Climate Change Impacts and Adaptation by Communities in a Tribal Region of Central Himalaya: A Study from Uttarakhand Himalaya India

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ABSTRACT

Impact of climate change is more pronounced in ecologically fragile mountain areas such as Himalayas where rapid altitudinal change results in high degree of variation in relief, natural vegetation and hydrology within short horizontal distance. The area selected for this study is located in Uttarakhand Himalaya which forms parts of Central Himalayan region of India. It is a mountainous tract with altitudinal range of 450mt to 3000mt and experiences cool-temperate climate. While forests cover 44% of the area, the cropping area is less than 10 % and another 43% is occupied by Common Pool Resourcesô area. The tribal population comprises of 56% whereas another marginal community, the Scheduled Castes, makes up 34% of total population. The area and lags behind in development with low literacy rate (55%), poor health facilities and 70% of population being below poverty line. The climate data from regional meteorological observatories situated at distant locations from study area show the increase of average temperature by 0.5^0 C, decrease in rainfall, upward shifting of vegetation line etc in last 40 years. The Vulnerability Atlas of Indian Agriculture has classified the area as moderately vulnerable and having low adaptation capability. Thus it was chosen for understanding the impending climate change impacts and adaptation strategies.

The analysis presented in the paper, apart from some secondary information, is based on climate data from local weather stations and primary survey conducted in six villages situated between altitude 900mt and 2000mt. A total of 95 households representing different socio-economic strata were randomly selected for in-depth interviews. The response unambiguously indicates increase in temperature, decrease and erratic nature of rainfall, long dry spells during monsoons, decrease in snowfall, increase in crop diseases and decreased water discharge in springs etc. during last couple of decades.

The impact of climate change has been assessed on the farming and horticulture which are primary economic activity of local communities being practiced by 75 % of the population. Overwhelming majority of respondents reported that the climate variation has adversely affected yield of traditional mixed crops, cereals, pulses, oil seeds and horticultural crops such as apple. As an adaptation strategy, the farming communities are concentrating on cash crops in better managed fields in place of low-yielding scattered land. They are replacing traditional crops with more remunerative vegetable crops (Tomato, Chillies, Ginger, and Peas etc) that can provide better economic returns. However with only 10 % of geographical area under cultivation and 85% of it being rain-fed, this strategy is unable to support community needs. This has resulted in increased out-migration which has become a supporting mechanism for some households. Additionally, communities are adapting other strategies such as change in crop varieties and alternative employment etc.

Key words: Mountains, communities, climate change, adaptation, tribal region, Himalaya

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INTRODUCTION

Climate, as one of the dominant natural phenomenon, impacts all spheres of human activities. The seasonal and regional variations in climate have shaped the living and livelihood patterns of human society since time immemorial. However, the societal evolution of human civilization from hunting/gathering through agricultural to industrial stage has also witnessed the changing relationship between human and natural systems. The symbiotic relationship between climate, as one of the key component of natural systems, and human society began to change with growing industrialization in the world in 19th century and assumed serious dimensions in last century. The adversity of relationship between anthropogenic activities and climatic conditions impacting each other has emerged as one of the most serious challenges being faced by human society in 21st century. ôThe accumulation of green house gases...has reached dangerous levels threatening climate change and global warming beyond the limits of human tolerance (Raghunandan, 2010). The latest report of Intergovernmental Panel on Climate Change (IPCC) has stated that the ôWarming of the climate system is unequivocal and since 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amount of snow and ice have diminished, and sea level has risenô (IPCC, 2014). This is once again the reiteration of the conclusions presented in the IPCC Fourth Assessment Report. This underlines the fact that the adverse affects of human actions on climate system are on increases and at the same time óclimate changes have widespread impacts on human and natural systemsô (IPCC, 2014). The analysis of data for more than 150 years reveals that the earthôs temperature has increased by 0.74^{o}C in last hundred years and 12 out of last 13 years are among the warmest years since 1850 (GoU, 2011). In case of India, there is clear evidence of global warming in 20th century and this is going to accelerate in 21st century (Srininvasan, 2012).

Climate Change Impacts in Uttarakhand Himalaya

Impact of climate change is more pronounced in ecologically fragile mountain areas such as Himalayas where rapid altitudinal change results in high degree of variation in relief, temperature, rainfall, natural vegetation, water regimes and other associated phenomena. Climate change is a major and growing challenge in mountain areas where óeven small shifts in temperature can jeopardize the fragile balance of natural environments, which are defined by extreme climatic conditions, steep topography, and a wide variety of ecological zones and associated microhabitats with distinct biodiversityô (Kotru et al, 2014). ôThe impact of climate change on the mountain system are evident in the rapid melting of glaciers, loss of snow cover, changes in vegetation cover, biodiversity loss, erratic weather patterns and increasing frequency and magnitude of natural disasters (Shrestha, 2011). The Himalayas which are the largest high-land mass in the World not only play important role in global climate but are themselves subject to climate change impact and warming here is predicted to be well above the global average (Pandey and Venkatraman, 2012). A well documented study has indicated higher rate of warming in Himalayas than the global average and faster receding of glaciers. It has expressed serious concern about it as the region has more snow and ice than any other region in the world outside the polar caps and Himalayas affect the climate of much of the South Asia (Singh, 2012). According to another report net increase in temperature in the Himalayan region in 2030s is forecasted to increase between 1.7^{0}C to

2.2^0C (0.6 ± 0.7 ^{0}C) with respect to 1970s and seasonal air temperatures are also forecasted to rise in all seasons (GoU, 2012a).

The reliable climate data on some of parameters available from few locations of Uttarakhand Himalaya such as Dehradun, Pantnagar, Almora, Nainital and Muketshwar indicate changes in climatic parameters. For example data from a lesser Himalayan hill station, Almora (1640m) show average temperature increase by 0.46^0 C in last 53 years (1955-2007) and the average temperature is rising in the hills (UCOST, 2012). The rainfall records of Almora and Nainital show decreasing trend. Similarly meteorological data of Dehradun (670m) has also indicated rising trend in temperature and decreasing trend in rainfall during period 1981-2008 (Devlal, 2010). Another long-term study (1967-2007) has also shown increasing tendency in annual, seasonal and monthly temperatures at Dehradun, the closest location to study area where reliable climate records are being maintained (Singh et al, 2013). Uttarakhand Himalaya is also experiencing changes in other climatic related parameters such as retreat of glaciers, upward shifting of vegetation line, increased cloud cover duration, reduction in sunshine hours etc as indicated by various studies (Pratap, 2013).

While the recorded data are taken to be definite scientific evidence of climatic change, the perception of local communities is no less important in understanding the climate change patterns as they are the ones directly affected by these changes and have to adapt and cope with them. These communities have perceived variations in temperature, rainfall, snowfall and incidence of crop diseases in last couple of decades. Depending on their traditional wisdom and available resources, they are resorting to different adaptation mechanism in different locations. Shift in timing of rainfall, reduction in rainfall spells, increased intensity of rainfall, decrease in snowfall and increased average temperature etc have been reported from 20 villages of Tehri Garhwal district in a study sponsored by Oxfam (MVDA, 2011). A case study of two middle Himalayan districts of Uttarakhand (Tehri Garhwal and Almora) reports that community perceives a definite change in climate by way of decrease in rainfall, delay in monsoon, reduction in winter rain and snowfall, increase in temperature and increase in crop disease and pests (Macchi, et al, 2011a) . Based on different studies and consultations held by Uttarakhand Centre on Climate Change, Uttarakhand State Action Plan for climate Change (2012) has reported the main trends as: Overall less and more erratic rainfall; increasing temperatures; increased frequency of intense rainfall events; less or absent winter rains; overall decreased water availability; warmer and shorter winter etc. (GoU, 2012b).

The farming community is responding to these changes by various methods such as adjusting their agricultural calendar on a yearly basis by delaying or advancing the sowing of crops, changes in crop verities, cultivating less land, the revival of traditional irrigation system with water sharing rules and regulations etc (Macchi, et al, 2011b). A study conducted in Bhagirathi and Pinder river valleys of the region, brings out the relative levels of vulnerability and the coping mechanisms developed by local community. While in one valley, rural community is exploring alternative crops (e.g. Tomato in place of Apple) to support their livelihood strategy, the residents of another valley, facing decline in crop production due to increased aridity in winters, are either increasingly depending on external support through remittances or seeking alternative employment or even migrating to other location (Lokgariwar, 2009). Another study of 6 villages highlights community coping strategies as mix of change in cropping pattern, switching to cash crops, revival of traditional farming methods, change in crop rotation and shift in sowing timings, income diversification and increasing dependence on government initiated employment schemes (BBA, 2011).

The available literature, evidences provided by regional climatic data and peopleôs perception indicate change/variability in climatic conditions in Uttarakhand Himalaya. Studies also bring out the fact that local communities affected by the changes, have resorted to variety of adaptation and coping strategies. However, given the large variation in physical and socio-economic conditions of the region, the above cited studies could not be taken as indicative for whole of Uttarakhand Himalaya but at the same time, it is necessary that local level studies are conducted to understand the perception of climate change and mitigating and coping strategies being adopted by different communities in diverse locations of Uttarakhand. The present study presents the assessment of the nature and intensity of climate change perception and adaptations strategies from a tribal community/region of Uttarakhand Himalaya.

OBJECTIVES OF THE STUDY

The main objectives of the study are:

(a) To understand the nature of climate change and the perception of local community regarding its variability
(b) To analyse the adaptations strategies of farming community to overcome the problems caused by climate change/variability

STUDY AREA

The area selected for this study is located in Uttarakhand Himalaya which forms parts of Central Himalayan region of India. The area comprising of Chakrata and Kalsi blocks of Dehradun district is located in north-western hilly tract of the district (Fig. 1). Extending between 30^0 26ô and 31^0 2ô North Latitude and 77^0 38ô and 78^0 4ô East Longitude, it covers an area of about 1000 sq. kms. It is a mountainous tract with altitudinal range of 450mt to 3000mt and experiences cool-temperate climate. While forests cover 44% of the area, 28.42% is recorded as culturable waste land, 8.28 % as grazing land, 6.84 % as area under orchards and miscellaneous tree crops, and the cropping area is restricted to less than 10 %. The area is inhabited by a population of 1, 25,486 persons of which the tribal population comprises of 56% whereas another marginal community, the Scheduled Castes, make up 34% of the population. while the sex ratio in the study area stands at 923, the area lags behind in development with low literacy rate (55%), poor health facilities and 70% of population being below poverty line. Salient features of the study area are presented in Table 1 below:

Table 1: Salient demographic characteristics of study area (based on 2011data)

S. No.	Characteristics	Numbers/Percentages
1.	Total population	1,25,486
2.	Sex ratio	923
3.	Literacy rate	54.58 %
4.	Scheduled Tribes population	56.14 %
5.	Scheduled Castes population	34.38 %
6.	Cultivators as percentage to main workers	75.18 %
7.	Cultivators as percentage to total workers	56.92 %
8.	Agricultural labourers as percentage to total workers	4.36 %
9.	Other workers as percentage to total workers	13.22 %

Source: Statistical Magazine, District Dehradun, Year- 2013, Office of the Economic and Statistical Officer, Dehradun

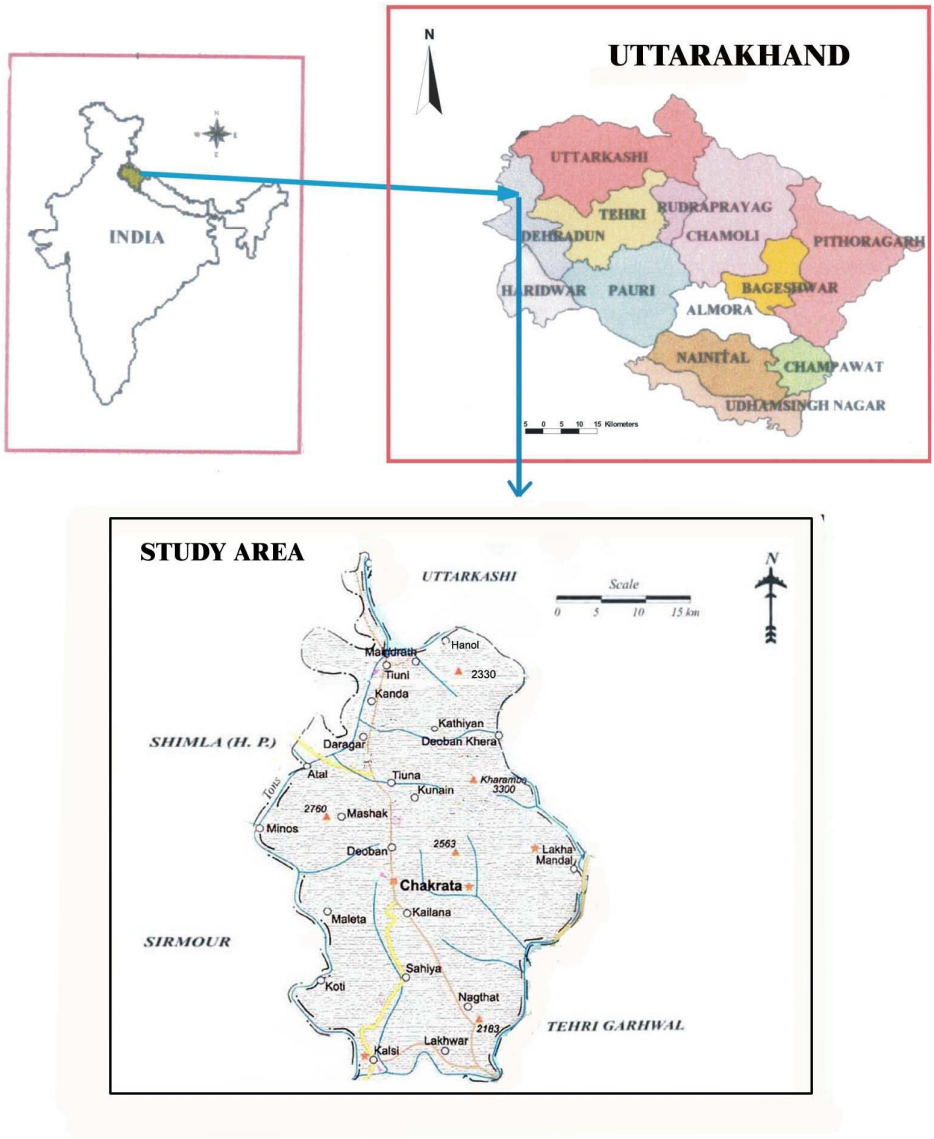

Fig. 1 : Location Map

DATA BASE AND RESEARCH METHODOLOGY

The analysis presented in the paper is based on secondary as well as primary data. The secondary data relates to climatic parameters and socio-economic characteristics of the region. Since limited rainfall and temperature data from two meteorological observatory situated in the region were available, the same has been presented to draw tentative conclusions. The primary data has been obtained through the survey conducted in six sample villages situated between altitude 900mt and 2000mt and located in different parts of the region. As the study is primarily aimed to assess the nature of climatic variability/change and coping strategies by farming community, the data related to these two broad objectives has been collected and analysed. The primary data is of greater significance as the study has investigated the perception and strategies of community with regard to climate and

agricultural activities. Thus village and household schedules have been used as primary tool of data collection.

The sample villages were randomly selected for conducting the village and household survey. Four of the villages selected are from Kalsi block whereas two are from Chakrata block. The sample villages are representative of the universe as they vary in their locational aspects as well as with respect to population size, literacy rates and composition of scheduled castes and scheduled tribes population. The details of sample villages are presented in Table 2 below:

Table 2: Some Characteristics of Sample Villages

S.No.	Name of the village	Total population	Literacy rate (in %)	Scheduled Tribes population (in %)	Scheduled Castes population (in %)	No. of sample households
1.	Sakni	326	61.96	80.06	19.93	11
2.	Deo	327	30.88	60.24	39.76	11
3.	Dhoera	900	54.55	37.44	61.33	20
4.	Kothi-Bondi	280	52.85	00.00	100.00	11
5.	Phanar	482	56.22	77.59	9.75	14
6.	Birnad-Bastil	1990	71.85	54.82	13.01	28

The household survey was conducted with a help of structured schedule to enlist the opinion of randomly selected 95 sample households representing different socio-economic strata of the community. The respondents were from different age groups, educational background, landownership and occupational categories. Of the total respondents, 77% were males and 23% females whereas in terms of age-group majority (51.57%) were in the age group of 18-45 years, 31.57% were between 45 and 60 years of age and rest were above 60 years. The information regarding their educational qualifications reveals that 40 % are illiterate and another 43.15% are educated up to higher secondary level (Table 3). As far as landownership is concerned, the primary data show that largest number of respondents (42%) own between 1.0 and 2.0 acre of land. In terms of primary source of income, highest number (34.73%) is dependent on agriculture and animal husbandry, followed by those dependent on agriculture alone (22.10%), wage labour (15.78%), government service (13.68%), small business (6.31%) and others (7.36%). Table 3 presents the salient characteristics of sample households:

Table 3: Salient characteristics of sample households (as % of total)

Educational qualification of respondents

Illiterate	Primary	Higher Secondary	Graduate	Post-graduate
40.00	22.10	21.05	9.47	7.36

Land ownership

Landless	Less than 1 acre	1-2 acres	2-5 acres	More than 5 acres
5.26	31.57	42.10	18.94	2.10

Primary source of income

Agriculture	Agriculture and animal husbandry	Wage labour	Government service	Shop-keeping	Others
22.10	34.73	15.78	13.68	6.31	7.36

RESULTS AND DISCUSSION

Climate Change: Secondary Information

As has been pointed out in an earlier section of this paper, a number of climatic parameters seem to indicate climate change in Himalayan region. It has been reported that ôanalysis of 100 year weather data for four stations in Uttarakhand revels an increasing trend for the maximum temperatures while minimum temperatures were either constant or decreased slightlyô and the decrease in precipitation, drastic decrease in snowfall and increase in extreme weather events can be directly attributed to climate change in Uttarakhand Himalaya (PSI,2010). It has also been underlined that ôclimate change has emerged as critical issue in this disaster prone state. Uncertainty of rain and snow appears to be increasing. Winter rains have almost disappeared and inner Himalayan peaks sport much less snow than earlierô (Chopra, 2014).

The results of the survey conducted for this study also points to these changes to some extent. The limited data with some gaps were available on two climatic parameters from two locations - Chakrata (2118mt) and Chibro (680 mt) situated at different elevations within the study area. The available data on temperature indicate a mix trend in maximum and minimum temperature. The data for Chakrata for the period 1987-95 and 1996-2005 show that while the average maximum temperature has been more or less constant, the average minimum temperature, except for May and August, has been lower during the second period (Fig.2 and Fig.3). However at the lower elevation Chibro weather station for which the data were available for three time periods, the maximum temperature has been higher in the period 1996-2006 as compared to 1967-74 as well as 1977-85 (Fig.4). But in case of minimum temperature, it has been recorded low for all the months in the period 1996-2006 as compared to both the earlier periods i.e. 1967-74 and 1977-85 (Fig5). Thus, we can tentatively conclude that while maximum temperature has shown an increasing trend at the lower altitude, in case of minimum temperature, a decreasing trend can be noticed at both the locations.

Longer term data are available for rainfall. In case of Chakrata, the rainfall records are available from 1972 to 2005 and they show a decreasing trend throughout this period except between 1982 and 1987. The total amount of rain that peaked at 3040 mm in 1987 has been constantly decreasing and has been lower than 1200mm after 1991 (Fig.6). The monthly average rainfall reflects the same trend (Fig.7). In case of Chibro for which the data is available for three time periods viz. 1967-74, 1977-86 and 1996-2006, the total rainfall has shown decreasing trend from 1988 onward (Fig.8) but fluctuations can be seen in monthly averages (Fig.9). Thus the available limited data with some gaps indicate significant change in rainfall and marginal variations in temperature in the study area.

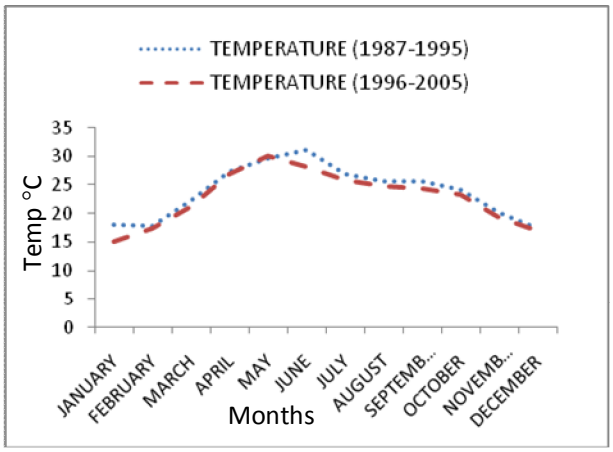

Fig. 2 : Chakrata Maximum Temperature (Monthly Average)

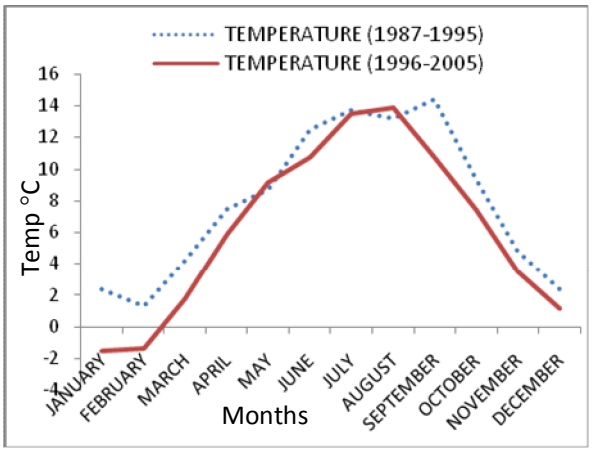

Fig. 3 : Chakrata Minimum Temperature (Monthly Average)

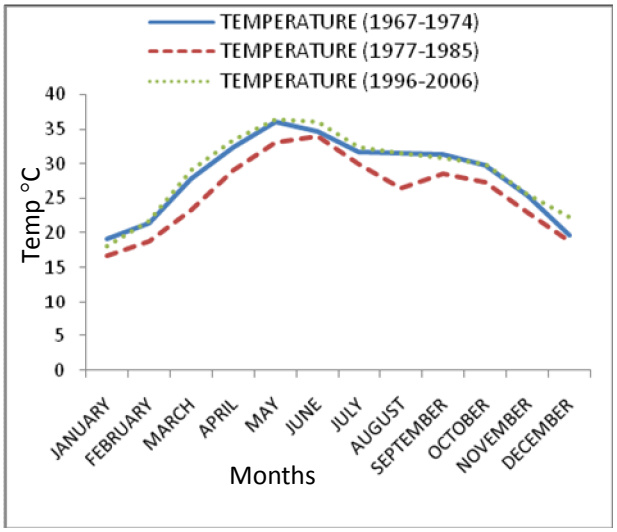

Fig. 4 : Chibro Maximum Temperature (Monthly Average)

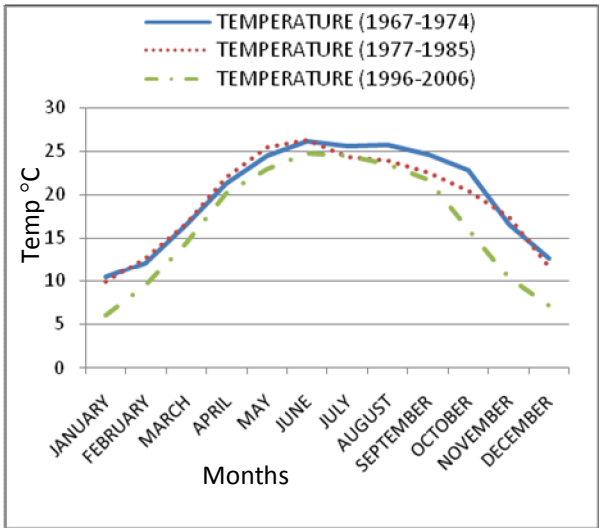

Fig. 5 : Chibro Minimum Temperature (Monthly Average)

Source: Forest Working Plans for different periods, Department of Forest, Government of U.P. and Govt of Uttarakhand

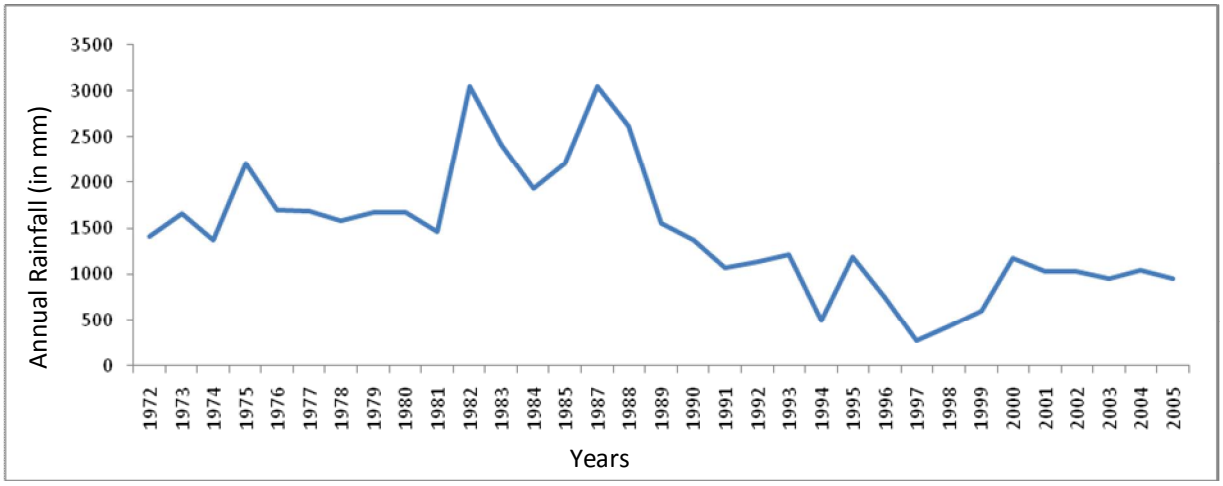

Fig. 6 : Chakrata Annual Rainfall

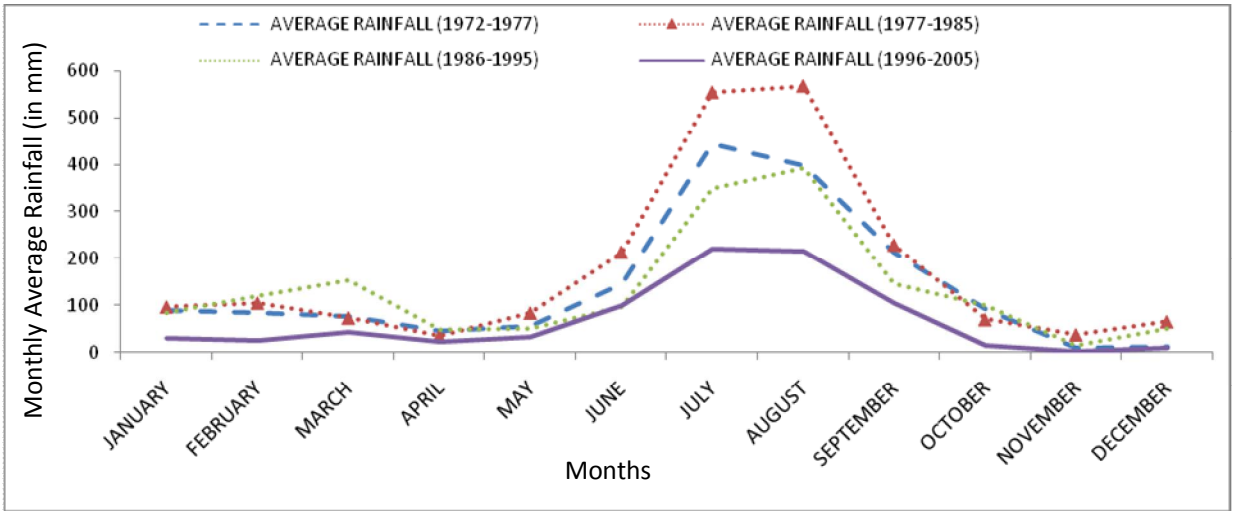

Fig. 7 : Chakrata Monthly Average Rainfall

Source: Forest Working Plans for different periods, Department of Forest, Government of U.P. and Govt of Uttarakhand

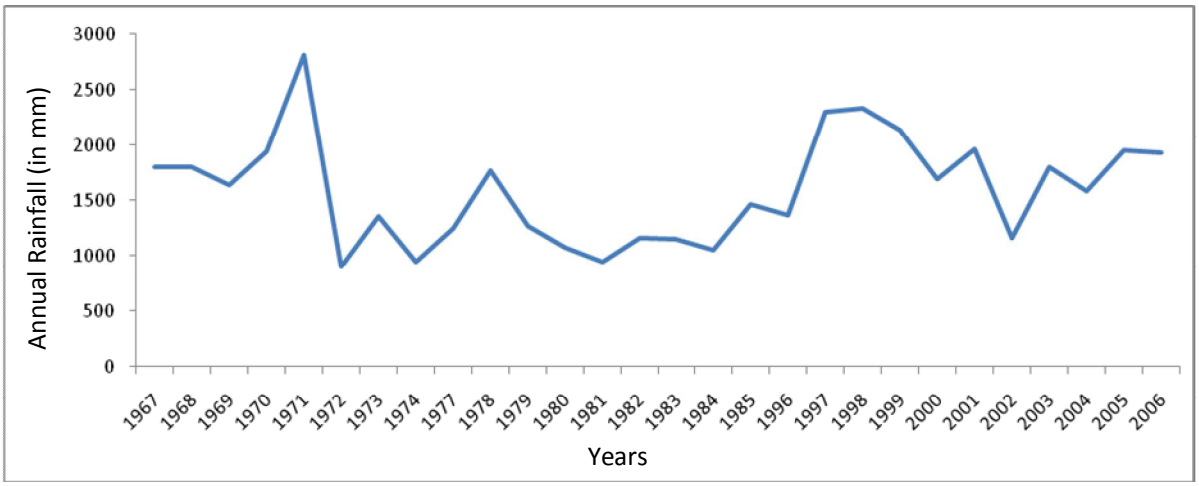

Fig. 8 : Chibro Annual Rainfall

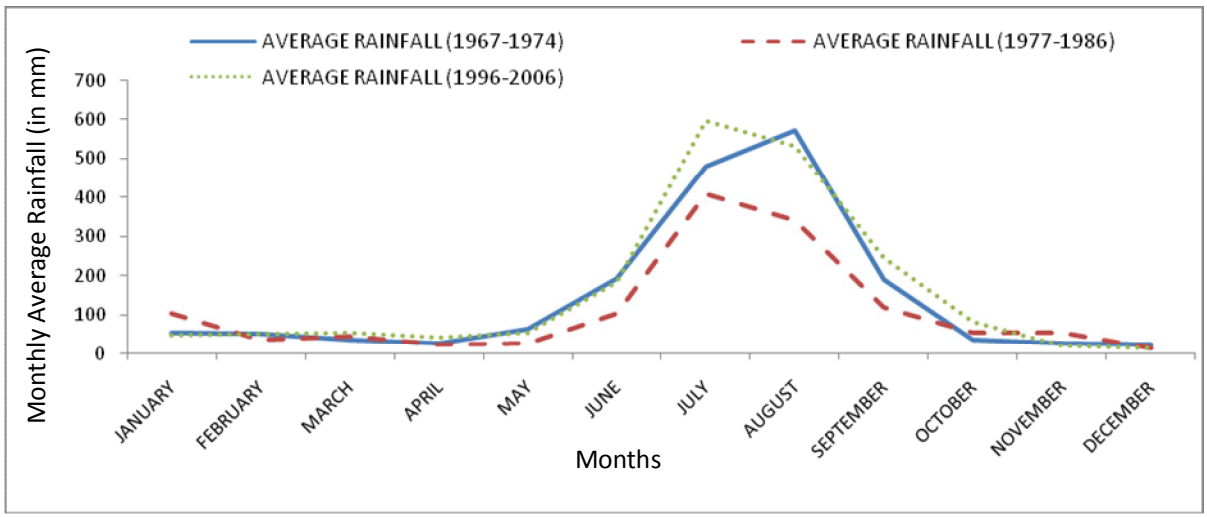

Fig. 9 : Chibro Monthly Average Rainfall

Source: Forest Working Plans for different periods, Department of Forest, Government of U.P. and Govt of Uttarakhand

Climate Change: Primary Information

One of the main objectives of this study was to understand the perception of the community members about climate/variability in the study area. The respondents were asked questions related to changes in rainfall, temperature, snowfall, drought and fog etc. in last 20 years. The results show that the respondents are almost unanimous in their answers. All of them (100%) felt that the overall quantity of rainfall has decreased in last 20 years, the timings of occurring of rains have shifted from June, July, August to July, August, September, the decrease in rainfall has taken place in Monsoon period (when major share of rains occur in north India) as well as in winter months. A major variation in rainfall in last 20 years was reported with regard to its erratic behaviour. Not only the uncertainty has increased but the duration of rainfall spells have also reduced and its intensity has increased. Since the study area is rain-fed agricultural region, irrigation being limited to less than 15 % of net sown area, timely availability of rains is extremely crucial for the local community. It is therefore but natural that they are concerned with changes in rainfall pattern and observe these changes very keenly.

Similarly response could also be noticed regarding change in temperature. The respondents were asked their perception of change in overall, summer and winter temperatures with the four options to choose for answering the questions. Has there been increase, decrease, no change in the temperatures or is the respondent not sure of the answer? The respondents (100%) were categorical that there has been increasing trend in overall, summer and winter temperatures. In case of variation in snowfall, the respondents of the villages which are in snowfall zone felt that the overall quantity of snow has decreased in last 20 years and even the reduced quantity is occurring late as compared to earlier period. The increasing occurrence of drought was perceived by all the respondents but only few could specify the years of its occurrence. The answer regarding water discharge from springs, the main source of drinking water revealed that all sample villages have experienced its reduction to the extent of 30-60% during summers in last two decades.

The above analysis of instrument records as well as peoplesô perception clearly indicates climate change/variability in study area. In case of rainfall, the respondents overwhelmingly reported overall decrease, changes in timings, increased uncertainty and erratic nature of its occurrence. Similarly, reduction in snowfall and increased occurrence of drought were reported by majority of them. However, there were certain variations between recorded data and communityôs observations with regard to temperature.

Adaptation Strategies by Local Communities

The discussion in the preceding section makes it amply clear that the climate in the study region is undergoing change. While the recorded data of rainfall and temperature indicate minor shifts in their pattern, in the perception of community, these shifts are more pronounced and effective as far as the basic livelihood bases are concerned. The change in amount and timings of rainfall, temperature, snowfall etc has had negative effect on the agricultural and horticultural production in the study area. In response to a question as to whether climate change has affected crop productivity 79 % of respondents answered in affirmative. The community has accordingly adapted to various measures to overcome these negativities. The analysis of information collected through primary household survey, presented below, brings out some of these adaptation mechanisms.

Major Adaptation Measures

As pointed out earlier, more than 50% of the workforce in the study area is engaged as cultivators in the study area and therefore agricultural remains priority for them. However the reducing productivity and failure of crops due to uncertainty of climate has compelled the agricultural community to adapt measures that could help them in changing scenario. The measures such as cultivation of new crops (70 % of respondents), utilization of new seeds (59%), use of chemical fertilizers (56%) and change in timings of sowing of crops (27%) have been adopted by local community.

Change in crops

The study area, as mentioned earlier, is primarily dependent on rainfall for its agricultural crop production. Again, as reported in the previous section, the total rainfall and timing patterns have shifted which have affected the production of traditional crops. In order to adapt to the changing climatic conditions as well as to meet the growing demand of cash income, the community has shifted its cropping pattern from traditional cereals crops to vegetable cash crops as can be very well understood from following table. It is amply clear that the vegetable crops such as Arbi, Chilly and Tomato that were almost non-existent two decades ago have replaced the traditional crops of Barley, Jhangora and Madua. It is also clear that the crop such as maize has lost its importance but potato as a cash crop has gained importance.

Table 4: Change in major crops grown by respondents 20 years back and now

Types of Crop	Mix of major crops grown 20 years back by respondents (% of respondents)	Mix of major crops grown now by respondents (% of respondents)
Wheat	82.10	69.47
Barley	56.82	-
Mandua (a corse cereals)	41.05	-
Maize	41.05	-
Paddy	36.84	28.42
Jhangora (a corse cereal)	13.68	-
Potato	8.42	28.42
Arbi (colocasia roots)	-	52.63
Chilly	-	56.82
Tomato	-	16.84

Reasons for Change in crops

Inquiry into the causes of this change reveals multiple reasons but along with priority to cash crops and reduction in productivity, reduction and uncertainty in rainfall and increase in temperature have been mentioned prominently. Reduction in productivity was also attributed to climate variability. The survey brings out the fact that damage by wild animals and increase in crop diseases are some other prominent factors responsible for this change. The main and multiple reasons of change as mentioned by respondents are reported in the table 5:

Table 5: Main reasons for change in crops (in %)

Reason for change	Multiple mix of responses by respondents
Priority to cash crops	92.63
Reduction in productivity	87.36
Reduction in rainfall amount	80.40
Uncertainty of rainfall	57.60
Increase in temperature	38.94
Damage by wild animals	23.15
Increase in crop diseases	6.31

Climate Change and Horticulture

The climatic conditions of the study area, ranging from sub-tropical to temperate, are suitable for horticultural production also. However, small landholdings are a hindrance in taking up this activity on the commercial scale as main economic activity by the local community. But at the same time local community in this tribal region of Himalaya try to grow some horticultural crop. It has emerged during the survey of 6 sample villages that 57.75 % of the households have planted some horticultural crop, some having apple orchards of more than two acres. There were 76% of the households who owned apple orchards while 9% each had combination of apple and pear, and walnut trees and another 6% had mango trees on their land. It was reported by 83.59% of horticulture growers that there is a decrease in fruit yield in last 10 years and it has been largely to climate phenomena of decrease in rainfall and insufficient quantity of snow (Table 6).

Table 6: Horticulture and adaptation strategy

<u>Reasons for decreased production</u>	
Decrease in rainfall	56.71 %
Insufficient snowfall	32.83 %
Collapsing of old trees	7.46 %
Others	2.98 %
<u>Measures to maintain/improve yield</u>	
Replacement of old plants	32.83 %
Grafting	16.41 %
Replacement of plants and grafting combined	35.82 %
Increased use of chemical fertilizers	14.92 %

As in case of agriculture, the village community has taken various measures to maintain and improve the productivity of horticultural crops. It was reported by 36% of the respondents among those having horticultural crops that replacement of old plantations and grafting are being undertaken as an important measures, where as 33% are undertaking only replacement of old plants and 15% are resorting to use of chemical fertilizers for maintenance of crop production. Thus the impact of climate change is also being encountered in case of horticulture and the concerned community is taking measures to overcome its adverse impacts.

Alternative Employment as Adaption Measure for Climate Change

Agriculture along with animal husbandry and horticulture has been traditional sources of livelihood in this tribal region of Uttarakhand Himalaya. The change in climatic parameters has affected these traditional livelihood sources of local community. The community has responded to this impact by adapting various measures in agriculture and horticulture such as change in crops, timings of crop-sowing, use of chemical fertilizers, replacing old plants etc. However these measures are not enough to offset the adverse impacts of climate change. During field survey, it emerged that the respondents are not only resorting to alternative employment but are going out of region to support their families. The survey revealed that only 55% of the respondents are able to meet their livelihood requirements from their primary source of income e.g. agriculture and animal husbandry, and horticulture. A large number of respondents reported that they have to supplement their income through other sources such as wage labour. Not only this, the people have to go out of region to get seasonal employment to support their families. While outmigration (seasonal/permanent) helps in supporting the community back home, it still remains a temporary strategy of livelihood. The data in this regard is presented below:

Table 7: Alternative Employment as adaptation strategy

Sufficiency of primary income source for livelihood requirements	
Yes	54.74 %
No	45.26 %
Nature of alternative employment	
Wage Labour	72.10 %
Agriculture	11.63 %
Private job	09.30 %
Others	06.97 %
Seeking supplementary employment out of region	
Yes	43.00 %
No	57.00 %

CONCLUSIONS

The information gathered during the course of this study indicates the change in climate characteristics, their impact on livelihood activities of local communities and the adaptation measures adopted. The climate data from weather stations from the study area show marginal increase in maximum temperature and decrease in minimum temperature. The amount of rainfall has also shown decreasing trend. These weather records have been corroborated by the perception of local community to a large extent.

The analysis presented in the paper is based on primary survey conducted in six sample villages situated between altitude 900mt and 2000mt. It is based on the information collected from 95 households representing different socio-economic strata. The impact of climate

change was mostly felt on crop-production and horticulture. The adverse impact on crop yield has forced the farmers to opt for short duration cash crops, change in traditional seeds, resorting to the use of chemical fertilizers and changing the crop calendar as per weather conditions. But with only 10 % of geographical area being under cultivation and 85% of it being rain-fed, this strategy is not able to completely support the local community needs and they have to seek alternative employment, not only in the region but have to move outside the region as well. Given the present scenario of climate change impact and the adaptation strategies, it can be safely concluded that the local community in study area needs to be supported by supplementary measures such as government sponsored rain-water harvesting, storage and marketing facilities for vegetable and fruit crops and preventive measures for crop-damage by wild animals.

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