agreement on Climate Change at the 21st Conference of Parties (COP 21), under the United National Framework Convention on Climate Change. Internationally, it is accepted to prevent new risks and reduce existing risks as an inclusive approach to address vulnerability and risk assessment. Local knowledge of the community may be utilised that will strengthen societal and environmental resilience, as an essential element of a safer world in the twenty-first century. The United Nations also focused on building 'Disaster Resilient Communities' by promoting the approach for disaster risk reduction and making it an integral component of sustainable development. It is also encouraged to disseminate and use traditional indigenous knowledge to mitigate the impact of disasters and promote community-based disaster management planning[3].

India is known for its rich traditional knowledge, which has been nurtured, practiced, and amassed over centuries and transferred through generations in form of technical know-how, skills, practices, and beliefs. Traditional knowledge that is referred to traditional ecological knowledge, traditional technical knowledge, and traditional ethic and values evolved through an understanding of natural and human features[4]. Although the concept of disaster prevention and mitigation seems to be innovative, it has been an inherent component of the traditional buildings of India that survived various devastative disasters[5-8]. Traditional settlements involved a method of

organizing space on the selected land, ranging from the scale of the individual house to the scale of the village and the town by employing patterns and practices that are a legacy of the past that continues to be transmitted from one generation to another[9,10]. It is also pointed out that the understanding of any community with nature is reflected in its cultural practices, traditions, and ceremonies[11]. Yet, there is insufficient evidence suggesting the effectiveness of traditional knowledge towards disaster prevention and mitigation in the holistic approach of the whole traditional settlement.

This research aims to document and understand the strategies adopted by the hill community of Uttarakhand in their traditional settlements that helped them to cope with the disasters in the region. The rationale of this study is to document the knowledge embedded in the selected traditional settlements and identify significant strategies to avoid exposure to hazards and adaptive capacity that were embedded in their traditional settlements depending on ecological and socio-economic conditions. This paper also essentially created a database of the selected two hill settlements as well as comprehensive documentation highlighting the accountability with the region's history, geography, culture, and people through which the arguments are presented.

The findings from the study will significantly contribute to the conspicuous literature gap on traditional knowledge and multiple disaster risk reduction in the hill region of Uttarakhand. The results are a useful source of information for varied professionals to set the regulations, byelaws, and policies that will enhance the government's institutional capacity to effectively encounter multiple hazards and thus in sustainable development. The paper also highlights that the community has respected their traditional beliefs and followed the self-developed norm that helps them to cope with multiple disasters for ages and is acceptable to the residents. It is high time to incorporate knowledge of traditional settlements to address the challenges posed by multiple disasters, with the changing need for simple human-centric solutions that are more effective, adaptive, and sustainable.

Methodology

The study is qualitative since it is descriptive, interpretive, and emergent design[12]. The study is focused on documenting the coping strategies adopted by the hill communities, hence hill region of North India is identified. The Central Himalayan state of Uttarakhand is subject to five main categories of natural disasters- landslides, floods, droughts, forest fires, and earthquakes[13]. In addition, the state boasts an age-old traditional knowledge, pilgrimage sites, and exceptional biodiversity and geodiversity, so further studied. The case study technique helped to learn how the traditional settlements deal with various challenges of the region to either resist, avoid, and mitigate the disaster, to contribute in reducing disaster risk[14].

Study area

Geographically Uttarakhand State lies between latitude $28^0$43'N to $31^0$27'N and $77^0$34'E to $81^0$02'E longitude, with an area of 53,484 sq. km. of which 93% is mountainous[15]. Uttarakhand has a total of 13 districts and is divided into the Garhwal division and the Kumaon division. The Garhwal division is further selected considering larger population, larger number of reported disasters, and two major and older rivers- Ganga and Yamuna, where the oldest settlement could be found. Overlapping with earthquake zone, landslide zone, and drainage of river Ganga and Yamuna, Uttarkashi district was selected.

Out of six administrative blocks of Uttarkashi district, the Bhatwari block falls under Earthquake Zone-IV and V; prone to landslides; drained by river Bhagirathi (later known as Ganga, oldest and largest watershed area) which has mythological evident from ancient literatures. Moreover, Bhatwari block has a maximum number of houses (17529 houses, as per Census, 2011) taken for further study[16]. The main reasons for the settlement of population on the hills were availability of water, fertile land for agriculture, availability and suitability for animal husbandry, forestry for hunting, climate/temperature, opportunities for horticulture, woollen work, and availability of wood flow[17], that is evident in Bhagirathi valley and has mythological and spiritual significance. Gangotri is one of the main religious towns among the four *Char Dham* pilgrimage in Bhatwari block and the villages nearby are traditional settlements that served the pilgrims and sustained them were selected for study.

Sampling, sample size and selection of case study

Major pilgrimage and trading routes were mapped, and examples of hill communities were studied to arrive at the case study. According to 2011 Census, Bhatwari block consist of 100 villages and 2 towns

and during the pilot study, Gangotri town and nearby villages were explored. It was observed that the villages in proximity to one another are more related than those that are farther apart. Out of villages identified in Group I, lies in hazardous areas yet survived many disasters over centuries (Fig. 1) were investigated. During field visit, it was observed that most of the villages like Dharali, Mukhba, Purga, and others, were located considering the comparative flat available in the region. However, Bagori village was distinctive in this area because of its linear layout and proximity to the river. Two major hill settlements Mukhba and Bagori, as indicative sample case study based on population, community, and their significant form of expression of traditional knowledge were selected for in-depth study.

Bagori

Bagori, a high-altitude (2469 mt) village of Uttarkashi district is located at a latitude 31°01′59″N, and longitude 78°43′59″E, belongs to the Bhotiyas tribe settlement. Their main sources of livelihood are animal husbandry, agriculture, trade, unskilled and semi-skilled labour[18]. It falls on the Indo-Tibetan and traditional pilgrimage route to Gangotri. On the way to Gangotri, it was the last camping site before entering Bhairogathi and high mountain valleys of Nelang and Jadung. This enables them to sell their goods and provides travelers with food, shelter, and warm clothes. Bhotiyas are transhumance because of their pastoral occupation and extreme climatic, migrating northward during the summers and southward during the winters with their livestock[19]. They practice Buddhism and Hinduism.

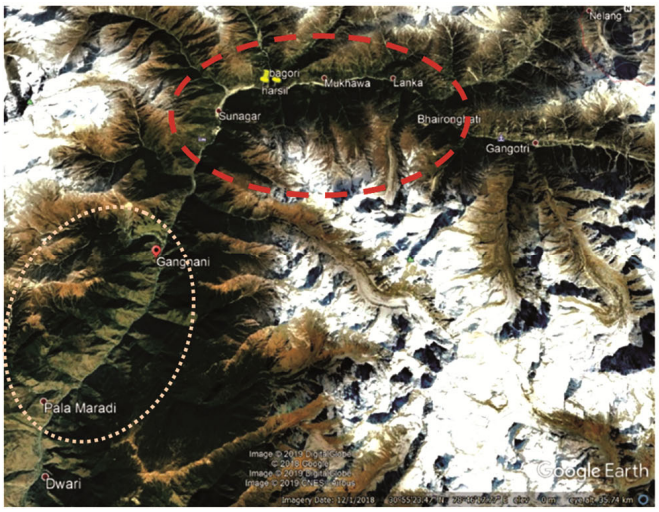
Mukhba

Mukhba, a high altitude (2494 mt) village of Uttarkashi district is located at a latitude 31° 2'39.74"N and longitude 78°46'45.57"E. The village is originally known as Mukhyamath, belong to priest (Hindu Brahmins) homogenous community, who serve the Gangotri temple for ages, lies on the traditional pilgrimage route. They follow Hinduism and worship the holy river, the Ganges, as a divinity. The village is considered as *maika* (*bride's parental home*) of the goddess Ganga, as the goddess idol is shifted to Mukhyamath's temple during the winter and returned in the summer, when the main temple re-opens. The community priest leads a procession on the pedestrian pathway as part of the enthusiastic and zestful celebration of this process.

Materials and Methods

The study uses archival, anthropological, and architectural methods to document the coping strategies of the hill community in living traditional practices in the two selected villages in 2015, 2017, and 2019.

The primary data was collected using archives methods from various sources including maps, census data, and local news to understand the region and settlements. Anthropological methods like field observation, mental maps, interviews, and discussion with the local populace help to connect with the archives' data. Key questions included socio-economic and environmental factors that were considered for the layout of the settlement; hazards encountered in their villages and region; community mitigation and prevention strategies; and role of



S.No.	Group I	Group II
1	Dharali	Gangnani
2	Mukhaba	Hurry
3	Purga	Sungar
4	Bagori	Tihar
5	Harsil	Bhukki
6	Purali	Kunjan
7	Jhala	Salang
8	Sunagar	Pala Maradi
9	Jaspur	Kyark
10	Sukki	Barsu

Fig. 1— List and grouping of 20 villages based on their location. (Source: Google Earth)

community institutions. Data was collected through semi-structured key informant interviews on purposefully selected individuals based on gender, age and community institution. The snowballing approach was also used to identify the interviewers to provide insight of traditional settlement, and their mitigation and preventive measures. This mix of purposive and snowball sampling helped to get a wide network of different experiences. Hindi language was used as the most accepted language of the region. The local villagers and Pradhan were asked to draw mental maps of their villages to demonstrate their understanding of the village.

Architectural illustrations such as the layouts maps of both the settlements were prepared beforehand using Google images which were validated during the site visits and updated. The contour map and drainage pattern were developed using ArcGIS to understand the topography and drainage pattern. Photography on the sequential approach of buildings and videography were used to record field study, to verify the illustrations drawn on-site and develop the architectural drawing of the settlement layout. The oral recordings were transcribed into English to co-relate with the drawings prepared. The socio-cultural data such as interviews and the field observation on the site helped to understand the relationship between the human and natural settings.

The multiple data collected were triangulated, to verify, corroborate, enhance the credibility and trustworthiness or validity of the data[12]. It identified the parameters which were characterized into natural characteristics of the region and human characteristics based on social and economic needs of community. Further, the layout of both the traditional villages was compared and co-existence of the natural and human characteristics of the local context was mapped as inventory of traditional knowledge in Table 1. The last column of the table reflects the strategies adopted by the hill community to address the preventive and mitigation measures to cope with the disasters in the region.

Results

The findings are reflection of co-relation of the natural and human characteristics, and coping strategies adopted to reduce the impact of multiple disasters derived from the inventory of the traditional knowledge.

Setting of villages

Geographically, Bagori and Mukhba are located away from the Main Boundary Thrust (MBT) and Main Central Thrust (MCT) fault zones, which prevents regional threats of earthquake and is often recognised as a safe regional site[3,13].

Both villages are situated between two major streams of high order, flowing on the respective valley formed on the concave ridge, which minimizes the risk of a flash flood. It is also noted that Bagori lies on the foothill and is well protected by the bulging concave mass, while the agricultural farmlands were towards the riverbank (Fig. 2), which keeps the habitable residential area safe from flooding. Mukhba also flourished between the two folds formed in the terrain. The moderate slope allows the inhabitants to carve out the site for residential purpose (Fig. 3). The villagers know that their ancestors have selected safe locations on hard strata rock (quartzite), with vegetation that is not susceptible to landslides. The unobstructed drainage flow and building footprints on a gradual slope mitigates the

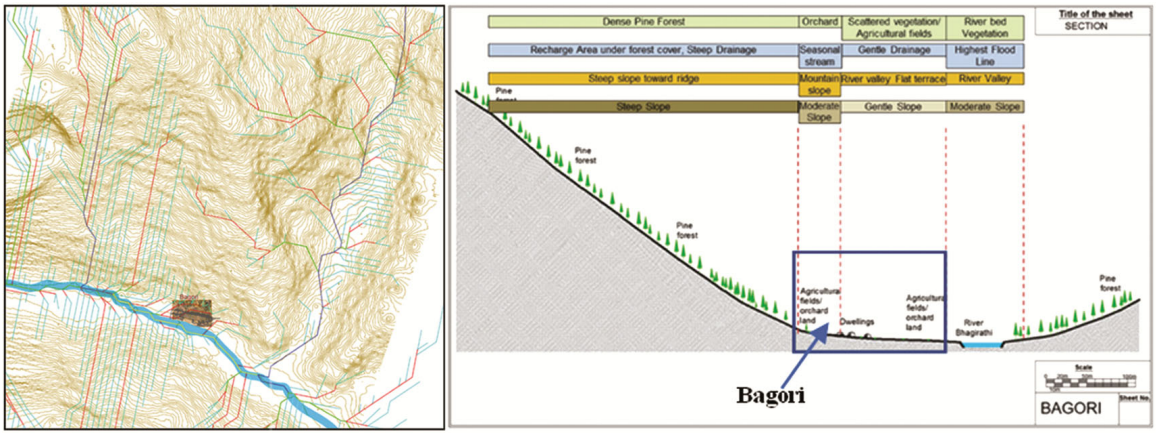


Fig. 2— Location of Bagori & transverse section; (Source: Author)

risk of mass movement that is critical at high-intensity annual precipitation and steep slope.

Social systems

During the winter the Bhotiyas of Bagori migrate to low altitudes, where fodder is available for livestock. The community identify forest and grassland for grazing, which keep on rotation on regular basis to utilize and conserve the natural resources. This prevents the possibility of landslides and mass movement because the vegetation and soil of the area do not deteriorate. Although the community relies on wood for fuel, they have restricted looping of forest but are allowed to gather fallen leaves and stems. Additionally, the forest is devoted to local deities, believing in their safety and blessings.

Table 1 — Inventory of traditional knowledge based on field visit to Bagori & Mukhba, (Source: Author)

Natural Characteristics	What they Know (Risk/ safety factor)	Human Characteristics	Outcome	How they responded or adapted (Preventive or Mitigating measures).
Physiography	People were aware of the traditional pilgrimage route to Gangotri, its trading potential, and the river Bhagirathi's significance in selecting a settlement site.	Community need, Human History, Economics	Location of village	A linear settlement evolved respecting the natural settings on the identified relative flat plain on the foothill along the traditional pilgrimage route.
	People know about the traditional pilgrimage route but being the priest community serving Gangotri, the settlement was placed away from the main road			The settlement pattern evolved organically, considering the natural setting and proximity to the access road.
Slope	People know about the suitable land parcels for constructing buildings or agricultural/orchards use, considering their safety.	Community need, Land-use, Demography	Setting limit	The road was aligned along the contour, with buildings placed on shorter sides to ensure their frontage toward the road.
				The buildings were placed parallel to the contour on the suitable land parcel.
Micro climatic conditions	The sun was considered to provide a comfortable and habitable environment.	Community need	Orientation of building	The buildings were oriented to receive maximum direct sun exposure.
Hierarchy of semi/ open spaces	Small open areas in front of their houses serve as display areas for selling commodities and their working area.	Community need, Economics	Aspect	The buildings have adjacent open space, but there is no community open space.
	The temple complex necessitates large, open spaces for conducting various rituals and ceremonies.	Community need, Community organisation		They have open space as front yard of the building, and a community open space in the temple complex.
Drainage	People signify the role of water and understood that flow of stream is natural and cannot be control.	Community need, Land use	Surface drainage	Detached buildings were built to prevent obstruction of downhill water flow, allowing for immediate water clearance and preventing accumulation.
Flood plain	They recognized the water-related risk and identified the High-Flood-Level.	Defining the land-use	Setting limit	The buildings were strategically placed above the identified HFL and away from the river to mitigate the risk of floods in the settlement.
Land use	They are aware of the water level and the land covered by it during the monsoon season.			The buildings were placed away from the river while agricultural land was toward the riverside.
Soil	They know the importance of soil quality for settlement and agricultural land.	Community need, Land use	Location of village	They identify the suitable soil conditions for buildings and agricultural land.
	They know and practice soil conditions testing to ensure soil quality for settlement.			They prioritize the suitable soil conditions for buildings over agriculture due to their reliance on dairy product.

Settlement layout

Bagori lies on the traditional pilgrim route on the riverbank and is involved in serving the Gangotri pilgrims as well as trading from neighbouring countries. The pilgrim road and the natural contours dictate the linear pattern of settlement, parallel to the river/ road (Fig. 4) and buildings were oriented to have direct access, to minimise the cutting of hill. The residential areas are kept approximately 150-meters away from the river edge, while the agricultural fields are towards the riverside or hillside. Further north, on a steep slope, are few farms and orchards, and then a dense forest, uphill towards the crest (Fig. 3). Dense vegetation on steep slopes stabilize the soil and reduces the risk of landslides. At the time of heavy rainfall, the overflow of river entre the agricultural field, and the dwellings are not affected by the floodwater. The silt deposited also enriches

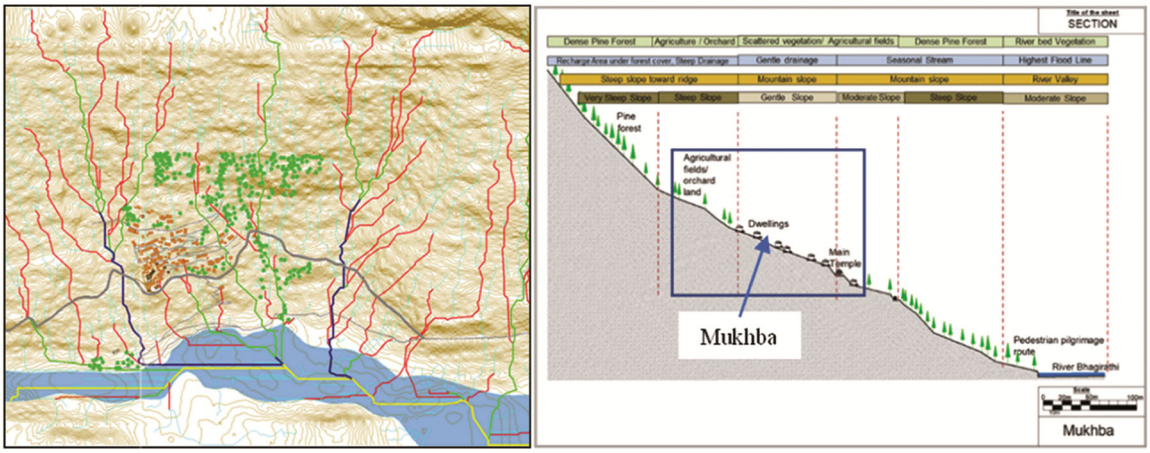


Fig. 3 — Location of Mukhba & transverse section; (Source: Author)

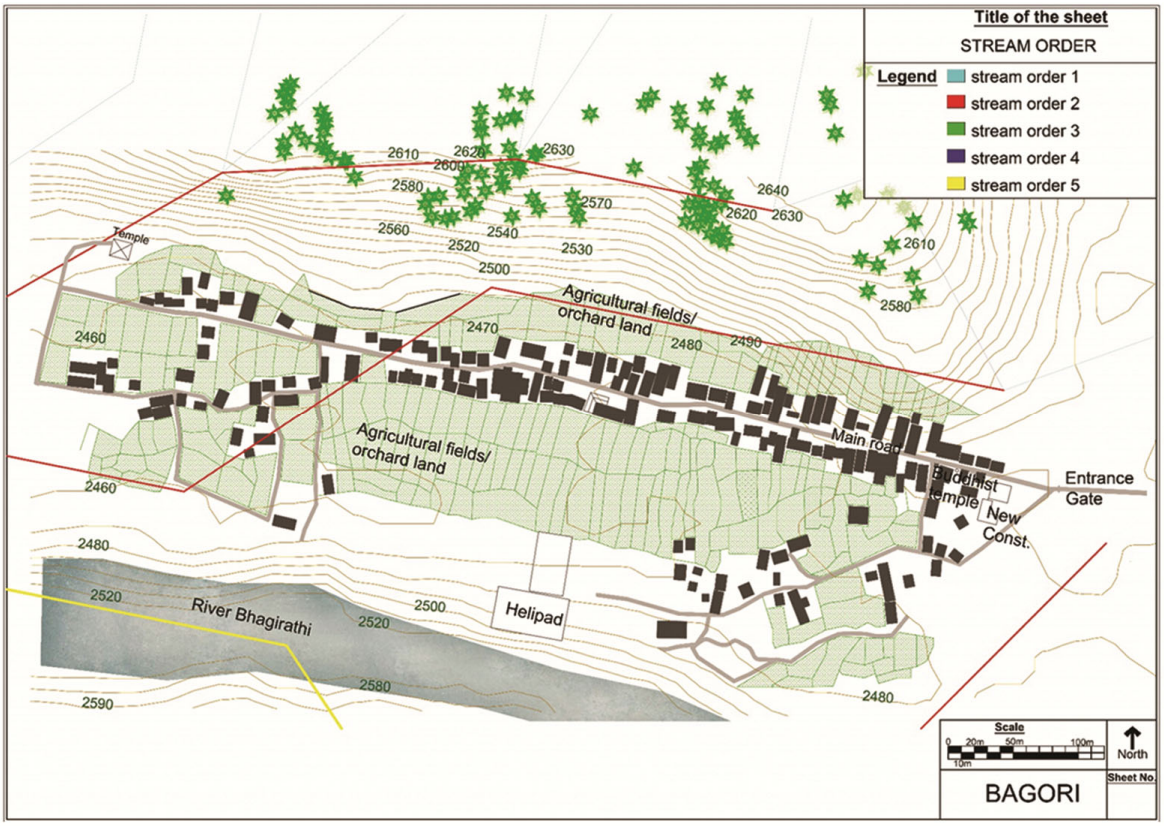


Fig. 4 — Surface drainage and settlement layout of Bagori; Source: Author

agricultural land. At the entrance gate lies the Buddhist temple, while at the extent of the village lies a Hindu Temple (*Ringali Devi Sidhpith*). These two temples mark the extent of the village, and the inhabitant believes that the settlement between the two temples is a safer location. Forests also play a role in attenuating and blocking debris flows and rockfalls by forming a physical barrier against sliding and falling material.

Mukhba also lies on the traditional pilgrim route in midland valley. The communities living here render their services as a priest to Gangotri and Mukhba temple. The pilgrim route provides access to the village, while the settlement is located and flourished in an accessible flat area with a slight slope towards the river within topographical constraints. With the growth of population, the extension of the village was observed beyond the temple and the major valley as seen in (Fig. 5). The village is accessed by ramped foot passage that leads to the Mukhba temple (winter temple of river Ganga) court, while at the extent of the village lies a waterfall (*Bheem Dhara*). The community considers the safe location for the settlement between the temple and waterfall. Dense forest and steep slopes toward the north restrict uphill development, while the river Bhagirathi limits the expansion toward the south.

The local people had developed the technique to identify the gentle slope based on the force of stones thrown from the higher altitude. They believe that if the stone is thrown, and it moves very fast, it indicates an evil spirit, so people don't choose that area for any settlement. During the 2014 flash flood, people from both the villages reported that there is no major damage in their villages, only the volume and speed of the water in the water channels were high.

Orientation

In Bagori most of the houses that aged more than 200 years were placed perpendicular to the main access road due to socio-economic reasons. The orientation of the building is adopted to avoid the harsh wind in the valley. The impact area of the buildings that may be affected by the riverbank flood or hillside landslide will lie on the shorter side of the building. There were few buildings placed parallel to the main road, but they all have an open space in front of it (Fig. 5). Open areas and semi-open balconies are oriented towards SEE, SWW to have maximum

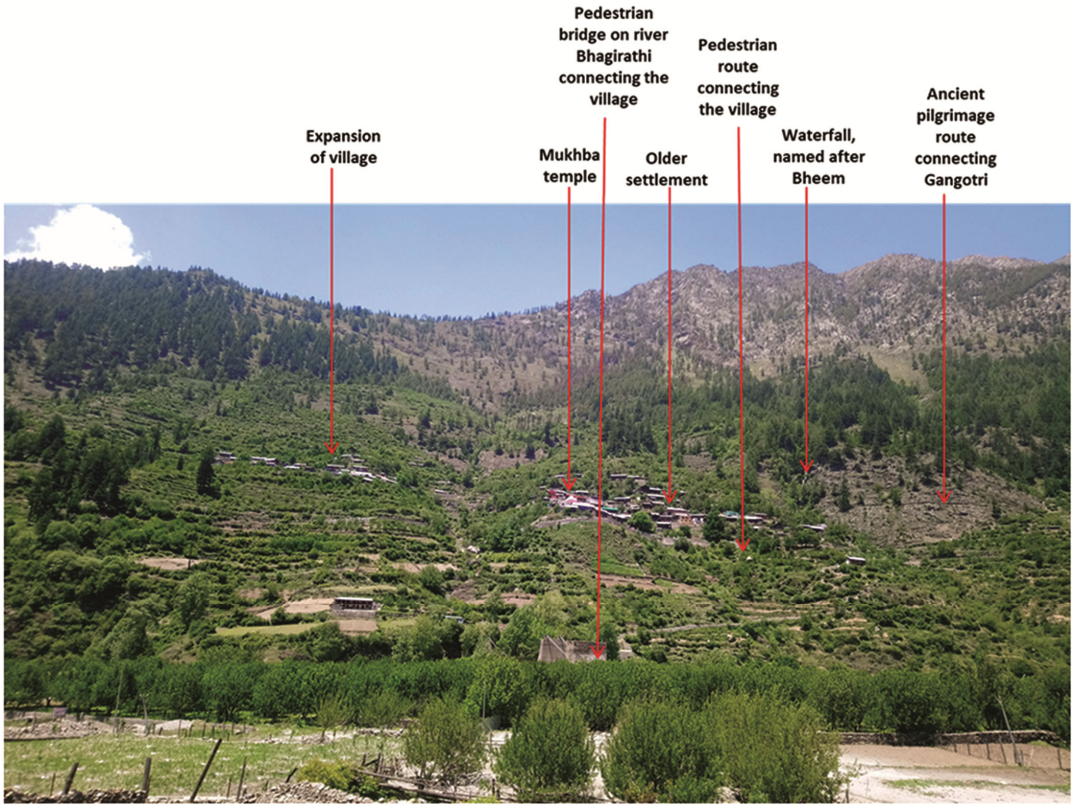


Fig. 5 — The Mukhba village extends within the limits demarked by a temple, and streams; (Source: Author)

exposure to sun and used throughout the day, especially during the winter and used for the display of their products that could be sold off to the pilgrims.

The settlement layout in Mukhba is organic and buildings are oriented to have maximum exposure to the sun. The whole village has pedestrian walkways, and so buildings were located at different levels on the available buildable site for construction. People are associated with the daily ritual to worship the sun and holy rivers. This orientation allows having maximum exposure to the sun on the longer side and especially till sunset. This contributes to providing warmth throughout the day. The community celebrates their festival by singing, performing dances, and rituals jointly in the major open area space in front of the main Mukhba temple. The dwellings have front open space, which is used for household activities and gathering space.

Surface drainage

The drainage pattern and stream orders were considered in both the villages for the settlement pattern (Fig. 4 & Fig. 6). Each dwelling is a detached building and has a clear passage in between the buildings. A setback of at least 450 mm between the building and the rear hillside allows the excess water to drain out. The natural flow of water is considered to place the buildings that save them from the risk of hydro-meteorological hazards and its impact.

Building footprint

The buildings in Bagori have a smaller footprint than in Mukhba, due to their economic stability and spatial requirements. The buildings are detached, stilted, and consist of two stories in Bagori, and three-storied in Mukhba. But in both villages, the ground floor is used as animal shed (*goshala*), and fodder storage while the upper floors as living areas. This spatial organization provides enough time to move to higher ground with their possession, in case of flash floods and landslides. The building plan is simple rectangular, symmetrical, and earthquake resistive. As communicated by locals, traditional buildings in both the villages were built by their great-great-grandfathers that encountered several hazards in the region, but still standing intact for ages. Local people believe that structures are multiple disaster-resistant, and their presence is evident.

Traditional warning system, preparedness, and mitigation

Early warnings in nature are indicated by the appearance and behaviour of flora and fauna that help the community to take preparedness and mitigation measures[20]. Many indicators such as the early return of rearing cattle, the appearance of wild boar and wild crow, chippering and movement of birds, movements of insects, barking of dogs, flow and colour of water in the river indicate the possibility of an earthquake, flash flood and concurrently landside as narrated by interviewers. This allows the community to take

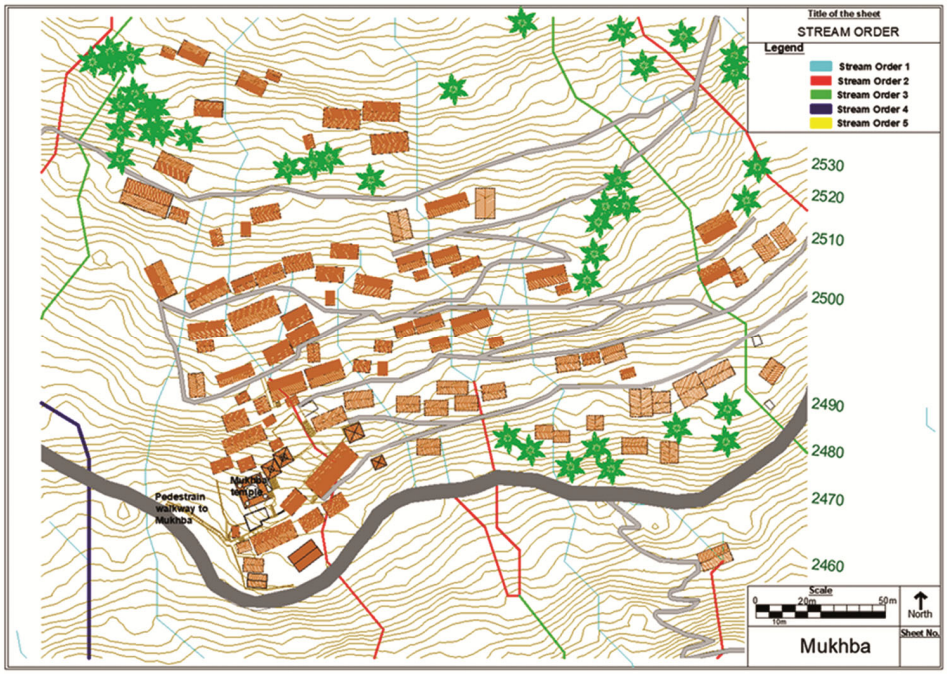


Fig. 6 — Surface drainage and settlement layout of Mukhba, (Source: Author)

preparedness measures within a short duration. The community takes their possession to the upper floors in the living area and sometimes have to shift their livestock to a safer hill area.

High temperature and humidity led to early blossoming and ripping for apples. Similarly, the early harvesting of kidney beans indicates heavy rainfall helps the community to take preparedness measures. The community prepares and repairs their dwellings, harvests their crops, embanks agricultural land, cleans the drainage, performs the ritual, and takes care of livestock diseases.

Coping and adaptive strategies for food and water

The residential buildings in both the villages have significant food storage, indicating their traditional food security. The respondents at Bagori shared that during the flash flood in 2014, they provided shelter and food to over 100 tourists for a week at the community level, reducing the daily meals (generally two) per day and relying on available resources to cope with the situation. Open spaces in front of the temple have their associated belief and act as gathering places. The community's homogeneous socio-economic status unifies them during critical situations. They were also aware of the location of portable spring water, indicating the awareness of the risk of consuming contaminated water and not wasting their resources in boiling the water.

Both the villages were strategically located based on the topography aspect of the region, which does not allow water to accumulate and stagnant but continuous flow through the water channels. This led to coping and reducing their vulnerability related to food, drinking water and health issues.

Discussion

The findings of this research show that traditional settlements of Bagori and Mukhba are based on the knowledge gained to prevent and mitigate the disasters over years that are reflected in their practices and beliefs that are greatly influenced by the natural and human characteristics of the local context. It is much influenced by community needs, community organization, economic aspects, designated land use, and human history as shown in Table 1. The preventive or mitigating measures evolved are further mapped to understand the factors of disaster risk reduction. As Cutter[21] mentioned, social and biophysical vulnerability interact to produce the overall place vulnerability. The settlement layout parameter and its participation in avoiding the hazard and adapting capacity, which eventually reduces the vulnerability thus disaster risk reduction as shown in Table 2. The strategies and responses are considered based on three parameters, *i.e.,* slope, drainage, and soil, corresponding to avoiding the hazard and adapting

Table 2 — Relevance of traditional knowledge in disaster risk reduction; (Source: Author)

	Disaster Risk Reducing = Hazard X Vulnerability	
Parameter	Description	Code
Physiography	Adapting natural setting to evolve linear/ organic settlement pattern respecting their socio-economic aspects.	AC
Slope	Avoiding steep slope and adapting capacity to evolved suitable settlement pattern.	AH + AC
(Micro) Climatic conditions	The buildings are adapting the natural resources and oriented to reduce the environmental vulnerability.	AC
Hierarchy of open Spaces	Adapting natural setting according to their socio-economic aspects.	AC
Drainage	Adapting to the natural drainage pattern and avoiding the risk due to water.	AH +AC
Flood plain	Adapted the natural settings and defined the land use to reduce vulnerability Settlement was placed at higher elevation to avoid flood naturally.	AC
Land use	Land use at micro planning level is based on identified safer zone to avoid hazard like flash flood, flood and landslide.	AH
Soil	Adapted the natural settings to get increase in the fertility of land and reduce economical vulnerability by additional source of income. Adapted the natural settings to place their buildings and reduce vulnerability.	AH+AC

AH	1
AC	4
AH+AC	3

capacity accordingly. Hence it seems that 1 parameter contributes to avoiding hazard (AH), 4 parameters contribute to adapting capacity (AC), and 3 parameter combinations of avoiding hazard and adapting capacity (AH+ AC).

Uttarakhand state is prone to earthquakes (Zone IV and Zone V), but in the settlement layout, the risk of flood and landslide was prioritized. Thus, we can see that vulnerability is reduced due to the following factors:

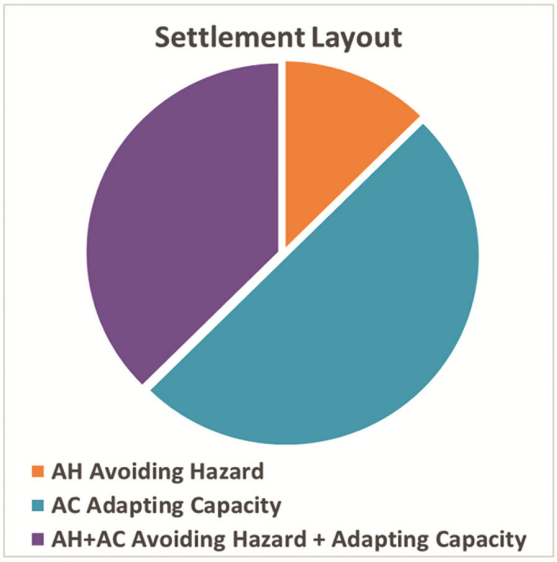


Fig. 7 — Pie chart showing the distribution of strategies in avoiding hazards and adapting capacity in settlement layout; (Source: Author)

The settlement pattern helps to reduce the risk factor. As seen in Bagori, the residential buildings are placed between the agricultural fields and orchard toward the river or hillside creating a barrier between water and rockfall. While in Mukhba the settlement is placed at an elevation of about 300 mt away from the river, so residential units are towards the roadside, and agricultural fields are towards the hillside.

The area falling on the natural drainage is left as an open area/ playground as seen in Bagori as well as Mukhba to avoid any hindrance in the passage of water, especially during the rain.

It is clearly understood that strategies employed through the traditional knowledge are less highlighted in the form of avoiding hazards than adapting capacity (Table 2 and Fig. 7) when it comes to determining settlement layout in a specific location. With the population growth and urbanization, there are few initiative in the development are taken in urban area, but not addressed in the rural area[22]. This reveals that the hill community utilised their knowledge in their traditional settlement to either resist, prevent and mitigate the disaster and participate in reducing disaster risk and developed as the framework shown in (Fig. 8) and explained further.

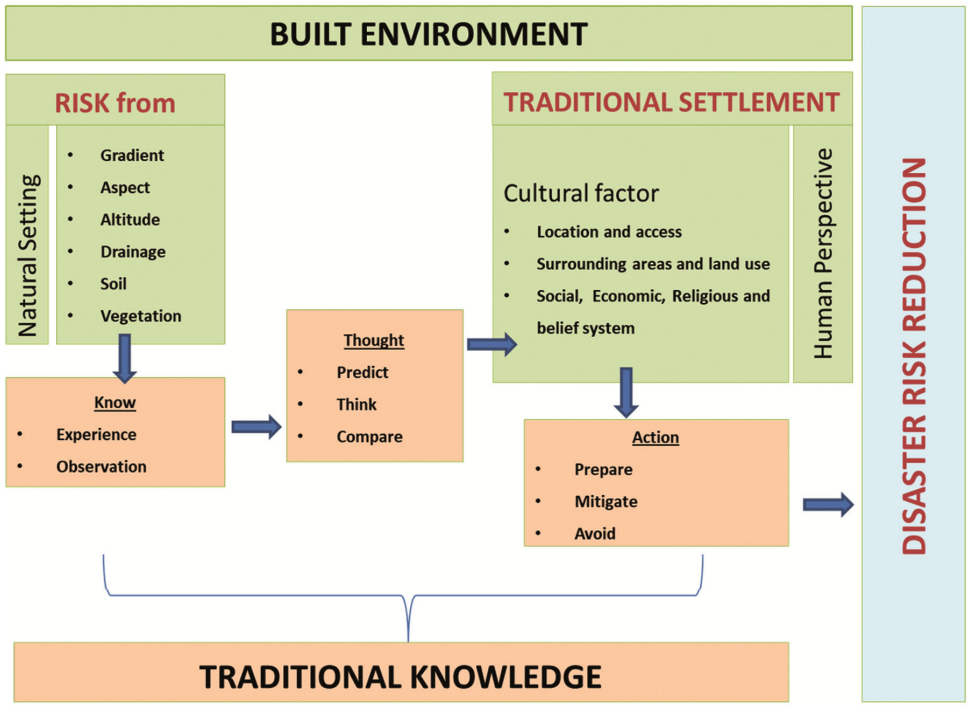


Fig. 8 — A framework on the understanding-built environment and traditional knowledge and its participation in disaster risk reduction; (Source: Author)

Conclusions

This research paper discusses the potential of traditional settlement considering the case study of Bagori and Mukhba to cope with major five hazards *viz.,* flood, landslide, drought, forest fire and earthquake that have disastrous impacts on people and the environment in the hill region of Uttarakhand. The hazard potential in the form of risk from geographical factors such as gradient, aspect, altitude, drainage, soil, and vegetation present in the natural settings is filtered based on the hill community's experience and observation.

They acquired cognitive knowledge based on their ability to think, compare, forecast, and take measures that help in lessening the effect of multiple disasters, which is a significant challenge in Uttarakhand's hill area. This resulted in identifying and defining the safer site's location, the situation of the place, and its social fabric. The social fabric is based on the community's critical cognitive understanding and influenced by social, economic, religious, and belief systems. The issue of vulnerability is the outcome of three factors, exposure (to the natural settings), sensitivity (understanding the surroundings and responding accordingly), and adaptive capacity (the ability of people to deal with the effect). The community adopted different traditional preventive and mitigating measures.

The culture-place factors evolved in the form of land use, understanding of the surrounding area, established social, economic, religious, and belief systems, and inbuilt them have enabled them to take actions which prepare, mitigate, and avoid the challenging risk of that region. Avoiding flood or landslide-prone areas while building a home and staying away from dangerous areas at times of the year, such as not transporting cattle up mountain valleys during spring floods, are among the land-use techniques.

The locals follow their norm and laws based on their traditions which are not regulated; hence it is the need of the hour to develop guidelines based on the traditional knowledge that could be incorporated in contemporary practices to ensure the disaster risk reduction. Traditional knowledge has enabled the communities to mitigate risk and develop strategic measures to plan their settlements accordingly. These measures taken in their lifestyle and belief system were based on their traditional knowledge and are followed by the indigenous people carefully in their contemporary practices. So, it is important to value this traditional knowledge not limited to recognised, conserve, and document but also to adopt the coping strategies leading to disaster risk reduction in modern architectural practices and encouraged in the following ways:

- Various specific traditional practices and strategies embedded in the knowledge can be transferred and adapted with contemporary practices.
- Incorporation of traditional knowledge in the existing practices and policies will encourage the participation of the affected community and empower its members to take the leading role in all disaster risk reduction.
- The information contained in traditional knowledge can help to improve the project implementation by providing valuable information about the local context.
- The dissemination of non-formal traditional knowledge will gear other education on disaster risk reduction.

Furthermore, building level magnitude of knowledge could be also explored through detailed case study and fieldwork that would help in developing building regulations that will address the contemporary need of the people.

Acknowledgements

This study is a part of doctoral research and did not receive any grant from funding agencies in the public, commercial, or non-profit sectors. The author thanks the people of the Bagori and Mukhba for sharing valuable information on traditional practices and beliefs associated with the settlement level. Gratitude to Dr Ram Sateesh Pasupuleti, IIT Roorkee, to accompany the author on a field visit and for his critical suggestion for this research work.

Conflict of Interest

The author declares no competing or conflict of interest.

Author Contributions

NS have conceptualize, design and conducted the field study that were analyzed and prepared the manuscript.

Ethical Approval

The interviewees were informed about the research and given their consent to conduct the interview and record it. The identity of the interviewees was not disclosed at any point in the study.

Data Availability

The dataset generated and /or analysed during this research are part of the doctoral research available in the library of SPA Bhopal and portal of Shodhganga.

References

1 Birkmann J, *Measuring vulnerability to natural hazards: Towards disaster resilient societies*, First ed., (edited by Birkmann J), (TERI Press, New Delhi), 2006.

2 Kitamono M, *Total Disaster Risk Management - Good Practices*, (Asian Disaster Reduction Center, Kobe), 2005.

3 UNISDR, Sendai Framework for Disaster Risk Reduction 2015-2030, *Available online www.preventionweb.net/go/sfdrr*, 2015.

4 Govt of India D, Traditional Knowledge System, *National Children's Science Congress, Available Online :*, (*http://www.astec.gov.in/ncsc/agb_5_tks.pdf*), 2018.

5 Choudhary M, Jaiswal K S & Sinha R, *HOUSING REPORT: Traditional rural house in Kutch region of India* (*Bhonga*), 2003.

6 Rautela P & Joshi G C, *Earthquake Safe Banal Architecture of Uttarakhand*, (Disaster Mitigation and Managment Centre, Department of Disaster Management, Uttarakhand Secretariat, India, Dehradun), 2007.

7 Langenbach R, *Don't Tear it Down! Preserving the Earthquake Resistant Vernacular Architecture of Kashmir*, (UNESCO), 2009.

8 Joshi V, Rawat M S, Sharma A K, Kumar K & Panda A K, Traditional knowledge of natural disaster mitigation and ethno medicine practices in Himalaya with special reference to Sikkim, *Indian J Tradit Know*, 10 (1) 2011 198-206.

9 Bourdier J P & Al Sayyad N, *Dwellings, settlements and Tradition*, (University Press of America), 1989.

10 Pasupuleti R S, Understanding the role of culture in post disaster development contexts- The case of Tsunami reconstruction in Tamilnadu, Southern India, PhD. thesis (University of Welminster, London, UK), 2011.

11 Chand K, Use of Traditional Knowledge System (TKS) for Disaster Risk Reduction in Kullu Valley, North-Western Indian Himalaya, In: *Research Trends in Environmental Science*, edited by Sharma P, (AkiNik Publications, New Delhi), (2019) 109-126.

12 Creswell J W & Creswell D J, *Research Design Qualitative, Quantitative and Mixed Method Approaches*, Third Ed., (SAGE, New Delhi), 2009.

13 Satendra, Gupta A K, Naik V K, Roy T K S, Sharma A K, *et al.*, *Uttarakhand Disaster 2013*, (NIDM, New Delhi), 2014.

14 Swanborn P G, *Case Study Research*, (SAGE Publications India Pvt Ltd), 2012.

15 Government U, *Uttarakhand at a Glance 2018-19*, (Directorate of Economics and Statistics, Department of Planning, Dehradun), 2020.

16 Singh N R, Khare A, Pasupuleti R S & Singh G, Disaster risk reduction: Lessons from traditional knowledge, *Int J Recent Technol Eng*, 8 (6) 2020 1209-1216.

17 Majumder B, *Housing on the Hills in India*, (Concept Publishing Company Pvt. Ltd, New Delhi), 2011.

18 Bhatt P, A Study of Traditional Costumes of the Tribes in Uttarakhand, (Govind Ballabh Pant University of Agricultutre & Technolgy), 2016.

19 Srichandan S, Pasupuleti R S & Mishra A J, The transhumance route of Pithoragarh: A cultural route?, *Environ Challenges*, 5 (2021) 100291.

20 Kanwal V, Sirohi S & Chand P, Farmers' perception on climate extremes and their coping mechanism: Evidences from disaster prone regions of India, *Indian J Tradit Know*, 20 (2) (2021) 512-519.

21 Cutter S L, Vulnerability to environmental hazards, *Prog Hum Geogr*, 20 (4) (1996) 529-539.

22 Joshi N, Wende W & Tiwari P C, Urban planning as an instrument for disaster risk reduction in the Uttarakhand Himalayas, *Mt Res Dev*, 42 (2) (2022) D13-D21.