

Changing With The Seasons: How Himalayan communities cope with climate change

Chicu Lokgariwar
Peoples' Science Institute
252/1 Vasant Vihar
Dehra Doon



Abstract

Mountain areas and communities are susceptible to climate change. The Peoples' Science Institute conducted a participatory study in the Bhagirathi and Pindar valleys of Uttarakhand in 2009 to determine the effects of climate change that have the most impact on rural livelihoods. This work also yielded evidence of the coping strategies developed by the communities to deal with an unprecedented and only partially understood threat. This paper describes these strategies and attempts to assess the vulnerability of the communities in each valley.

Keywords: baseline; Himalayas; resource-based livelihoods;

Table of Contents

1. Background 3

2. Study Area 5

3. Materials and methods 6

4. Coping strategies: 8

5. Vulnerability 11

6. Conclusions 13

7. References 15

8. Acknowledgements: 16

1. Background

Climate change is being seen as one of the most serious challenges facing civilization. The mountain communities of Uttarakhand depend on the varied forest types and alpine meadows to provide for their personal needs and their livestock's sustenance (Sati, 2006). Fluctuations in the physical environment of the Himalayan glaciers are being reflected in the livelihood changes of the local communities.

Research on climate change in the Himalayas displays consensus on some important points. It has been observed that the main trends are increasing aridity and warmer winters (Dash and Hunt, 2007). Communities are adversely affected by increasing variability in rainfall. Untimely precipitation, unexpected frosts and storms play havoc with crops (Renton, 2009). Crops that were originally not grown in the areas are now cultivated, opening up an avenue of income to farmers, or at the least compensating for the loss of older sources of income (Singh S.P, 2007). Crops that need warmer weather, such as tomatoes and other vegetables, thrive while crops that need freezing temperatures, such as apples, are on the decline.

As for ecosystems, here too the lower altitude ecosystems thrive. Warmer temperatures facilitate migration to higher altitudes and open up larger areas for colonization. Rhododendron and pine are beginning to invade high altitude meadows (Singh et al 2010). Higher altitude ecosystems, notably the alpine meadows, however are limited by the topography and are squeezed into increasingly narrower belts (Erickson M. 2007).

Oxfam international (Briefing paper 130 and Gum, 2009) has listed a number of strategies that need to be implemented in the short term if hunger is to be effectively combated. Increase in irrigation, and shift from traditional crops to vegetables are recommended. Disasters will probably increase and need to be planned for. ICIMOD's perspective paper (Eriksson et al) makes a strong argument for reducing scientific uncertainty and including research while formulating policy. The International Labour office warns that climate change impacts will make it more difficult to achieve the Millennium Development goals, especially those of achieving food security.

In the midst of these debates and formulation of strategies, local communities find themselves facing challenges with the limited tools at their disposal. Unpredictability of weather patterns and the local scale of some impacts mean that global and national policies have little or no impact on communities. In addition, there is the question of time. While debates among governments and academia continue, climate change is affecting lives and livelihoods in the mountains. The defining characteristic of climate change is an increasing unpredictability. This makes it difficult for mountain communities to plan strategies to cope with the events they witness, especially as very few of them are aware of the existence of this global phenomenon.

Communities and ecosystems are intimately linked with each other, a change in one affecting the other. This interdependence has been acknowledged leading to the term 'Ecocultures' (http://www.essex.ac.uk/global_challenges/). The extent to which communities and ecosystems are affected by external changes is influenced by several factors (cropping pattern, access to resources, access to knowledge etc) which collectively describe the resilience of these systems.

The classical definition of resilience describes it as a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between

populations or state variables (Holling 1973). With its implication of a closed system subject to external forces, this definition is appropriate for a study of the impact of climate change on an ecosystem with little or no human interference. However, in this case, the valleys studied have been subject to centuries of modification by humans. Both valleys where surveys were conducted have been cultivated for centuries, their timber harvested, and their meadows set fire to. The researcher is then faced with the problem of defining a steady state that the system can attempt to persist in. The operational definition of resilience as the ability of the system to maintain its identity in the face of internal change and external shocks and disturbances (Cumming et al 2005) is better suited to the study as it allows for an anthropocentric influence on the ecosystem. In this case, the two valleys have an established state the residents identify with. The identity of the areas surveyed may be defined by the following factors:

Ecosystemic composition:

Forests: pine, deodar (Bhagirathi valley), rhododendron, oak (Pindar valley)

Meadows: herbs

Communities: small villages with a predominantly agricultural focus. The Bhagirathi valley is well known for its apple orchards, while the Pindar valley is a popular trekker's destination as it offers access to three glaciers (the Pindari, Sunderdunga, and Kafni glaciers)

This paper attempts to examine the vulnerability of these communities to unpredictable environmental changes and list the strategies developed by them to cope with these stresses.

2. Study Area

This paper draws upon a study on climate change impacts carried out in 2009 and PSI's experience working in the mountain villages of Uttarakhand for the last two decades.

For the climate change study, reconnaissance surveys were carried out in the Bhagirathi, Pindar and Tons valleys of Uttarakhand. Following these, two valleys were selected for detailed surveys, the Bhagirathi and the Pindar valleys. The altitude range surveyed was from 2400-3800 metres above sea level.

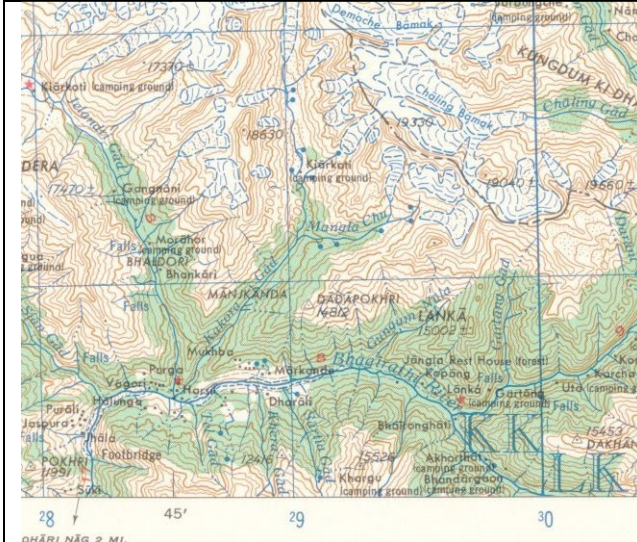


Figure 1¹ Map of the Bhagirathi Valley

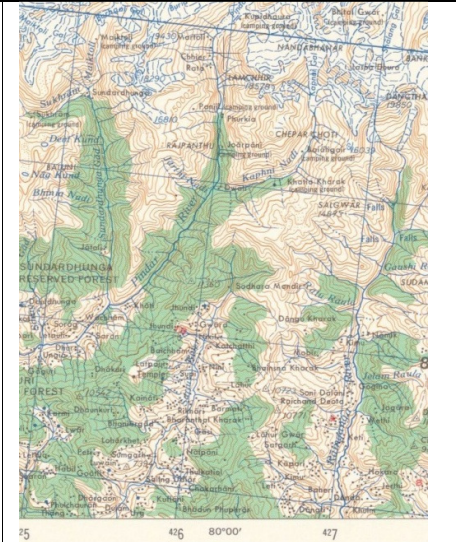


Figure 2 Map of the Pindar valley

District/ village	population	no. of households
Uttarkashi (Bhagirathi Valley)		
Dharali	594	121
Mukhba	1001	170
Jaspur	454	88
Bageshwar (Pindar Valley)		
Dwali	177	33
Khati	307	47
Wachhum	1018	181
Munsyari		
Bona	348	85
Golpha	387	83
Zimiya	149	34
Almora		
Sakdena	147	27

Table 1 Population details of surveyed villages (Source: Census India 2001)

¹ Maps extracted from NH44-01 and NH-44-06, obtained from the Perry Castaneda Map Collection, University of Texas, available online at <http://www.lib.utexas.edu/maps/asia.html>

The villagers in the Bhagirathi valley practice horticulture, agriculture and pastoralism. The area is famous for apples, though production has been declining in recent years. The villagers practice transhumance, with the cultivators moving lower down the valley to Dunda from November to March, while the shepherds move between the high-altitude meadows and the forests in the Terai. Tourism is confined to a very short pilgrimage season.

Pindar valley relies a great deal on revenue generated through adventure tourism. Nearly all villagers are either directly catering to trekkers' needs or participating in supplementary activities. Potatoes are the major crop, followed by finger millet which is largely grown as a fodder crop. Some wheat is also grown for personal consumption, but this is on the decline.

3. Materials and methods

The survey included a mix of qualitative and quantitative techniques. A reconnaissance survey was followed by detailed field surveys in two selected valleys. Participatory methods such as group interviews and transect walks were used to obtain information about agriculture, pastoralism, historical events and perceived changes. The composition of forests and meadows was determined using quadrat surveys using selective sampling (Chaturvedi and Khanna, 2000).

Hydrology	Ground Freezing: Period, number of incidents
	Snowfall: Period, number of incidents, max depth
Weather patterns	Extreme events
	Changes in seasonality
Agriculture / Horticulture	Crop calendar
	Pests
	Cropping area and yield
	Dates of flowering of fruit trees
	Orchard maintenance calendar
Forests/ meadows	Quadrat survey: Shift in predominant species and endangered species
	Use of non-timber forest products: species harvested (with amounts where applicable)
Transhumance	Calendar
	Number and species of animals
	Number of pastoralists
	Income
Perception	What are your most pressing concerns? Since when have these become apparent? Why do you think this is happening? What are the main changes that affect you? What steps are being taken to compensate? What more needs to be done?

Table 2 Summary of baseline format

In order to obtain quantitative evidence of the changes in weather, it was decided to analyse weather data. Accordingly, temperature and precipitation data for four weather stations in

Uttarakhand were obtained from the Indian meteorological office² and analyzed. In order to decrease the influence of the solar cycles on temperature, data for the last 100 years was obtained. The data was obtained for the following stations:

Station number	Name	Nominal elevation (metres above sea level)
42111	Dehradun	682
42114	Ranichauri	2100
42147	Chaubatia	1829
42148	Pant Nagar	233

Table 3 Weather stations for which data was obtained

Weather data for two of the four stations (Ranichauri and Pant Nagar) had several gaps, and so the stations for which long-term data was available were used for detailed analysis. Dehradun data may be considered as representative of valley conditions and the Chaubatia data of elevated altitudes.

Parameter	Observations	Conclusions	Remarks
Temperature	Summer: Increase in maximum temperatures, decrease in minimum temperatures	Increasing extremes in weather, with hotter summers and colder spells in winters	Min temp in June, and max temp in Jan for Dehradun run counter to this trend
	Winter: Increase in maximum temperatures, decrease in minimum temperatures		
Amount of precipitation	Declining trend	Increasing aridity	
Intensity of winters	The number of months with below-freezing temperatures show an overall declining trend, while deviations increase	Increasing unpredictability of winters, with an overall decline of freezing temperatures	The analysis looks at the months where freezing temperatures have occurred, and not the number of such occurrences within a month
Rainfall pattern	The periods of heavy rainfall are shifting towards later months. Deviation is also increasing with the heaviest rainfall occurring towards the end of the monsoon	Increasing variability as well as a tendency towards later monsoons	

Table 4 Summary of weather data analysis

² National Data Center, ADGM(R) office, IMD Shivaji Nagar, Pune- 411 005, Maharashtra. <http://www.imd.gov.in>

4. Coping strategies:

The surveys conducted indicate that the two valleys visited are experiencing stress due to both anthropogenic factors as well as those due to climate change. Among the anthropogenic factors, increasing population and market demand are accelerating environmental degradation and a shift in agricultural practices. Climate change is leading to a decrease in winter rainfall, lack of freezing temperatures and increase in the frequency of extreme weather events. These changes were related to us by the respondents and confirmed by analysis of weather data. The residents of the valleys surveyed had modified their crop patterns and livelihoods in an attempt to cope with these changes.

Horticulture: Dharali and Mukhba in the Bhagirathi valley are major producers of apples. These areas are experiencing the effects of climate change with early flowering of apples. While apple trees would normally flower in the second or third week of April, in 2009 flowering occurred in the fourth week of March. Apple trees need a minimum of 10 weeks where temperatures do not rise above 5°C (Abbot, 1984). The lack of chilling temperatures is leading to a decrease in fruit setting while untimely hailstorms are decimating the crop. Their crop has been poor for the last two years. In 2010, cloudbursts destroyed 30% of the crop in Uttarakhand (Press Trust of India, 2010). In 2009, half the crop was ruined by unseasonal hail (Thapliyal, 2009). This series of events supports the farmers' claims that unpredictable weather and extreme events are on the rise. In addition to changes in the weather, secondary changes are also being felt. There is an increase in the occurrence of apple pests with mites making their first appearance 4 years ago.

The survey indicated that villagers have recognized the inevitability of climate change and the increasing unsuitability of the area to traditional crops. Tomatoes were first introduced into the Bhagirathi valley eight years ago, and are now adopted by several farmers. During the reconnaissance survey, Naugaon block in the Tons Valley was visited where farmers have taken up tomato cultivation on a large scale. These efforts are proving successful.

It is distressing that the other major stakeholder-the government- seems to be unaware of the major approach shift that climate change calls for. The operational guidelines for the National Horticulture Mission (2010) only states once that it will 'specially focus on...addressing challenges of climate change' without any other discussion of strategies. Similarly, despite the fact that consecutive years of crop failure-for ever changing reasons- are leading farmers to look at alternative means of livelihood, the state government still seeks to increase the area under apple cultivation. By attempting tomato cultivation almost a decade ago, the local farmers now have a secondary means of livelihood should apple crops fail- as they have been doing. However, the government persistence in promoting apple cultivation is an instance of rigidity, and a lack of awareness of ground realities.

Agriculture: Monsoons are occurring later than usual. This coupled with the increasing aridity and fewer freezes means that the traditional means of agriculture is no longer viable. It is necessary to adapt to these changes in the weather. However, merely shifting the agricultural calendar will not serve the purpose, as this will not account for the increasing variability. The cultivation of tomatoes and other vegetables indicates that this aspect is recognized by village communities. Nearly all the villages visited show increasing adoption of plains crops such as wheat and vegetables and a lack of interest in traditional hill crops such as millets, buckwheat, and barley.

However, not all the villages have adopted the strategy of changing their cropping pattern. In Khati and Wachhum villages in the Pindar Valley, agriculture seems to have been sidelined. Horticulture was never popular here, but potatoes, wheat and mustard used to be grown on a large scale. However, with winter aridity, the wheat yields have been decreasing. Potato yield has also decreased, and in addition it is beset by pests. Interviews with the villagers failed to reveal any efforts being made to improve agricultural yield. A oft-repeated complaint was the lack of winter rainfall, which led to a decrease in yield. However, alternative sources of water were not accessed instead. In Khati, a perennial stream runs through the village which if tapped, would aid irrigation. This is not being done. The use of grey water for kitchen gardens is also ignored. Direct questioning invariably yielded the response of 'the government should do something.'

Pastoralism: Mid-altitude (~2500 metres above sea level) areas are home to several transhumant communities that move up to the higher altitude meadows in summer. Pastoralism was traditionally a major source of livelihood in the mountains, as the shepherds also participated in trade with Tibet. However, after the closure of the old trade routes not only has this source of income disappeared, but the availability of yaks for crossbreeding with local cows has also decreased (Theophilus, 2010). This is leading to the decline of the yak-cow crossbreeds in the hills. However, while the villagers regretted the decline of the first-generation crossbreeds, they also commented that the yaks tend to eat the twigs in the apple orchards when they overwinter. It may be speculated that lack of freezing is making the area more amenable for cows.

Shepherds travel to higher regions in spring and come back down after the rains. This makes them aware of changes in snowfall. The shepherds interviewed at Wachhum mentioned that there is no longer snow on the paths where they were accustomed to it. In addition Kafni glacier has retreated by several hundred meters. This observation is confirmed by GPIHED which is studying the glacier.

The number of shepherds, and of the sheep owned by families is also rapidly declining. Shepherds spoken with mentioned that it is now difficult to convince younger generations to take up a demanding occupation which is not very lucrative. According to the respondents at Wachhum, this too is led by a desire to enable future generations to lead a 'mainstream' life. This is part of the dynamic growth of communities and the shift to a consumer lifestyle.

Collection of Non-timber forest produce: The residents of the valleys mentioned a decrease in the availability of herbs and other non-timber forest products. However the relative influence of over-exploitation and climate change is a matter for further study. In the case of the brahma-kamal which is harvested in large quantities for a festival for instance, over-exploitation seems to be a key cause. Similarly, the practice of setting fire to the meadows encourages the growth of fodder grasses at the cost of other herbs. Thus, changes in the composition of the Kafni Bugyal are due to human interference. Illegal harvesting of the caterpillar fungus *Cordyceps Sinensis* without due attention paid to rotation of harvesting areas as stipulated by both the Forest Department and traditional village boards is leading to a rapid decline of the species (Lachungpa, 2008).

However, shifts in flowering times are directly influenced by the changing climate. The early flowering of rhododendron in the Pindar valley is directly linked to rising temperatures. Similarly, the observed lack of regeneration in oak (at Dharali), and deodar (Mukhba, Jaspur) can be indicators of a lack of the freezing temperatures required by the seeds in addition to over-grazing (JC Rana and SK Sharma, 2009).

Culture and livelihood dynamics: Subsistence farmers, especially those in the Pindar valley exhibited a lack of interest in developing strategies to continue agriculture in the face of climate change. In some cases, such as irrigation of kitchen gardens in the Pindar valley, solutions that seemed obvious to the external observer were ignored by the farmers. While it is tempting to condemn this attitude and conclude that no effort is being made to adapt to climate change, this 'lack of interest' in improving agriculture is in reality the communities' adaptation strategy. Farmers in the Pindar valley are also seeking to diversify their livelihood options by taking up jobs (either skilled or as unskilled labour) or increasing their involvement in the tourism industry. This may be partly explained by a desire to serve tourists' needs, and also perhaps by a desire to be a part of urban India and so help assimilation.

From the ethnographers' or the botanists' points of view, this shift is saddening and marks the decline of traditional mountain cultures. However, the preservation of cultures, like the preservation of wilderness areas is the hallmark of an outside perspective. It is now recognized that ecosystems are dynamic; similarly mountain and tribal cultures are also moving towards an urban ethos of consumerism. It is telling that barley is now a much-appreciated food product in Delhi and other urban areas selling at twice the price of wheat in high-end outlets (The Altitude Store, 2010). The farmers in the Pindar valley meanwhile, no longer eat it and only grow it as a fodder crop.

The mountain villages of Uttarakhand, are increasing their dependence on a remittance economy. In Pithoragarh district, which may be considered representative of the mountain areas of the state, 56% of the households have at least one migrant family member (CEDAR, 2010). However, this was earlier temporary in nature, and food crops would still be grown. However, migration has now become permanent in nature with most migrants being men of 20-50 years of age. The loss of this workforce has negative consequences on self-sufficiency. In Pithoragarh, agriculture only provides food security for an average of two months (CEDAR, 2010). This lack of food security illustrates the negative impact of migration on the resilience of communities. However, migration is an important tool for communities to diversify their livelihoods. This provides them with a buffer in case of crop failure thereby spreading risk-an important consideration in the face of climate change. In addition to this, migrant workers also increase social resilience by developing links to networks outside the community (Adger N.W et al, 2002).

Disasters: Fold mountains are inherently unstable and prone to slips. This is exacerbated by anthropogenic changes to the sub-watershed and climate change. Deforestation makes hill slopes more susceptible to soil erosion and landslides. Habitations were historically scattered, with traditional houses designed to withstand subsidence. However increasing population has led to increasing density of construction while urban influence has led to the popularity of large concrete houses. These increase the weight borne by the slopes, which triggers landslides. High-intensity rainfall, especially cloudbursts saturate the soil and increase susceptibility to landslides (Sah and Bartarya, 2006). The post-monsoon rains in 2010 caused widespread damage to life and property in the state. As per the records of the Disaster Management and Mitigation Center, Government of Uttarakhand for 25 September 2010, 65 persons lost their lives in the state in that month due to landslides. PSI's work in the construction of temporary shelters in the aftermath of these monsoons indicates that increasing the diversity of livelihoods also increases resilience to disasters. People whose family members were working outside the valley had access to money, and an alternative

source of shelter. On the other hand, subsistence farmers and agricultural labourers were hardest hit by these events.

5. Vulnerability

At a time when the scientific community is struggling to understand the extent and the impacts of climate change, mountain peoples are learning to live with it. Most of the people spoken with in the course of this survey had not heard of the global phenomenon, but their observations echoed those of scientists worldwide. Local communities have learnt that their traditional calendars and practices are no longer applicable to an increasingly unpredictable weather system, and are in the process of developing various strategies to cope with climate change. This process is made difficult by the vulnerability of Himalayan communities. The IPCC Vulnerability Framework (2007) regards vulnerability as a function of sensitivity (the degree to which a system is affected) and adaptive capacity (the ability of the system to adjust).

The Mountain Vulnerability Framework (Brodnig G and Prasad V 2010) lists parameters for assessment of sensitivity and adaptive capacity.

Sensitivity				Adaptive Capacity			
Spatial Marginality	Social Marginality	Resilience	Social Fragility	Biodiversity	Ethnic/Livelihood	Spatial Accessibility	Political Accessibility
Marginality		Fragility		Diversity		Accessibility	

Figure 3 Mountain Vulnerability framework (adapted from Brodnig and Prasad, 2010)

Mid- and high- altitude settlements in the Himalayas have been considered as ‘separate’ from the rest of the nation. This is visible in the desire of these communities to govern themselves, one such movement leading to the formation of Uttarakhand in 2000. The disadvantages that mountain communities face in accessing infrastructure, education, health, finances, or governance clearly indicate the extent of marginalization at the national scale.

Mukhba, Dharali, Bagori and Jaspur are all located on the main pilgrim route to the source of the Ganga. The reputation of their apples has created strong ties with the market. In addition, the area is of strategic importance and has a military outpost at Harshil. Several villagers practice transhumance and have houses in lower down the valley near Uttarkashi which is a major commercial hub. All these factors contribute to the villagers feeling a part of ‘mainstream’ India.

On the other hand, the Pindar valley is currently accessible only by foot (though plans for a road to Khati were in progress at the time of the survey). It is a popular trekking route, but trekkers in their search for wilderness tend to emphasize the remote nature of the land rather than dilute it. The agricultural produce is used locally and does not have the place identity that Harshil apples, Dunda wool, or Munsyari rajma can claim. Interaction with the nation outside the valley has occurred when the Nandadevi Biosphere was created, which further alienated local communities.

This comparison indicates that villages in the Pindar valley are marginalised more than those of the Bhagirathi valley. However, villages in both the valleys are largely self-contained with a clear distinction between ‘inside’ (inside the valley, home, farm, access to produce and forest products) and ‘outside’ (past the roadhead, commercial transactions, migration).

Socially too, the people of Bhagirathi valley have the characteristics of low marginalization. Their proximity to one of the most sacred Hindu places has conferred them with a certain amount of self-esteem. In addition, the Semwal clan in Mukhba is traditionally responsible for the Goddess Ganga and control nearly all of the land and most of the proceedings in Gangotri. This has led to their being revered by most communities in the area. Other villagers too have access to finances, education and other services due to their proximity to both a pilgrim centre (Gangotri) and a military centre (Harshil). The respect accorded to both priests and horticulturists only adds to this.

People in Wachhum and Khati villages however, exhibited high levels of despondency and malaise. This contrasted with the residents of the Bhagirathi valley who took pride in their identity and the ownership of their assets. The village meeting and subsequent interviews at Khati also revealed a lack of cohesion among the villagers. There was a palpable air of waiting for either the Government or 'Someone' to do something to revolutionise the valley. Suggestions for irrigation or improved agricultural techniques would be met with a request for a government grant. It is difficult to ascribe a distinct reason for this valley-wide depression, but one reason could be a feeling of lack of control. Most visitors were either self-contained solo trekkers or part of package groups led by state and national organisations. Locals had a comparatively low-status though crucial role to play as porters or muleteers.

The people of Pindar valley are thus both spatially and socially marginalized at a macro level as compared to their counterparts in the Bhagirathi valley.

These valleys are both set in fragile ecosystems, with the Pindar valley being richer in biodiversity than the Bhagirathi. In either case the villagers' access to natural resources is curtailed by both lack of access to reserve forests and by overharvesting of available species. Quadrat surveys showed a lack of regeneration of oak in the Pindar valley, while pine was regenerating more rapidly than cedar in the Bhagirathi valley. Respondents reported a decrease in the amount of produce gathered from forests and meadows. Thus both areas are experiencing the effects of ecosystemic degeneration. Reported changes in weather are identical in both cases. Thus the ecological stresses faced by both these valleys are considerable and predict a lack of availability of natural resources in the near future.

Spatial accessibility is easier in the Bhagirathi valley. It lies on the main road to Gangotri, which is maintained in superlative condition by the Indian Army. The road is closed in winter, but that is also when most of the population moves lower down the valley. The Pindar valley is not connected by motorable road, and all items need to be brought in by porters or by mules. Politically too, the social marginalization discussed earlier makes it difficult for the villagers to express their views.

The relative levels of vulnerability are reflected in the coping mechanisms developed in each valley. By exploring alternative crops and focusing on keeping cows rather than yaks, the villagers in the Bhagirathi valley seem to be developing strategies that will enable them to continue maintaining their current way of life. With the appearance of mites, the farmers adopted commercial spraying. Now with the resultant ecological imbalance and the necessity of spraying, several of them seem to be questioning the wisdom of reliance on chemical pesticides. Even inevitable change- primarily lack of snowfall- is seen as a spur to adapt. Along with pride in their current lives, a strong sense of community is present. The focus group discussions in both Dharali and Mukhba seemed to be an extension of their regular conversations. Climate change and other problems seem to be discussed

openly. This is also linked to a sense of ownership as the villagers are analysing the situation and making requisite changes themselves without waiting for external leadership.

Increased stress in the form of climate change has strengthened dissatisfaction in the case of the residents of Pindari valley. Here as in the Bhagirathi valley, there is a keen observation of changes in climate. The next step of developing processes that compensate for these changes (eg. Initiating irrigation to combat winter aridity) is not taken. During the survey, drought relief payments were being distributed among the villagers. This dependence on external support is one of the mechanisms adopted by the villagers that will eventually lead to a decline in agriculture and 'force' them to seek livelihood elsewhere. Instead of attempting to adapt to new conditions, the villagers look upon them with fatalism. Several villagers informed us-correctly- that lack of a rest period for lopped trees has led to the decline of the forest. However, this did not lead to the creation of a lopping cycle, or demarcation of rest zones. The villagers preferred coping mechanism then seems to be to change their lives and lessen marginalization by joining the 'mainstream' – the urban areas in the plains.

In the case of resilience to climate impacts that threaten livelihoods, the above analysis indicates that vulnerability is to some extent linked to geography. Living in an area that offers access to and interests a larger community lessens vulnerability. Thus the people of the Pindar and Bhagirathi valleys exhibit a certain amount of homogeneity in the strategies adopted by them to climate change. However, in the case of vulnerability to disasters it is financial ability rather than geographical situation that influences ability to cope with disasters.

With an increase in extreme events comes an increase in landslides, and floods . Work carried out in the Munyari and Almora districts of Uttarakhand after the monsoons in 2010 indicates that climate change increases the incidence of disasters, but poverty and market-driven changes in lifestyles are the primary factors influencing vulnerability to disasters. A shift to a cash economy means an increasing reliance on the market. Formerly self-sufficient villages now largely grow cash crops like chillies or apples and rely on purchase of grain. Landslides damage roads which drastically affects supplies of goods. Perishable goods are also destroyed, leading to a loss of income. . The well-to-do often have access to education which enables them to have jobs in the private and government sectors. This frequently means that they have second homes at their place of work which enables them to cope with crises. On the other hand poor villagers, especially those that belong to scheduled castes, bear heavy losses.

6. Conclusions

The uncertainty in the weather is a strong argument for focusing on increasing the resilience of the communities and ecosystems to enable them to adapt to unpredictable change (Tompkins and Adger, 2004). The major concerns of the communities are their dependence on monoculture and on winter rainfall. Strategies to decrease their reliance on these factors will increase their resilience to climate change impact. The villages in the Bhagirathi valley form communities with strong social capital in the form of social ties, respect, and lack of marginalization. This has led them to formulate strategies that might help them continue their way of life. On the other hand, the marginalized communities in the Pindar valley have adopted out-migration and dependence on external support as their coping mechanism. This will eventually cause them to abandon their current lifestyles.

Given the increase in the number of deserted villages in Uttarakhand, this seems to be a mechanism adopted by several communities.

Villagers in both valleys are attempting to reduce this dependence on a single crop by a variety of means which range from growing vegetables to increasing dependence on remittances. These methods have repercussions that impact the cultural dynamic of these communities by strengthening linkages with the national network.

These linkages add to the variety of options available to the communities and drastically increase their chances of survival. The external observer is however, faced with the paradox of Theseus' ship. If every plank of the ship was replaced over the years, is it still the original ship? The elements that define mountain communities today- their reliance on high-altitude crops, self-sufficiency, use of natural resources- are changing, and necessarily so. With the changes in weather patterns, communities need to adopt a wide range of crops to survive. With increasing unpredictability, communities need to diversify their support networks and livelihood options to guard against disasters. Both these strategies lead to an adoption of urban materials and influences. With these changes, can mountain agrarian communities be said to survive, or to become extinct?

7. References

- Adger, W. N., Kelly, P. M., Winkels, A., Huy, L. Q. and Locke, C. (2002) Migration, remittances, livelihood trajectories and social resilience, *Ambio* 31(5), 358-366. [Online] URL: <http://www.uea.ac.uk/env/people/adgerwn/Ambio%20Adger.sep.pdf>
- Altitude Store, The. 2010 Available online at: <http://thealtitudestore.com/wholegrains.html> last accessed: 02 December 2010
- Brodnig Gernot and Prasad Vivek 2010, A View From The Top: Vulnerability in Mountain Systems, Social development notes No.128. World Bank, June 2010. [Available online] atURL: http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/244362-1164107274725/3182370-1164201144397/3187094-1277143060338/Vulnerability_Mountain_Systems_June_2010.pdf
- CEDAR, 2010. Findings of the SRTT funded cash-flow study-Pithoragarh District, Uttarakhand. March 2010. [Online] URL: http://www.srtt.org/institutional_grants/pdf/cash_flow_report.pdf
- Cumming, G. S., and J. Collier. 2005. Change and identity in complex systems. *Ecology and Society* 10(1): 29. [online] URL: <http://www.ecologyandsociety.org/vol10/iss1/art29/>
- Eriksson, Mat et al. The changing Himalayas: Impact of climate change on water resources and livelihoods in the Greater Himalaya, ICIMOD
- Holling, C. S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4:1-23.
- IPCC, (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Accessed from [Online] URL: <http://www.ipcc.ch/ipccreports/ar4-wg1.htm>
- Lachungpa, Usha. 2008. Indigenous lifestyles and biodiversity conservation issues in North Sikkim. *Indian Journal of Traditional Knowledge*, Vol 8 (1) January 2009, pp 51-55. [Online] URL: <http://nopr.niscair.res.in/handle/123456789/2964>
- National Horticulture Mission, 2010. Operating guidelines, April 2010, Ministry of Agriculture and Co-operation, Government of India.
- Press Trust of India, 2010. Floods cause large scale damage to apple crops in Uttarakhand. Business Standard, 22 September 2010, Available online at : <http://www.business-standard.com/india/news/floods-cause-large-scale-damage-to-apple-crops-in-uttarakhand/109434/on> last accessed: 02 December 2010
- Rana, J.C. and Sharma S.K, Impact of climate change on western Himalayan region and adaptive strategies thereof, presented at National Conference On Forestry Solutions: Strategies For Mitigation And Adaptation Of The Impacts Of Climate Change In Western Himalayan Mountain States, Shimla, HP, November 19 to 21 2009
- Rao P., G. Areendran and R. Sareen: Potential Impacts of Climate Change in the Uttarakhand Himalayas , WWF India
- Renton, Alex et al. Suffering the Science: climate change, people and poverty, Oxfam briefing paper 130, July 2009
- S.K. Dash and J.C. R. Hunt, Variability of climate change in India, *Current Science*, 782 Vol. 93, No. 6, 25 September 2007
- Sah M P and Bartarya SK. (2006). Landslide Hazards in the Himalaya: Strategy for their management. In: Valdiya K S *Coping With Natural Hazards: Indian Context*. Pune: Orient Blackswan. p165-178.
- Sati, Vishambar Prasad. June 2006. Forest Resource Management in Mountain Regions: A case for the Pindar basin of Uttaranchal Himalaya, Vishambhar Prasad Sati, June 2006 (retrieved from : <http://www.lyonia.org/downloadPDF.php?pdfID=2.478.1> on May 26, 2010)

- Singh SP, Singh Vishal, Skutsch Margaret, 2010. Rapid warming in the Himalayas: Ecosystem responses and development options. [Climate and Development](#), Volume 2, Number 3, 2010 , pp. 221-232(12)
- Thapliyal Jotirmay, 2009. Over 50 percent apple crop lost, Tribune News Service, 04 September 2009, Available online at: <http://www.tribuneindia.com/2009/20090904/dplus.htm#1>, last accessed: 02 Dec 2010
- Theophilus Emmanuel, personal communication, 2010
- Thompson, L. G.: 2000, 'Ice Core Evidence for Climate Changes in the Tropics: Implications for Our Future', *Quat. Sci. Rev.* 19, 19–35.
- Tompkins, E. L. and W. N. Adger. 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society* 9(2): 10. [online] URL: <http://www.ecologyandsociety.org/vol9/iss2/art10/>

8. Acknowledgement:

This study was carried out with financial assistance from the Ecocultures Research Programme at the University of Essex (For enquiries contact Zareen Bharucha at zpbhar at essex.ac.uk).

Information on the Bhagirathi and Pindar valleys was gathered during a study of the impact of climate change on mountain communities in Uttarakhand conducted with the financial support of Himmothhan (India) in 2009. The impact of disasters on communities in Munsyari and Almora was studied while carrying out disaster response supported by the Sir Dorabji TataTrust (India) in 2010.