The Himalayan Communities and Climate Change Adaptations

Outcomes of an action based research study on Community Perception

A platform for Sustainable Mountain Development

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INTRODUCTION

The Himalayas being the youngest mountain chain of the World are considered to be amongst the most vulnerable to climate change. The Indian Himalayan Region (IHR) stretches across states in the western and eastern Himalaya and provides critical ecosystem services for communities in mountains and downstream plains. The IHR is home to nearly 4% of the country's population and provides directly or indirectly for their livelihood.

The last century witnessed a consistent warming of the Himalayan ecosystems. The Himalaya have become highly vulnerable due to geological reasons, additional stress caused by exploitation of natural resources, increased population pressure and other related challenges. These effects are likely to be exacerbated due to the impact of climate change, which may adversely impact the Himalayan communities through various means. Changes in Plant phenology, retreating of Himalayan glaciers, changed timings of hibernation and breeding, decreasing agricultural production, drying of natural springs, increase in pests, variations in precipitation (both rainfall and snowfall) and temperature suggest that the climate in the Himalayan region in in the process of change. Cloud bursts and intense episodes of rainfall in Uttarakhand and Nepal in June 2013 and also delayed but heavy rainfall in Jammu and Kashmir in September 2014 are a couple of climate change indicators in the Himalayas.

The impacts of climate change in Himalayas have local, regional and global implications (Thadani, R. *et.al*. 2015). Addressing climate change calls for a wide array of policy response and strategic actions at local, sub-national, national and global levels. India's National Action Plan on Climate Change, 2008 (NAPCC)) with its eight national missions, is designed to achieve sustainable development as a co-benefit of addressing climate change. The focus of NAPCC is on promoting understanding of climate change, adaptation, mitigation, energy efficiency and natural resource conservation while pursuing overall economic growth.

The economy of the Himalayan region is predominantly rural and highly dependent on climate-sensitive sectors such as the agri-horticultural and livestock sectors. The average landholdings are very small and are mostly rain-fed. Most agriculture is of the subsistence type and depends on suitable weather conditions for attaining good yields. In the last few

years, adoption of commercial farming or cultivation of cash crops (vegetables, fruits and medicinal plants) has provided significant cash income in rural areas of the Himalaya. In Himalayan region, migration has been an important element of an adaptive livelihood strategy, which, while obtaining cash income, leads to functionally women headed households for much of the year and thus contributes to high levels of labor responsibility for fuel wood, fodder and water collection as well as in agriculture for women.

MOUNTAIN FORUM HIMALAYAS (MFH) being the volunteer organization must intervene to undertake policy advocacy and strategic action (community and institutional) at local and national level. To achieve the targeted goals, MFH will work together with the local communities, Voluntary organizations, institutions, Government and grass roots organization, research organizations and the local and state level to make Himalayan communities more resilient at organizational and institutional levels to face the changing climate and its adversities.

The present action based research study on climate change in Higher Himalayas (between 2000-3000 m asl) covering community perception on climate change and its impacts on lifestyle, agricultural practices and agro-biodiversity, resource utilization pattern, food habits, health, etc. of the Himalayan communities and an assessment of available natural resource and the ecosystem services is one of such small initiative MFH has taken towards the targeted goal. The present study area lies in the higher Himalayan region of Uttarakhand and Himachal Pradesh in India. A total of 9 districts have been covered during the study of which 5 districts (viz. Uttarkashi, Rudraprayag, Chamoli, Pithoragarh and Bageshwar) belong to Uttarakhand and 4 districts (viz. Shimla, Lahaul Spiti, Kinnaur and Sirmaur) belong to Himachal Pradesh. A total of 13 villages (i.e. 9 villages in Uttarakhand and 4 villages in Himachal Pradesh) on random basis were selected for representative sampling covering 123 households on a set of criteria. The present study area is inhabited by various tribal communities and marginal farmers and is facing implications of climate change at greater scale.

Objectives

The objectives of the present study are:

- To understand the community perception about key indicators of climate change and interrelation of climate change and reoccurrence of incidences of natural disasters
- To analyze impacts of climate change on agriculture, biodiversity (floral and faunal), natural resources human healthand ecosystem services.
- To analyze impacts of climate change on quality of life of Higher Himalayan communities.
- To identify coping strategies applied by the communities to combat the impact of climate change.
- To identify issues/initiatives/actions needed/required to be taken up at policy level, advocacy level, community based organizational level and to be adopted by the communities.

REVIEW OF LITERATURE

Climate change is expected to have serious environmental, economic and social impacts in mountainous regions worldwide. Rural communities that depend on farming, livestock rearing and natural resources for their livelihood are likely to be affected by its adverse impacts (Vedwan & Rhoades 2001)

A number of scientific studies have so far been carried out to analyze the patterns and impacts of climate change in Himalayas. The Third Assessment Report of the Intergovernmental Panel on Climate Change has reported the projected rise in temperature (1.4 0C by 2020 and 3.8 0c by 2080s) and precipitation (3% by 2020 and 11% by 2080) over the Indian region resulting into flash floods, droughts, cyclones and forest fires (IPCC 2001, Rupa Kumar & Ashrit 2001). Various studies suggest that warming in the Himalayas has been much greater than the global average of 0.74°C over the last 100 years (IPCC 2007a; Du et al. 2004).

Most studies, however, confine, their inquiries to the biological and physical domains, concentrating mainly on representing the response of crops to various changes in climate. Studies focusing on the socio-economic aspect of climate change are sparse and have almost exclusively restricted their analyses to the impact of environmental modification on agricultural production (e.g. Parry 1978, Lamb, 1985, Post 1985, Parry et al. 1989, Scott et al. 1990, Chmielewski 1992). The studies documenting community perception on climate change has also been carried out in smaller pockets of the Himalaya (e.g. Lokgariwar 2009, Paudel et.al. 2017, Suberi et.al. 2018). Suberi et al. (2017) analyzed community's perception and experiences of climate change and assessed people's use of forest resources and possible implications for climate change adoption in central Bhutan. A study of local perception and response by Apple producers in Kullu Valley by Vedwan & Rhoades (2001) indicate the climate change is the temporal displacement of weather cycle, however, the changes themselves still are not perceived as altering the idealized weather calendar.

The major concern of the communities is their dependence on monoculture and on winter rainfall. The communities in Bhagirathi valley with strong social capital led them to formulate strategies that might help them continue their way of life, while in Pinder valley communities

adopt out migration and dependence on external support as their coping mechanism (Lokgariwar 2009). CEDAR, 2010 reveals that in Pithoragarh district, which may be considered representative of the mountain area of Uttarakhand, 56% of the households have at least one migrant family member.

There is a perception that the temperature distribution has undergone a significant shift an addition to an overall increase in temperatures (Vedwan & Rhoades 2001). The impact of global climatic change on agriculture has recently become a subject of increasing importance (Glantz 1988). While an increase in temperature may at first appear to be beneficial for cold mountain areas (such as Lahaul Spiti in Himachal Pradesh), further study is needed as rainfall and not temperature is typically limiting to productivity in the Himalaya and hence a better understanding of change in precipitation patterns is key to understanding Himalyan agricultural productivity (CEDAR, 2015).

Climate change may also lead to changes in water availability due to changes in upstream conditions – the melting of glaciers for example can deprive downstream areas of much needed irrigation water during the summers (CEDAR, 2015). Although, the area under cultivation of food grains in Uttarakhand has increased from 0.98 m ha to 1.03 m ha between 2000-01 and 2005-06, the yield has declined from 1742 kg/ha to 1548 kg/ha for the same period (Agriculture Statistics at a Glance, 2007). At the same time, not surprisingly, the farmers look at climate change primarily in relation to the decrease in their apple production in Kullu Valley, and as a 'deviation from the weather cycle ideal to apple production' (Vedwan and Rhoades, 2001).

The Press Trust of India (PTI), 2010 reports that the Peak Rainfall Time (PRT) has shifted from July-August to August-September and winter precipitation extended till February whereas, cloud bursts have become a regular phenomenon in the recent past. In 2010 cloudbursts destroyed 30% of the crops in Uttarakhand. Trend analysis of annual rainfall data (Ranbir, 2010) of last 25 years in different districts of Himachal Pradesh reveals that increasing trend of about 33.5%, 54.3% and 51.5% has been observed in district Kinnaur, Chamba and Lahaul & Spiti respectively on one hand and decrease of about 8.7%, 13.3% and 26.6% in district Solan, Shimla and Sirmour, respectively.

Thus on the basis of earlier records on climate change, it can be said that the present study covers a range of variables on geographical, socio-economic, cultural and community resilience for implications of climate change in the western Himalayan region for the first time. The study also emphasizes possible interventions at community, organizational and institutional level along with policy advocacy.

THE STUDY AREA

The present report draws upon a study on impacts of climate change on higher Himalayan communities carried out in 2018 and MFH's experience working in the mountain villages of Uttarakhand and Himachal Pradesh for the last decade. For the study, reconnaissance surveys were carried out across the state of Uttarakhand and Himachal Pradesh. Following these 13 Gram Panchayats were selected from 9 districts, of which 5 districts (viz. Uttarkashi, Rudraprayag, Chamoli, Bageshwar and Pithoragarh) belong to Uttarakhand and 4 districts (viz. Lahaul & Spiti, Kinnaur, Shimla and Sirmaur) belongs to Himachal Pradesh, for detailed study (Table 1 & 2). The altitude range surveyed was from 2000 to 4500 meters above sea level.

Geographically, Uttarakhand is situated in the northern part of India extending between 28° 43′ to 31° 27′ N latitude and 77° 34′ to 81° 02′ E longitude. The state has international boundaries with China (Tibet) in the north and Nepal in the east. In west and south, it is surrounded by Indian states of Himachal Pradesh and Uttar Pradesh respectively. As per Census of India 2011, the state of Uttarakhand has a population of 1,01,16,752 (Census, 2011) with a total geographical area of 53,483 sq.km. The state has 2 administrative division having 13 districts. Garhwal Division consists of Dehradun, Haridwar, Tehri Garhwal, Uttarkashi, Chamoli, Pauri Garhwal (commonly known as Garhwal) and Rudraprayag. Almora, Bageshwar, Champawat, Nainital, Pithoragarh and Udham Singh Nagar districts constitute Kumaon Division.

Himachal Pradesh is situated between 30o 22'40" and 330 12'20" North latitudes and 75^0 45'55" and 79^0 04'20" East longitudes. It covers a geographical area of 55,673 km^2. It is flanked by the state of Jammu and Kashmir in the north, Punjab and Haryana surround the state in the south and south-west. In the southeast, the state merges into Uttaranchal and in the northeast, it forms India's border with China (Tibet). Himachal Pradesh is divided into 12 districts viz. Hamirpur, Bilaspur, Una, Solan, Kangra, Mandi, Sirmaur, Shimla, Chamba, Kullu, Kinnaur and Lahaul & Spiti. Lahaul &. Spiti district is the biggest district and Hamirpur the smallest and accounts for 24.85% and 2.01% of the state's area, respectively.


Himachal Pradesh
N
Uttarakhand
INDIA

Table 1: Demographic details of the study area

SN	District Name	Block	Gram Panchayat Name	Revenue Village Name	Total HH	Population of the Study Area								
						Total Population of Village			Scheduled Cast			Scheduled Tribes		
						Total	Male	Female	Total	Male	Female	Total	Male	Female
Uttarakhand														
1.	Uttarkashi	Mori	Dhatmeer	Dhatmeer	192	809	366	443	220	106	114	0	0	0
2.	Uttarkashi	Bhatwari	Raithal	Raithal	192	1005	501	504	262	119	143	0	0	0
3.	Uttarkashi	Bhatwari	Raithal	Natin	44	198	103	95	0	0	0	0	0	0
4.	Uttarkashi	Bhatwari	Vandrani	Pahi	77	338	175	163	0	0	0	0	0	0
5.	Uttarkashi	Bhatwari	Bandrani	Bandrani	63	312	154	158	54	27	27	0	0	0
6.	Chamoli	Joshimath	Tapovan	Topovan	270	1064	605	459	228	113	115	126	62	64
7.	Chamoli	Joshimath	Malari	Malari	1076	1933	1427	506	74	62	12	911	478	433
8.	Chamoli	Dewal	Ghes	Ghes Chack Sarmata	28	92	47	45	0	0	0	0	0	0
9.	Chamoli	Dewal	Ghes	Ghes	156	702	330	372	90	36	54	0	0	0
10.	Rudraprayag	Jakholi	Badhani	Badhani	88	424	183	241	25	14	11	0	0	0
11.	Rudraprayag	Jakholi	Badhani	Jagtoli	14	84	38	46	7	4	3	0	0	0
12.	Pithoragarh	Munsiari	Harkot	Matena	28	100	41	59	54	21	33	7	3	4
13.	Pithoragarh	Munsiari	Harkot	Harkot	64	301	123	178	124	56	68	129	48	81
14.	Pithoragarh	Munsiari	Harkot	Malupati	29	115	62	53	0	0	0	17	9	8
15.	Bageshwar	Kapkot	Sorag	Sorag	181	959	490	469	137	79	58	0	0	0
	TOTAL UTTARAKHAND				**2502**	**8436**	**4645**	**3791**	**1275**	**637**	**638**	**1190**	**600**	**590**
Himachal Pradesh														
16.	Lahul & Spiti	Spiti	Kibber Khas	Kibber Khas	77	366	187	179	0	0	0	366	187	179
17.	Lahul & Spiti	Spiti	Kibber Khas	Pinjoor	15	47	30	17	0	0	0	47	30	17
18.	Lahul & Spiti	Spiti	Kibber Khas	Kee	69	367	217	150	0	0	0	367	217	150
19.	Lahul & Spiti	Spiti	Kibber Khas	Gettey	8	26	11	15	0	0	0	26	11	15
20.	Lahul & Spiti	Spiti	Kibber Khas	Tashi Gang	6	40	23	17	0	0	0	40	23	17
21.	Sirmaur	Renuka	Dewri	Kharahan	25	161	78	83	13	6	7	0	0	0
22.	Sirmaur	Renuka	Dewri	Dewri	101	588	288	300	169	75	94	2	1	1
23.	Sirmaur	Renuka	Dewri	Kharotiyon	121	557	294	263	83	50	33	0	0	0

SN	District Name	Block	Gram Panchayat Name	Revenue Village Name	Total HH	Population of the Study Area								
						Total Population of Village			Scheduled Cast			Scheduled Tribes		
						Total	Male	Female	Total	Male	Female	Total	Male	Female
24.	Shimla	Shimla (Rural)	Kufri Junga	Kufri Junga	77	319	158	161	121	60	61	2	2	0
25.	Shimla	Shimla (Rural)	Kufri Junga	Kufri Koti	53	239	126	113	14	7	7	0	0	0
26.	Shimla	Shimla (Rural)	Kufri Junga	Jangal Kufri Chharabra	1	1	1	0	0	0	0	0	0	0
27.	Shimla	Shimla (Rural)	Kufri Junga	Shoyah	37	196	106	90	48	29	19	0	0	0
28.	Shimla	Shimla (Rural)	Kufri Junga	Kuni	12	96	48	48	4	1	3	0	0	0
29.	Shimla	Shimla (Rural)	Kufri Junga	Doji Dhar	5	28	13	15	0	0	0	0	0	0
30.	Shimla	Shimla (Rural)	Kufri Junga	Chharabra	21	81	40	41	13	7	6	0	0	0
31.	Kinnaur	Sangla	Sangla	Sangla	536	2244	1119	1125	539	268	271	1393	634	759
32.	Kinnaur	Sangla	Sangla	Thapa Saring	112	476	234	242	174	77	97	190	91	99
33.	Kinnaur	Sangla	Sangla	Panpo Kanda	3	12	7	5	5	3	2	2	1	1
34.	Kinnaur	Sangla	Sangla	Boning Saring	153	628	296	332	101	45	56	523	248	275
35.	Kinnaur	Sangla	Sangla	Sangla Kanda	1	5	4	1	5	4	1	0	0	0
36.	Kinnaur	Sangla	Sangla	Dewar Kanda	0	0	0	0	0	0	0	0	0	0
	TOTAL HIMACHAL PRADESH				**1433**	**6477**	**3280**	**3197**	**1289**	**632**	**657**	**2958**	**1445**	**1513**
	GRAND TOTAL				**3935**	**14913**	**7925**	**6988**	**2564**	**1269**	**1295**			

Table 2. Landuse details of the study area

SN	District Name	Gram Panchayat Name	Revenue Village Name	Altitude (m asl)	Total Geo graphical Area (in Ha)	Forest Area (in Ha)	Area under Non-Agricultural Uses (in Ha)	Barren & Un-cultivable Land (in Ha)	Permanent Pastures and Other Grazing Land Area (in Ha)	Land Under Misc Tree Crops etc. (in Ha)	Culturable Waste Land (in Ha)	Fallows Land other than Current Fallows (in Ha)	Current Fallows (in Ha)	Net Area Sown (in Ha)	Total Unirrigated Land (in Ha)	Area Irrigated by Source (in Ha)
UTTARAKHAND																
37.	Uttarkashi	Dhatmeer	Dhatmeer		269.17	0	15.19	146.12	48.72	0.72	0.82	0.62	0.81	56.17	56.17	0
38.	Uttarkashi	Raithal	Raithal		375.07	5.62	29.3	167.23	12.22	0	9.77	7.31	2.11	141.51	141.51	0
39.	Uttarkashi	Raithal	Natin		85.73	4.28	43.2	0	1.16	0	0.21	2.7	0	34.18	34.18	0
40.	Uttarkashi	Vandrani	Pahi		84.62	14.44	67.81	0.15	0.43	0	0.78	0	0.62	0.39	0.39	0
41.	Uttarkashi	Bandrani	Bandrani		106.46	6.29	4.64	47.79	8.16	0	0.66	0.89	0	38.03	38.03	0
42.	Chamoli	Tapovan	Topovan		200.91	63.88	42.79	0.8	10	0	1	1.2	0.3	80.94	80.94	0
43.	Chamoli	Malari	Malari		10073.45	805.08	9083.71	0	40.63	0	0	1.3	0.06	142.67	142.67	0
44.	Chamoli	Ghes	Ghes Chack Sarmata		67.22	1.25	5.4	8.38	15.54	10.98	4	0	0	21.67	21.67	0
45.	Chamoli	Ghes	Ghes		337.93	207.98	1.72	8.24	15.28	0	13.78	0	0.31	90.62	90.62	0
46.	Rudraprayag	Badhani	Badhani		56.4	10.46	2.44	0	0	0	26.37	0	0	17.13	17.13	0
47.	Rudraprayag	Badhani	Jagtoli		11.68	1.68	0.68	0	0	0	3.77	0	0	5.55	5.55	0
48.	Pithoragarh	Harkot	Matena		182.38	60.72	30.5	25.02	33.35	0	10.98	3.79	0	18.02	18.02	0
49.	Pithoragarh	Harkot	Harkot		180.51	113.89	1.05	1.9	5.21	0	4.85	8.26	0	45.35	45.35	0
50.	Pithoragarh	Harkot	Malupati		44.29	14.14	1.5	2.01	4.35	0	3.78	7.93	0	10.58	10.58	0
51.	Bageshwar	Sorag	Sorag		500.48	21.63	0	184.04	0	195.6	0	0	0	99.21	99.21	0
	TOTAL UTTARAKHAND				**12576.3**	**1331.34**	**9329.93**	**591.68**	**195.05**	**207.3**	**80.77**	**34**	**4.21**	**802.02**	**802.02**	**0**
HIMACHAL PRADESH																
52.	Lahul & Spiti	Kibber Khas	Kibber Khas		465.18	0	23.65	0	389.16	0	7.69	0	0	44.68	0	44.68
53.	Lahul & Spiti	Kibber Khas	Pinjoor		168.43	0.39	11.79	0	126.04	0	3.01	0	0	27.2	0	27.2
54.	Lahul & Spiti	Kibber Khas	Kee		492.72	23.95	109.3	0	314.12	0.13	26.48	0	0	18.74	0	18.74
55.	Lahul & Spiti	Kibber Khas	Gettey		100.99	17.67	2.82	0	73.08	0	2.42	0	0	5	0	5
56.	Lahul & Spiti	Kibber Khas	Tashi Gang		69.51	0	0.95	0	0	58.71	4.6	0	0	5.25	0	5.25

SN	District Name	Gram Panchayat Name	Revenue Village Name	Altitude (m asl)	Total Geo graphical Area (in Ha)	Forest Area (in Ha)	Area under Non-Agricultural Uses (in Ha)	Barren & Un-cultivable Land (in Ha)	Permanent Pastures and Other Grazing Land Area (in Ha)	Land Under Misc Tree Crops etc. (in Ha)	Culturable Waste Land (in Ha)	Fallows Land other than Current Fallows (in Ha)	Current Fallows (in Ha)	Net Area Sown (in Ha)	Total Unirrigated Land (in Ha)	Area Irrigated by Source (in Ha)
57.	Sirmaur	Dewri	Kharahan		207	134	2	0	32	5	1	0	0	33	31	2
58.	Sirmaur	Dewri	Dewri		394	222	16	5	105	3	2	0	0	41	37	4
59.	Sirmaur	Dewri	Kharotiyon		125	0	4	0	97	10	2	0	0	12	0	12
60.	Shimla	Kufri Junga	Kufri Junga		115	0	12.68	17.9	52.12	1.58	7.53	0	0	23.19	23.19	0
61.	Shimla	Kufri Junga	Kufri Koti		37.56	0	0.99	3.13	6.91	8.1	2.32	0	0	16.11	16.11	0
62.	Shimla	Kufri Junga	Jangal Kufri Chharabra		145	137.79	4.41	2.8	0	0	0	0	0	0	0	0
63.	Shimla	Kufri Junga	Shoyah		107.92	0	4.59	33.59	42.49	0	3.56	0	0	23.69	19.94	3.75
64.	Shimla	Kufri Junga	Kuni		128.35	0	2.15	14.88	90.1	0	4.3	0	0	16.92	16.92	0
65.	Shimla	Kufri Junga	Doji Dhar		10.36	0	1.46	0.74	5.43	0	0.16	0	0	2.57	2.57	0
66.	Shimla	Kufri Junga	Chharabra		32.5	0	5.71	3.7	8.11	0	4.37	0	0	10.61	10.61	0
67.	Kinnaur	Sangla	Sangla		869.8	862.89	6.02	0	0	0	0	0	0	0.89	0.89	0
68.	Kinnaur	Sangla	Thapa Saring		309	1	51	0	106	0	12	0	30	109	4	105
69.	Kinnaur	Sangla	Panpo Kanda		287	0	50	0	168	0	9	0	0	60	2	58
70.	Kinnaur	Sangla	Boning Saring		1074	0	4	829	171	1	24	19	0	26	26	0
71.	Kinnaur	Sangla	Sangla Kanda		152	0	27	0	58	0	5	0	0	62	0	62
72.	Kinnaur	Sangla	Dewar Kanda		875	1	36	0	543	0	116	0	119	60	60	0
	TOTAL HIMACHAL PRADESH				**6166.32**	**1400.69**	**376.52**	910.74	**2387.56**	**87.52**	**237.44**	**19**	**149**	**597.85**	**250.23**	**347.62**
	GRAND TOTAL				18742.6	2732.03	9706.45	1502.42	2582.61	294.82	318.21	53	153.21	1399.87	1052.25	347.62

METHODOLOGY

Information on perception, responses to local and local knowledge of climate change, its impact on farming and adaptive strategies applied by the household was gathered through personal interviews, field observations, focused group discussions, transect walks and secondary data (Table 3). The members of community based Institutions having their prior presence; rapport and reputation in the targeted study area were associated as study teams to gauze the people's perception on impact of climate change on availability, accessibility, sustainability of the natural resources, agricultural production and also to identify indicators of climate change in the area.

The sample villages were selected randomly after reconnaissance survey across the states of Uttarakhand and Himachal Pradesh. The primary criteria being the village must be located above 2000 m asl. and a representative of the villages in the district with similar geographical setup. As the study is primarily aimed to assess the nature of climatic variability/changes and coping strategies by the mountain community at individual, cultural, organizational, and institutional levels, the primary data related these broad objectives has been collected and collated with available secondary data. The primary data is of great significance as the study has investigated the perception and strategies of mountain community with regard to climate change and its impact on their life and surroundings. Thus the structured village and household questionnaires have been developed and used as primary tool of data collection after initial field testing of the questionnaires.

The household survey was conducted through semi-structured and structured questionnaire to enlist the opinion of randomly selected households in the village. The sample household represented the different socio-economic strata of the community. A total of 125 respondent households (approx. 5-13 respondents/village) were selected through a systematic random sampling method for household survey (Fig 1). Of the total respondents, 84 were from 9 Gram Panchayats of Uttarakhand and 41 from 4 Gram Panchayats of Himachal Pradesh. The respondent households were selected from different age group, educational background and occupational categories such as women headed households (widow or husband migrated), differently abled households, traditional agriculture practicing farmer/ progressive farmer,

modern youth using technologies and gadgets for earning livelihood but staying in the village, households using modern alternate technologies, senior citizen, individual farmer and SHG/ CBO/ Farmers group/ Van Panchayat members. In each case, the head of each household was interviewed assuming that he/she was the most aware of the issues. The reported data is based on climate change experienced by the household is for the past 10 years.

Secondary data on policy, programs and activities regarding climate related risk management and adaption practices were also collected from various reports. Data collected from the household and Gram Panchayat surveys were analyzed using Microsoft excel. Qualitative information such as respondent's perception regarding climate change was analyzed using frequencies and percentages. The data collected may not be a true representative of the whole district. Thus, caution is warranted for the generalization of these household level results.

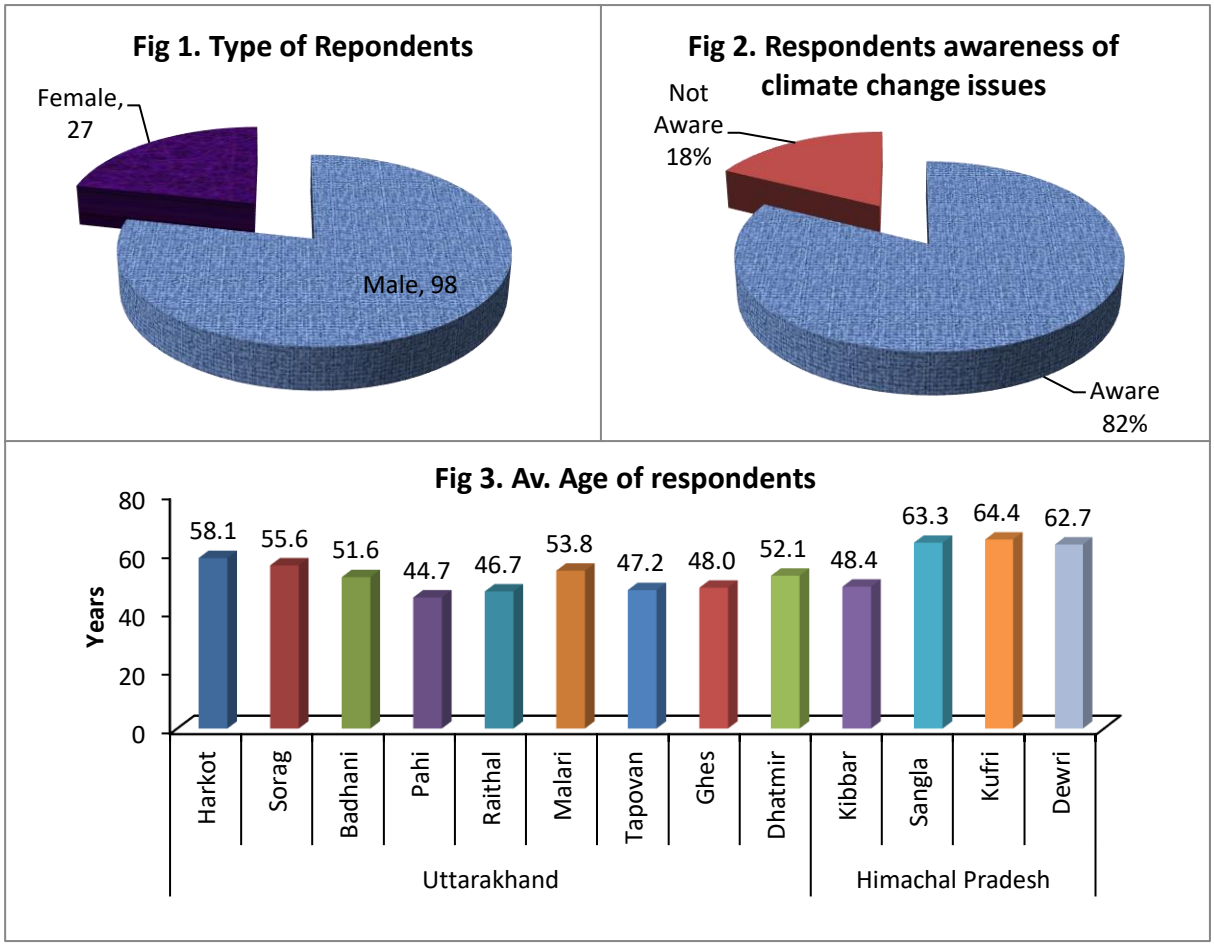
Table 3: Methodology and Tools adopted for data collection

Type of Tool	**Methodology Adopted for data collection**			
	FGD	**Intense interview**	**Transect Walk**	**Data Collection**
G.P Format	√	X	√	X
Household Format	X	√	X	X
Village PRA Map	X	X	√	X
Secondary Data	X	X		√

THE FINDINGS

A total of 125 HHs were selected for interview among 3935 households having a total population of 14913 from the selected 13 villages in both the states i.e. Uttarakhand and Himachal Pradesh. Of the total respondents 98 respondents were male and 27 respondents were female (Fig 1). Village wise details of respondents covered during the survey have been given in Fig 4 below. Maximum number of respondents (13) was covered in Dhatmir village (Uttarakhand).

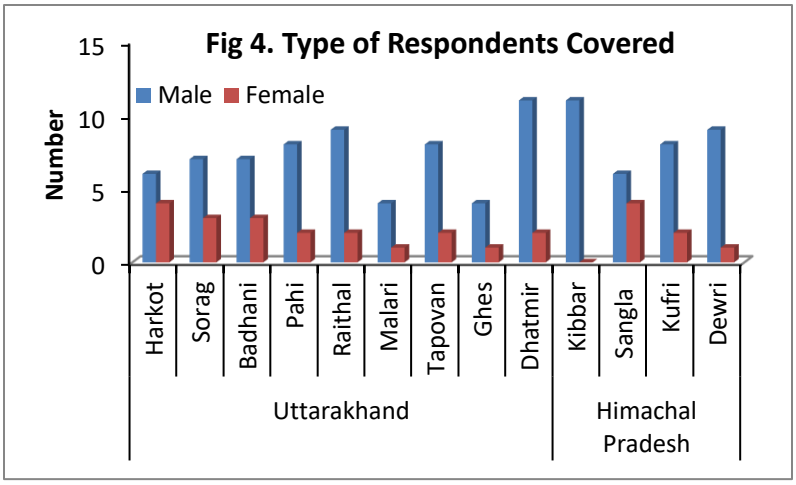
In each of the village surveyed only the adults (male and female both) were interacted. Of the total respondents 18% of the respondents were unaware of climate change and its impacts



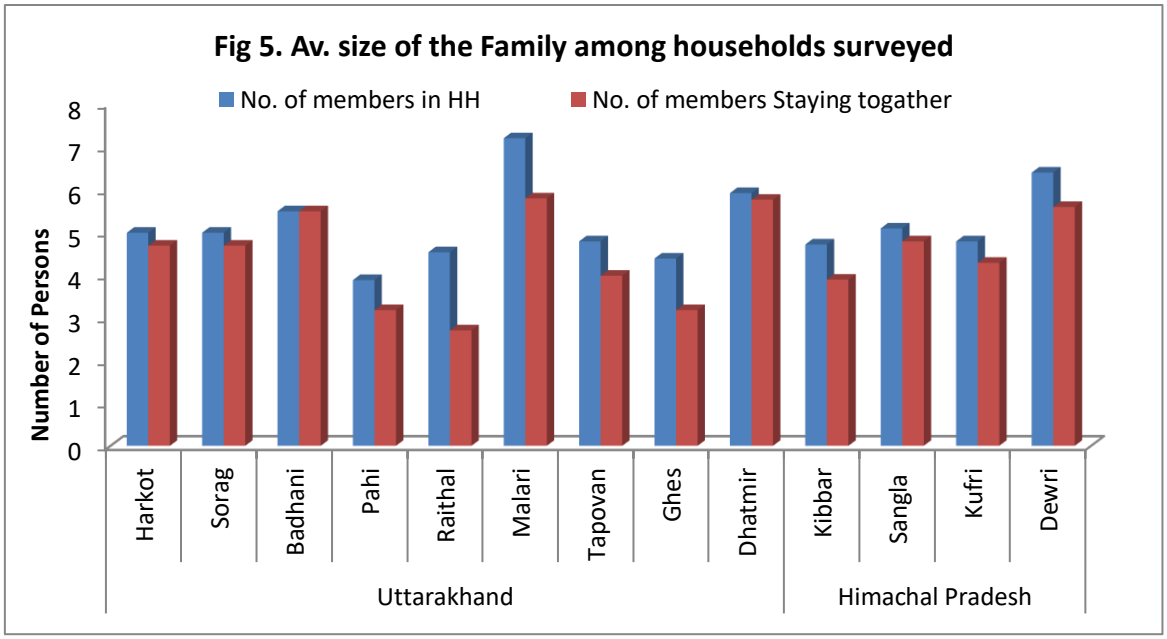
(Fig 2). The age of the respondent varied between 21 years to 105 who shared their experiences and perception on climate change and its impact on their life. The average age of

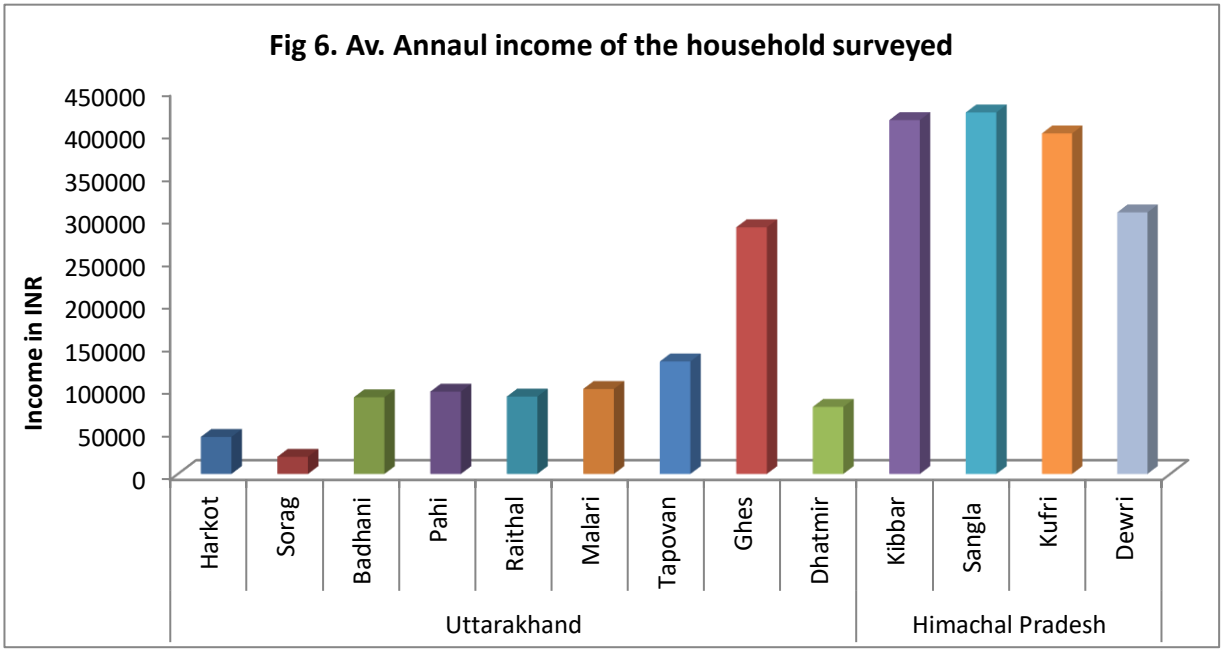
respondents varied between 44.7 in Pahi village of Uttarakhand to 64.3 years in Kufri village of Himachal Pradesh (Fig 3).

The average family size of the respondents was found to be maximum in Malari and minimum in Pahi village of Uttarakhand (Fig 5). It has been noticed that there is at least one member of each respondent household is migrated to other places owing to education, employment or some other reasons.



The average income of respondent varied between Rs 20000 (Sorag village, Uttarakhand) to more than Rs 423000 (Sangla village, Himachal Pradesh) (Fig 6). The overall average household income in villages of Uttarakhand was found to be low than the average income per household in Himachal Pradesh.





Landholdings

There is a variation in average landholdings (including available barren land) of the household in both the states. On comparison it was noticed that the households in Malari have minimum landholding (4.6 Nali/HH), while it was found maximum in Ghes (65.6 Nali/HH). On the other hand, in Himachal Pradesh minimum (9.73 bigha/HH or Approx. 39 Nali/HH) landholding was recorded for village Kibber, while maximum (18.9 bigha/HH or Approx. 76 Nali/HH) was found in Sangla village (Fig 7)

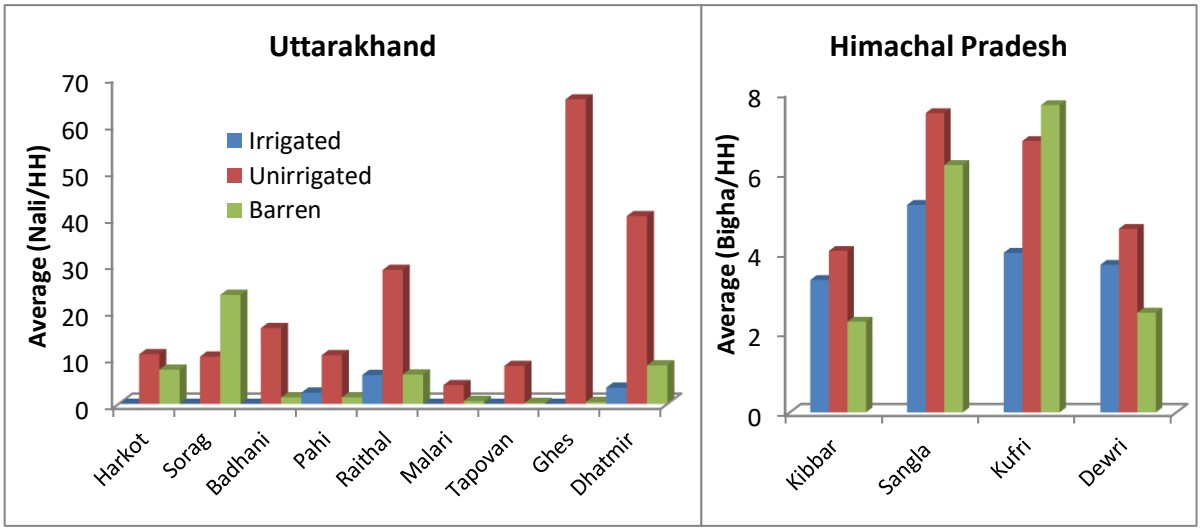
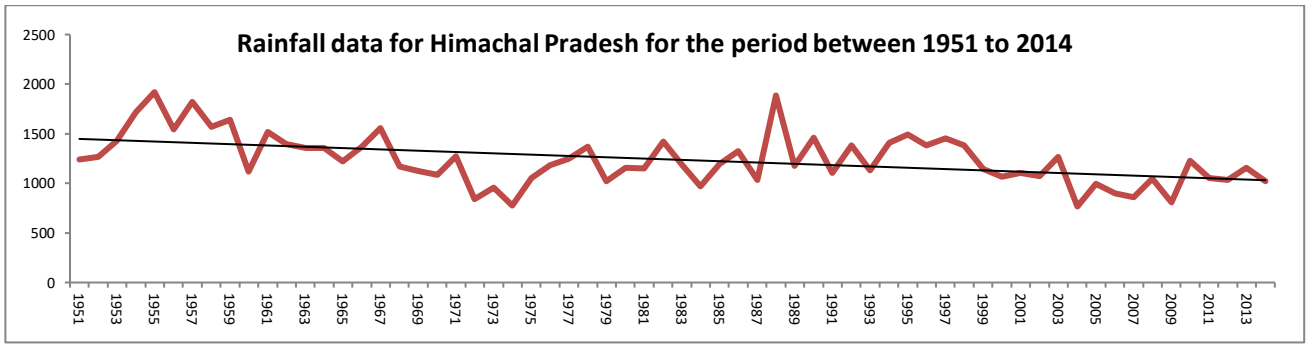


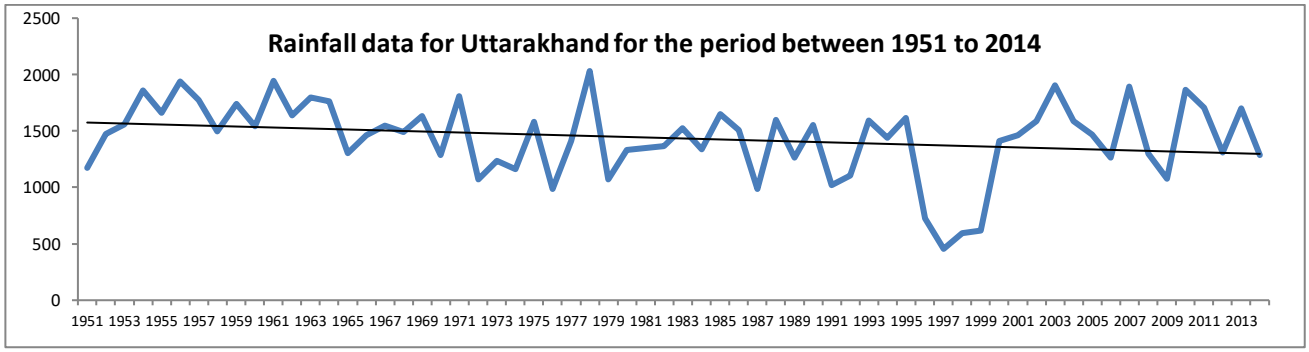
Fig 7. Average Landholding/Household among the Respondents

Temperature and Rainfall

The annual temperature has been forecast to increase from 0.9°C ± 0.6°C to 0.6°C ± 0.7°C in the 2030s. The net increase in temperature ranges from 1.7°C to 2.2°C with respect to the 1970s. Seasonal air temperatures are also forecast to rise in all seasons. However, winter temperatures (during October, November and December) are likely to decrease by 2.6°C in the 2030s with respect to the 1970s.

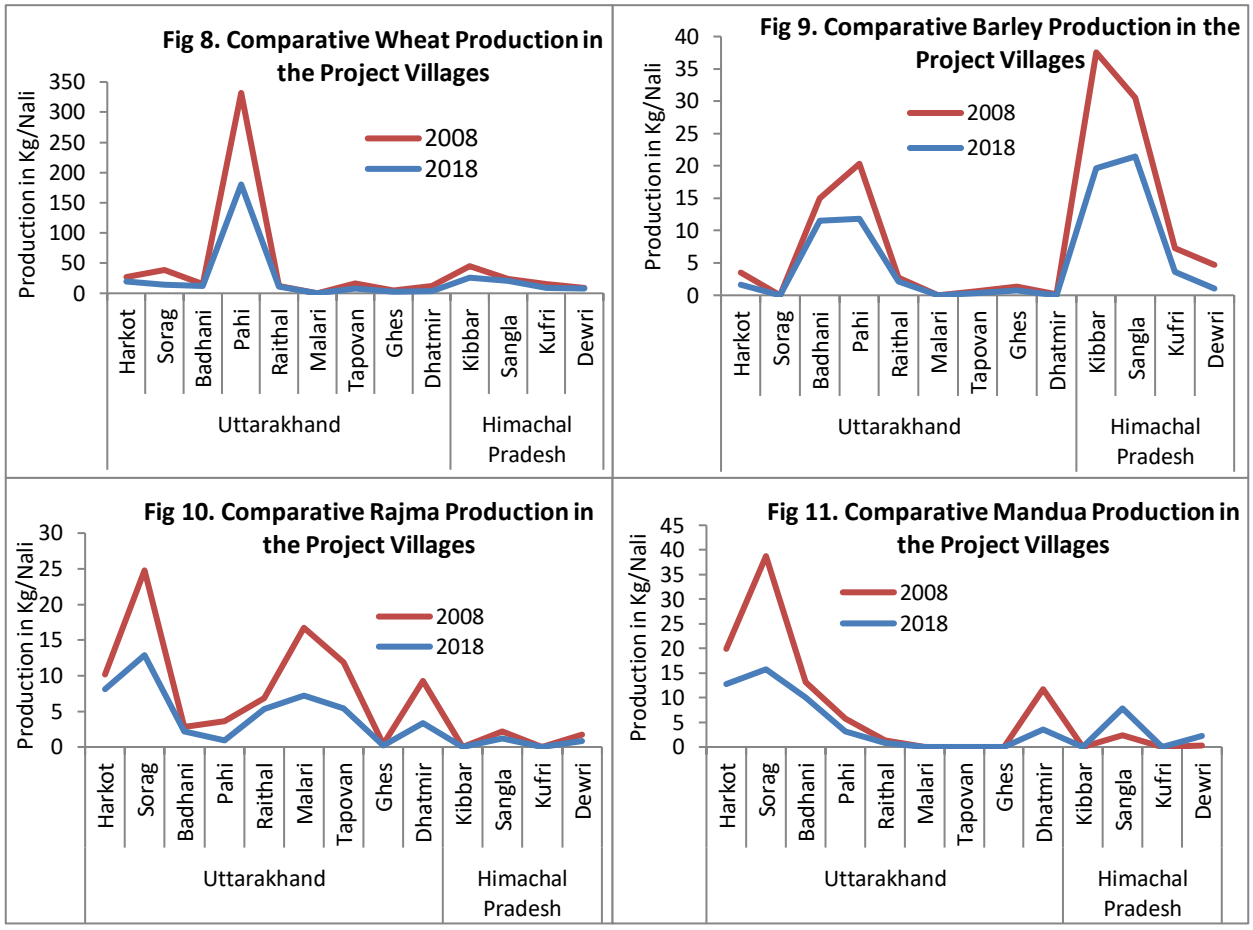
According to the 4 × 4 assessment, the annual rainfall in the Himalayan region may vary between 1268 ± 225.2 mm and 1604 ± 175.2 mm. The precipitation that has been forecast shows a net increase in the 2030s with respect to the simulated rainfall of the 1970s in the Himalayan region by 60 to 206 mm. The increase in the annual rainfall in the 2030s with respect to that of the 1970s ranges from 5% to 13%. All seasons in the Himalayan region are forecast to have an increase in rainfall, with the maximum increase in rainfall forecast to be in the monsoon months of June, July, August and September, 12 mm. The winter rain in the months of January and February is also forecast to increase by 5 mm in the 2030s with respect to the 1970s, with the minimum increase being in October, November and December.





Agricultural and Horticultural Production

During last one decade there has been a major shift in agri - horti production as well as in cultivation pattern among the villages. Majority of respondents believe that the crop



productivity has decreased while pest infestation has increased due to change in climatic conditions. The major crops grown in these areas include Paddy, Wheat, Barley, Mandua (Ragi), Maize, Barley Kuttu, Ramdana, etc. Among vegetables Potato, cabbage/cauliflower and Pea are cultivated in majority of the villages. Cabbage/Cauliflower and Pea are becoming suitable replacement of Rabi crops in these areas (Fig 8 to Fig 13).

The average production of traditionally cultivated crops declined drastically (Fig 8- Fig11) owing to changes in climate (especially temperature and rainfall), reduced soil productivity, decreasing cattle population (major source of manure to the fields), pest infestation, increase in weed population and increasing migration. Shrinking of landholdings due to developmental activities, bifurcation of households (increasing trend of nucleus families in place of joint families), lack of manpower (working population migrating to nearby towns in search of

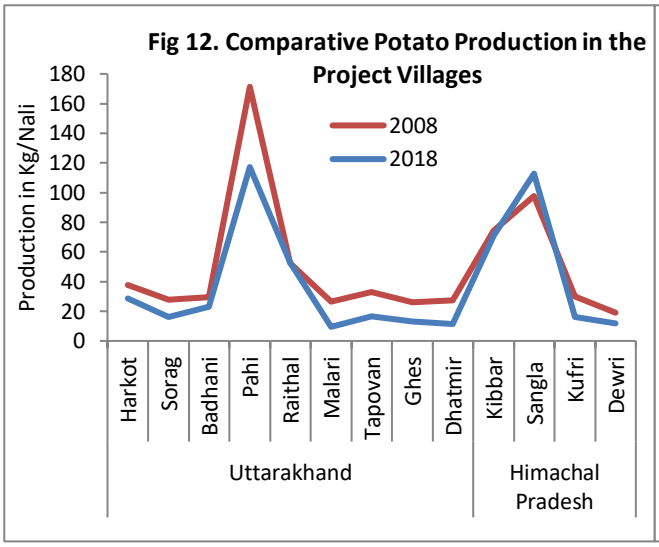


Fig 12. Comparative Potato Production in the Project Villages

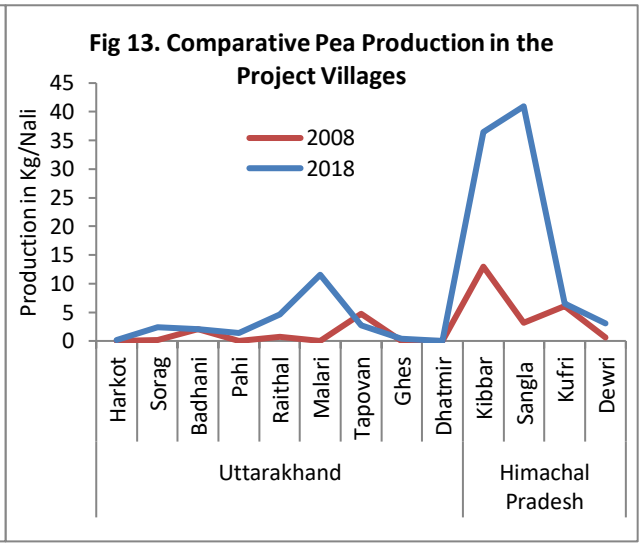


Fig 13. Comparative Pea Production in the Project Villages

education and employment leaving behind the old/aged person) has also led to decrease in production. Traditional millet crops such as Mandua (Ragi), Jhangora, Kauni, Cheena, Chaulai, Kuttu, etc. are now on the verge of extinction in the project area. Cultivation of mono crops or cash crops such as Cabbage and Pea in increasing in these villages (Fig 12-13).

Irrigation facilities are available only in three villages (viz. Pahi, Raithal and Dhatmir) of Uttarakhand, while in Himachal Pradesh irrigation facilities are available in all villages covered during the survey. Of the total cultivable land (excluding barren land) per household the irrigated lands accounts for 14.75%, 17.75% and 7.93% in Pahi, Raithal and Dhatmir villages of Uttarakhand. While in Himachal Pradesh, the total irrigated land accounted for 45.11%, 40.94%, 37.04% and 44.56% of total cultivable land in Kibber, Sangla, Kufri and Dewari villages respectively.

The phenological responses of plants are considered among the prominent biological indicators of climate change. Owing to shorter winter periods, plant dormancy is broken earlier which is reflected in early flowering not only among the crops and horticultural plants

but also in the wild. The plants flower during unsuitable weather conditions that are not favorable for their growth and survival. This way the blooming onsets even before the local pollinators are active reducing fruiting and thus productivity of crops. During period hailstorms are also becoming a common phenomenon in this region causing major losses.

Energy Sources

Even today the fuel wood collected from forest areas is the main source of energy in the project villages because of its being cheaper than any other source of energy. Fuel wood is used mainly for heating purposes during colder periods of the year.

The villagers collect fuel wood from nearby forest area, civil soyam and agricultural lands in Uttarakhand, while in Himachal Pradesh fuel wood is procured mainly from the Government Depot, established by the state government to provide uninterrupted supply of fuel wood and to minimize the community interference in the forest areas. In Kibber village cow dung is also used as replacement of fuel wood.

LPG is being used by majority of households in the project area except Badhani in Rudraprayag district, Uttarakhand (Fig 14). However most of the respondents were of the opinion that the LPG is primarily used to cook team and lunch for the family to save the time, while breakfast and dinner is cooked by using fuel wood.

Similarly, solar light is being used for lighting purposes in the project area except in the village Kufri and Dewari (Himachal Pradesh) (Fig 15).

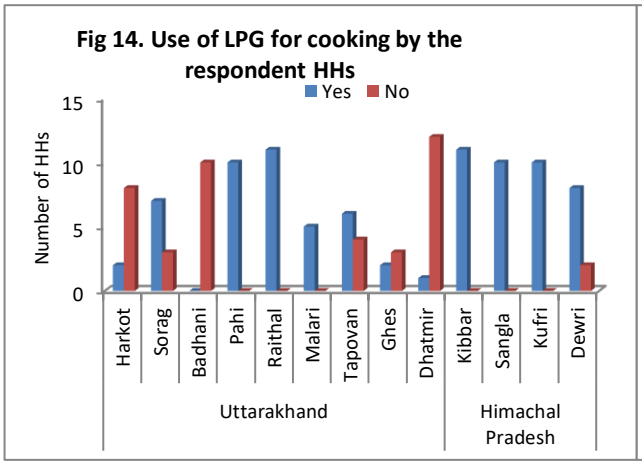


Fig 14. Use of LPG for cooking by the respondent HHs

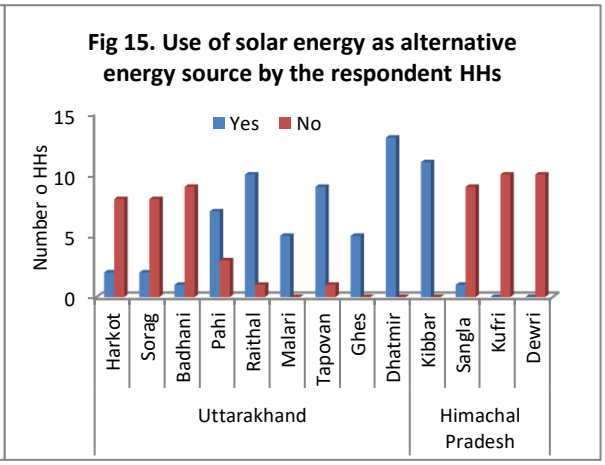


Fig 15. Use of solar energy as alternative energy source by the respondent HHs

Occurrence of Disasters

The study reveals that climate Change has led to increase in Disaster Occurrence in the region. Change in climate is found to have a concomitant change in the frequency of rainfall, floods, droughts, avalanches and landslides and threat to the livelihood and property of the people living in the Himalayan region.

Impact on natural resources

Natural resources are worst affected by climate change. Majority of respondents admit that the forest around their villages has become depleted and degraded due to developmental actviities (such as road construction, construction of hydro power projects, etc.), increased fuel wood use due to population pressure, loss of vegetation due to glacial action and other disasters, forest fires, overgrazing and decreased regeneration rates of trees in the forest area. Depletion of certain species from specific pockets and introduction of pine at higher reaches have also been reported during the study.

In addition, Rise in the density of agriculture, increase in population, unscientific developmental activities of the region and large amount of tourist inflows, etc. cause an impact on the available resources and the per capita share of these resources. Overuse and inappropriate use of resources to accommodate the increasing population and resource demands is causing resource degradation and stress.

CLIMATE ADAPTATION STRATEGIES BY THE NATIVE COMMUNITIES

The above findings clearly indicate that the climate in Himalayan region is changing drastically over the decades posing serious threats to agricultural and wild biodiversity of the Himalayas. The scale of adaption may be local, national, or regional; the context of the adaptation will determine the type of adaptation (e.g. new farming practices in a rural context or water demand management in an urban context); and the approach to adaptation may focus on general poverty alleviation, enhanced transparency in decision making, or the empowerment of women, among other things. There are few examples of successful adaption in various regions of the Himalaya, few of which are being described as below:

a. Modified cultivation strategies/Moving towards cash crops

The agriculture being the mainstay of livelihood in the Himalayas, has witnessed significant alterations. The Himalayan agriculture was known for its diversified pattern of cultivation known as *Barahnaja*. Agriculture practices of Himalayan region ensure sustainability to food and nutritional security of inhabitants of the region. However, in the past couple of decades, it has been felt that the agricultural production in declining sharply either directly due to climate change or due to climate induced factors such as drying up of natural water sources and receding of glaciers. The Himalayan communities are now adopting cash crops by replacing traditional crops such as millets and

Cash Crops Cultivation
Climate Change Adaptation Strategy

Vijay Singh Rana, a 48 year old farmer from village Raithal, Uttarkashi, Uttarakhand earns his livelihood from agriculture. There is no other source of income for his family. He used to practice traditional farming till 2013. About 14 years ago a farmer of his village started cultivation of pea, but no one followed him. During last decade due to erratic rainfall and temperature patterns, he suffered major losses in soyabeen and rajma, traditionally grown crops in the village. In 2015 he has sown Pea crop with technical support of Integrated Livelihood Support Project in 10 Nali land, where he harvested about 600 Kg of produce (gree pea), which he sold directly to Dehradun Mandi. Since then he not only continued growing pea, but also increased the area under cultivation by 50%. Last year he earned an income of Rs 60000/- even after low rates due to bumper crop production. To strengthen irrigation facilities he also constructed a LDPE tank with the support of the project.

Against all odd he fetched approx. Rs. 60,000 by selling his produce. ILSP also provided him LDPE tank to strengthen the irrigation facility.

He also started a home stay unit to cater accommodation needs of tourists coming to Dayara Bugyal located near the village. According to Mr Rana, where pea cultivation changed his economic condition, the home stay

following monoculture in place of diversified culture of cropping to gain immediate monetary benefits. With the increased access to markets and other resources, the communities at the higher altitudes are now opting for monoculture in place of diversified pattern of cultivation. It was also accompanied by changed time of sowing, use of fertilizers, replacement of traditional seeds, etc. This has not only increased the production but also provided instant cash support to the producers and enhanced their buying capacities. Increase in temperature at higher reaches enabled communities to cultivate cash crops such as pea, potato, cabbage, and cauliflower, etc. throughout the year. However, at the same time crops such as Cheena, Kauni, Bajra, Mandua, Jhangora, Kuttu, etc. are on the verge of extinction from these areas.

However, in addition to climate change, there are many other factors that are forcing communities to either switch on to cash crops by replacing the traditional crops or stop farming activities. Some of these are increased migration, small and scattered land holdings, low production, low interest of young generation in agricultural activities, wildlife conflicts, easy access to the retail shops/markets, etc.

b. Horticulture vs Agriculture

Pratap, D. (2015) reported adoption of horticulture as alternative strategy to mitigate climate change impacts in tribal belts of Uttarakhand. Communities in higher altitudes (such as in Mori block of district Uttarkashi) are opting for establishing apple orchards by replacing the year old tradition of cultivation of traditional millets such as Amaranth and potato. In addition, the community is also looking for alternatives to increase the horticultural production by means of replacement of old plantations, grafting, enhancing the use of chemical fertilizers for maintenance and production increment, etc.

c. Switching for Clean Energy Alternatives

Climate change is causing a reduction in natural resources available for use by native communities. It is leading to a decline in snow cover and shrinkage of the natural vegetation such as grasslands and forests that communities depend on, and rendering waste the lands that were productive. The communities are adopting alternative energy sources such as LPG and solar energy to cope up with the situation. The study data also reveal that there is an increasing trend of LPG and solar energy. However, the communities are now feeling detached with their surrounding natural resources, a valuable source of ecosystem services.

The water resources are also shrinking at a greater pace than expected, which is directly linked to the declining of forest cover and melting of glaciers due to rise in temperature across the Himalayan belt.

d. Opting for Alternative Livelihood

Traditionally, agriculture along with animal husbandry has been the main source of livelihood in the Himalayan region. The change in climate has affected almost all traditional livelihood sources of native 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 adaptations are not enough to offset the adverse impacts of climate change. During the study it was observed that the communities are not only opting for alternative livelihoods such as outmigration for employment to support their families. A large number of respondents were found 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 perceived changes, impacts on livelihoods, coping mechanisms and future risks are being summarized in Table 4.

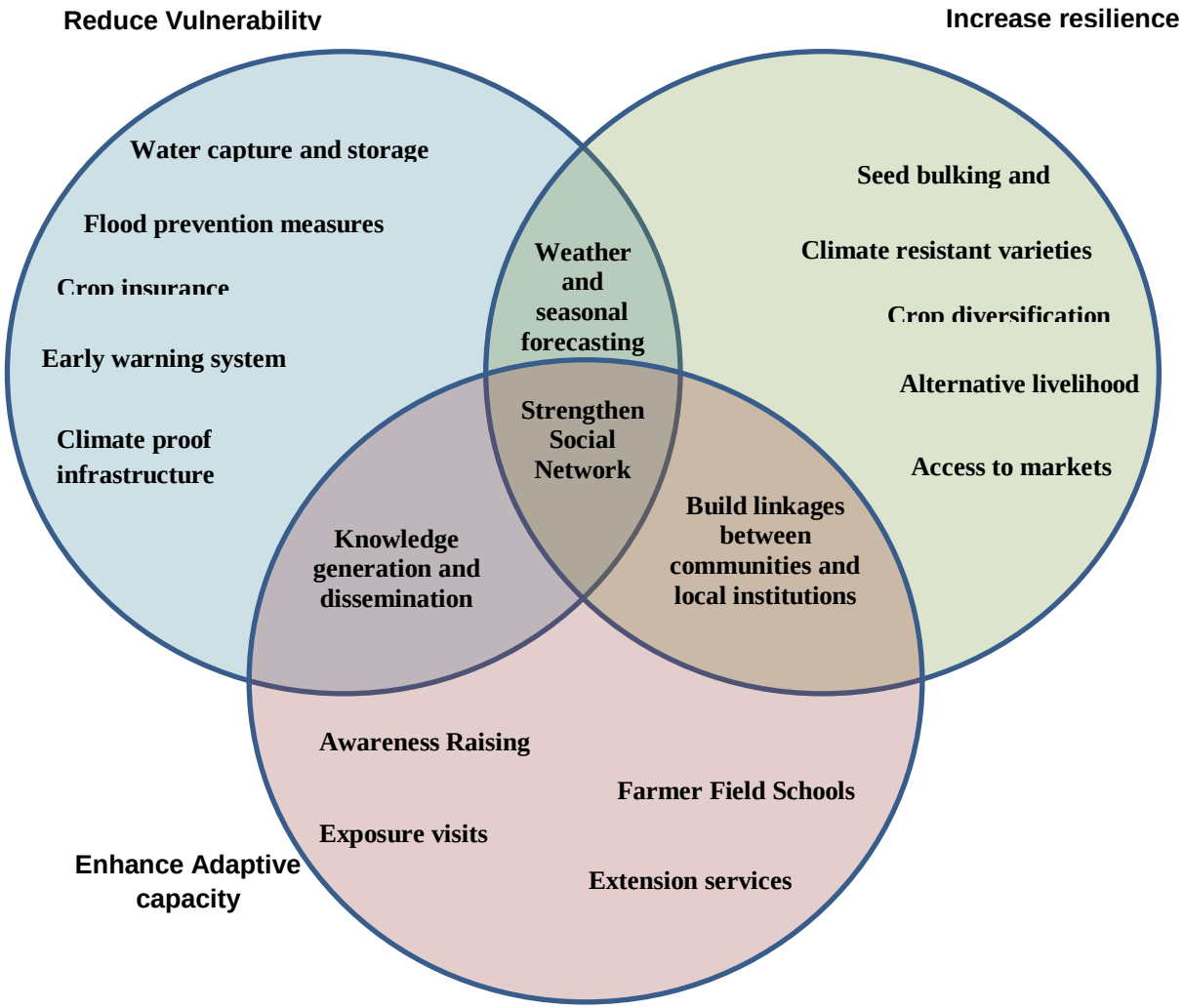
Table 4: The perceived changes, impacts on livelihoods, coping mechanisms and future risks

Communities' perception of change	Experienced impacts on livelihood system	Coping and adaptation	Potential future risks
Increase in temperature, Receding of glaciers, drying of natural water sources and decreased water availability	Early flowering, reduced pollination and low productivity	Early/delayed sowing, Crop replacement, shift to smaller livestock or no livestock, higher dependence on market	Growing food and livelihood in security, increased drudgery, Reduced crop diversity and nutritional insecurity, increased dependence on cash incomes.
Decrease in rainfall and unpredictable onset of monsoon	Decreased agricultural and horticultural productivity	Increased dependence on market, cultivation of cash crops, crop replacement, delayed sowing	Growing food and livelihood in security. Reduced crop diversity and nutritional insecurity
Larger dry spell, in some places drought like conditions	Drying up of springs, low discharge of springs and streams	Traditional water sharing system, delayed sowing	Water insecurity for drinking and irrigation purposes, increased workload of women and children, low production and sometimes crop failure.
Warmer winters and significantly low snowfall	increased incidences of pest and disease infestation, weeds and health problems	increased use of insecticides and pesticides	increased food and livelihood insecurity, harmful impacts on floral and faunal diversity due to reduced pollination
Reduced forest biodiversity and coverage	Reduced snowfall, increase in temperature	Afforestation Adoption of alternative energy sources (LPG and Solar energy) No coping strategy	impact on forest based livelihood (NTFP)

ACTION PLAN

A comprehensive action plan is required to be formulized both at community and administrative level. A comprehensive study followed by a series of consultations at various levels is required to be carried out to outline various adaptive strategies as coping mechanism to climate change. Such strategies must be included in the government policies prior to implementation of various programs oriented towards ecological restoration and community upliftment. The civil society organization can play a greater role in organizing the study and consultation at the community level and can bridge the communication between community and the government.

Due to persistent climate uncertainty, adaption measures in Himalayan region



Short to Medium Term Adaption: Climate Resilient Development (ICIMOD 2010)

will be limited to climate resistant development over the short and medium term, which means "no-regret" strategies are need regardless of the direction or magnitude of change (ICMIOD 2010). Climate resilient development includes three components" reducing vulnerability by minimizing risk without depending on a particular climate future, strengthening resilience so that the unexpected can be overcome, and enhancing adaptive capacity so that communities can take informed control over their future (Ensor 2009). Thus, in the medium and long term, it will be crucial to increase our knowledge in order to reduce uncertainty and enable adoption measures to be developed that tackle specific climate risk that are outside historic climate variability (ICMIOD 2010). Some of the action points are being outlined in Table 5 as below:

Table 5: Areas of intervention and requisite actions for intervention as adaptive measure at different levels

Areas of intervention	Requisite Actions for Interventions as adaptive measure			
	Institutional		Community Level	Policy /Advocacy Level
	MFH	Partner level		
A. Disaster				
1)Preparedness	Resource mobilization Follow-up and M&E Liaising with line departments at state and national level Carrying out Surveys (Pre and post disaster) Policy advocacy through partner agencies pressure groups, and communities	Raising awareness Preparation of CBDMP/ DMP Training & Capacity building Support in carrying out pre and post disaster surveys Coordination with line departments at district level Reporting and documentation	Participation in preparation of CBDMP/DMP and Adoption of action suggested in CBDMP Resource mobilization from PRIs for implementation of CBDMP	Review of state policy and advocacy for incorporating the lessons learned based on assessments and action based research by the institutions at various levels.
2) Rescue and rehabilitation	Resource mobilization based on Rapid Assessment Plan Follow-up and M&E Liaising with line departments at state and national level Carrying out Surveys (Pre and post disaster) Policy advocacy through pressure groups, partner agencies and communities	Facilitating implementation of Action plans based on rapid assessment carried out. Supporting disaster affected communities in rescue and rehabilitation Reporting and documentation	Supporting Rescue and Rehabilitation teams during the process Dovetailing of mobilized resources with PRIs	

Areas of intervention	Requisite Actions for Interventions as adaptive measure			
	Institutional		Community Level	Policy /Advocacy Level
	MFH	Partner level		
B. Technological Interventions				
1) Broad scaling of climate resilient technologies	Identification and documentation of best practice for climate resilient technologies in the domains of draught/pest/disease resistant crops, crops that distract wildlife, high value low volume crops, crops suitable for low water availability zones, climate responsive high value crops, etc. Dissemination through various means of communication Policy advocacy through pressure groups, partner agencies and communities	Facilitation in documentation of best practice for climate resilient technologies in identified domains by MCF. Support in dissemination of information through various means of communication to various stakeholders like communities, PRIs, district administration	Identification of best practice for climate resilient technologies in identified domains. Adoption of identified climate resilient technologies and package of practices .	Advocacy for adoption of climate resilient technologies, coping mechanism and package of practices in policy and action by line departments Advocacy for inclusion of climate resilient technologies, coping mechanism and package of practices in action plans being implemented by the department of agriculture, horticulture, animal husbandry, watershed management, and other allied boards and programs supported by national and international resource agencies.
2) Enhancing use of alternative energy resources	Identification and documentation of best practice on efficient alternative energy uses in production, post- harvest processing, storage, transportation under agriculture, horticulture, animal husbandry, and animal and human habitat, institutional buildings (green construction technologies), etc. Dissemination through various means of communication Policy advocacy through pressure groups, partner agencies and communities	Facilitation in identification and adoption of best practice on efficient alternative energy uses in production, post- harvest processing, storage, transportation under agriculture, horticulture, animal husbandry, and animal and human habitat, institutional buildings (green construction technologies), etc. Dissemination of information through various means of communication Facilitation for mobilizing the community support for policy advocacy and pressure groups.	Adoption of best practice on efficient alternative energy uses in production, post-harvest processing, storage, transportation under agriculture, horticulture, animal husbandry, and animal and human habitat, institutional buildings (green construction technologies), etc. Dissemination through various means of communication Dovetailing of resource with concurrent govt. schemes and programs through PRIs.	Advocacy for adoption of best practice on efficient alternative energy uses in production, post-harvest processing, storage, transportation under agriculture, horticulture, animal husbandry, and animal and human habitat, institutional buildings (green construction technologies), etc. in action plans being implemented by the department of Energy and UREDA other allied and programs supported by national and international resource agencies.

Areas of intervention	Requisite Actions for Interventions as adaptive measure			
	Institutional		Community Level	Policy /Advocacy Level
	MFH	Partner level		
C. Seasonal migration				
1) Intensive assessment of migration trends & impact	Resource mobilization Follow-up and M&E Liaising with line departments at state and national level Carrying out Seasonal Surveys Policy advocacy through partner agencies, pressure groups, and communities	Carrying out seasonal assessment of migration trends by developing a migration chart/register specifying requirement of human resource skills and specializations. Undertaking entrepreneurship skill development trainings at the cluster/village level for specified skill set/required specializations Creation of artisan guild.	Participation in seasonal assessment carried out to access the migration trends in terms of village level migration chart/register specifying requirement of human resource skills and specializations required. Participation in identifying the entrepreneurs for skill development trainings at the cluster/village level for specified skill set/required specializations Creation of artisan guild.	Recognizing the area specific artisan guilds for deployment under different departmental schemes/programs supported by national and international resource agencies.
D. Impact of Developmental Projects				
1) Awareness on approved EIAs/SIAs	Resource mobilization Identification of projects having large scale community impacts. Follow-up and M&E Liaising with project authorities and line departments at state and national level Policy advocacy through partner agencies, pressure groups, and communities	Community awareness regarding the provisions made under EIA and SIA of the identified projects. Dissemination of information through various means of communication Function as bridge between communities and identified project authorities Support in policy advocacy through communities Facilitation for mobilizing the community support for policy advocacy and pressure groups.	Ensuring implementation of the provisions made under EIA and SIA of the identified projects through PRIs and other concerned authorities.	Advocacy for adoption of a common guideline for rehabilitation of project affected communities by development projects and inclusion of the same to state policy.
E. Indigenous Communities	As per the recommendation given by the partners	As per the recommendation given by the partners	As per the recommendation given by the partners	As per the recommendation given by the partners

CONCLUSION

The present study reveals that the temperature and precipitation regime is changing in the Himalayan region. Both duration and amount of precipitation have changed significantly, majority of which is received as rain rather than snow. The changes in hydrological regime, agricultural-horticultural productivity, increased uses of alternative energy sources and phonological changes in wild and cultivated crops are common observations of the study.

The changes in climatic conditions has resulted in decline of livelihood sources, agro-horti-livestock conditions, increased incidents of pest and disease infestation and emergence of invasive species. A huge impact is perceived to be on the agricultural and horticultural sector that houses maximum share of the workforce of the region. This has persuaded the pace of migration (both seasonal and permanent) from the region. Climate change has an adverse impact on the livelihoods based on forestry, agriculture, animal husbandry, NTFP and MAP. The communities at the higher Himalayan regions were however, are also observed to have an opportunity of cultivating the crops which once were almost impossible to grow in these areas (such as cultivation of pea, cabbage in Kibber village of Himachal Pradesh and Malari village of Uttarakhand. Communities are opting for the crops which are best suited to the altered conditions and also have ready markets.

There is an urgent need to have long term adaptive strategies as the efforts being made by the native communities are certainly short of what is really required to cope up the situation. Suitable strategies to improvise adaptions upon traditional practices are required to be placed in for community actions, government policies and projects being implemented for the communities along with dovetailing of modern science and technology in the same.

REFERENCES

1. CEDAR, 2015: Climate Change in Uttarakhand: Current State of Knowledge and way forward. Bishan Singh Mahendra Pal Singh, 1-66.
2. Ensor; J (2009) 'Adaptation to climate change: the role of adaptive capacity and resilience.' Tecnología y Sociedad (Soluciones Prácticas, Lima) 16(8): 33-51
3. Mishra, A, 2014. Changing Climate of Uttarakhand: India. J Geol Geosci 3: 163 doi.10/4172/2329-6755.1000163
4. Du, MY; Kawashima, S; Yonemura, S; Zhang, XZ; Chen, SB (2004) 'Mutual influence between human activities and climate change in the tibetan plateau during recent years'. Global and Planetary Change 41: 241-249
5. Glantz MH (ed) (1998) Societal response to regional climatic change: forecasting by analogy. Westview Press, Boulder, CO
6. ICIMOD (2010) Rural Livelihoods and adaptation to climate change in the Himalayas. Information Sheet 5/10.
7. IPCC (2001) Climate Change 2001. Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge
8. Rupa Kumar T. and Ashrit R.G. (2001) Regional aspects of global climate change simulations: validations and assessment of climate response of the Indian monsoon region to increase of greenhouse gases and sulphate aerosols. Museum 52, 229-244
9. IPCC (2007a) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S; Qin, D; Manning, M; Chen, Z; Marquis, M; Averyt, KB; Tignor, M; Miller, HL (eds)]. Cambridge and New York: Cambridge University Press
10. 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.businessstandard. com/india/news/floods-cause-large-scale-damage-toapple-crops-inuttarakhand/109434/on last accessed: 02 December 2010.
11. Pradap, D. (2015) Climate Change Impacts and Adaptation by Communities in a Tribal Region of Central Himalaya: A Study from Uttarakhand Himalaya, India. Archives of IASC conference. Digital Library of Commons.
1. Agricultural Statistics at a glance (2007) http://eands.dacnet.nic.in/ At_Glance_2007.htm.
2. SAPCC, Himachal Pradesh, 2012
3. https://data.gov.in/resources