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Indigenous perceptions of Climate change *vis-a-vis* Mountain Agricultural activities in Himachal Pradesh, India

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The study assesses the effects of climatic and socioeconomic changes on the livelihoods of rural agricultural communities in the Himachal Pradesh of India. The farmers' perceptions on locally idealized traditional weather cycles with climate change are analyzed and compared for different agro climatic zones of Himachal Pradesh. Climate change is described by farmers as temporal displacement of weather cycles, reflecting changes in crop enterprises and livelihood options. Increasing temperature during summers, prolonged summers, delayed onset and uneven distribution of SW monsoon, delayed onset of winter, short winter periods, temperature above normal during winters, decreasing snowfall during winters, delayed snowfall and shorter winters, low temperature spells at high altitudes during winters and unpredictable rainfalls were the main experiences of the farmers regarding climate change across the elevation zones. Farmers' perceptions clearly indicated a shift in crop production in the low and mid hill regions, from crops requiring high moisture, like basmati rice and sugarcane, to those tolerating lower water like maize and local paddy rice. In addition, a shift of the apple growing belt to higher altitudes was noted, with former apple production areas replaced by vegetable crops. The study concludes that climate variability has a clear impact on crop productivity. In all elevations, farmers opined that a shift of labor earlier engaged in agriculture, to other enterprises is primarily due to handsome earnings in other enterprises, reflecting reduction in profits from agriculture and increase in vulnerability in climate dependent agricultural systems. Farmers in marginal areas are more vulnerable than small and large farmers from sub tropical climates in the mid hills to sub temperate climates at higher elevations.

Keywords: Climate Change, Mountain agriculture, Farmers perceptions and livelihood
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Himachal Pradesh is a mountainous state of India, and more than 70 % of the population is dependent on agriculture, which again is dependent on the climate of the area to a great extent. The share of agriculture and animal husbandry in the net state domestic product (NSDP) of Himachal has been reduced from 34.9 % in 1980-81 to 19.6 % in 2005-06[1]. Mountains being fragile environments are also rich repositories of biodiversity, water and providers of ecosystem goods and services to downstream communities. Global climate change and its effects are not uniform for all areas but differ with elevation. Specifically, under climate change, temperatures in mountain areas are predicted to increase more than the global mean in South Asia and especially on the Tibetan Plateau and in central Asia, with the greatest warming occurring at the highest altitudes. Overall, summer precipitation is likely to increase and winter precipitation to decrease in mountain areas, with precipitation increasingly in the form of rain instead of snow, and a predicted rise in the snow line by 150 m per degree Celsius temperature increase[2]. The mountain ecosystems are particularly vulnerable to climate change due to a high dependence of the people on natural resources for their livelihoods, comparatively higher exposure to extreme events and widespread poverty and marginalization[3]. The studies indicated that the Himalayas are warming at more than the global average rate[4]. Scientific evidence suggests that temperatures are rising at disproportionately higher rates at higher altitude, changing precipitation patterns, glacier recession, and the thawing of permafrost, resulting in the mountain areas becoming relative 'hotspots' of climate change[5].

Climate Change has significant effect on regional agricultural production[6] which is primarily dependent on weather. In this paper we present a study on the effects of changing climate on agriculture, horticulture, and socio-economic conditions of mountain-dwelling Indigenous peoples of the Himachal Pradesh region.

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The changing climate on one hand has proven to be detrimental in some areas in terms of decrease in crop yield, quality, etc. while in other areas people have benefitted from new opportunities brought weather conditions that are favorable for the introduction of new crops which earlier could not be grown in those localities.

Methodology

Study area and sample selection

The study was carried out across different agro-climatic zones representing different elevations of the state of Himachal Pradesh. A multistage stratified sampling technique was used to select the sample communities. After initial reconnaissance, field visits to the entire state and discussions with key informants/ stakeholders/ farmers in the different areas of the state, we identified five suitable pilot sites, where the impact of changing climate was particularly pronounced. In the first stage of sampling, we selected the following areas for our investigation: Fatehpur valley in Sirmour district representing an elevation of 700 m asl with a sub tropical climate; Bajaura Valley in Kullu district located at an elevation of 1500-2500 m asl with a sub-temperate to temperate climate; Theog region in Shimla district. representing an elevation of 2000-3250 m asl with a temperate climate; Palam valley in Kangra district with an elevation of 700-1500 m asl within sub-humid and sub temperate climates; and Lahaul valley in Lahaul and Spiti district, at an elevation above 3251 m asl and with a dry temperate climate. In the second stage of sampling, clusters of 4 to 5 villages were drawn from each of the selected study area for the final selection of farmers for interviewing. In the last stage of sampling, an adequate sample of 40 households/ farmers was drawn from each cluster of villages, making a total sample of 200 households. Based on the area of land holdings, the farmers were classified into three categories: those owning less than one hectare (termed marginal); those owning one to two hectares ("small"); and those owning more than two hectares (large).

Data collection

The primary data were collected on the basis of a well-structured and pre-tested interview schedule summarized in appendix 1. The data were collected for two time periods: viz. 2005-06 (period-I) and 1995-96 (period-II). The farmers' perceptions were also related to two major agricultural cropping season of India, viz. *Kharif* and *Rabi* seasons. The *Kharif* season from June to September is generally characterized by hot and wet climate during South West monsoon whereas *Rabi* season from October to May is characterized by cool and dry climate.

Secondary data were collected from meteorological stations located in Himachal Pradesh over different time periods and from different agro-climatic regions to measure the accuracy of the farmers' perceptions.

Results and discussion

Farmers' Perceptions regarding changing climate

People perceived a definite change in the climate over a period. The farmers we interviewed were of the opinion that there has been an overall increase in temperature, drying up of surface waters including of river water, springs, lakes and wetlands. They also perceived an earlier flowering of fruit crops. More than 90 % of the farmers of the sampled households in the Fatehpur valley had observed that there was a more uneven distribution of rainfall during the monsoon season, a delay in the onset of the winter season, a shorter winter period, and temperatures above the normal over the past 10-15 yrs in their region (Table 1). The similar study conducted in Kangchenjunga of Himalayas region of West Bengal, India revealed that farmers had significant knowledge of climate change and its effects on the weather, ecosystems, biodiversity and agriculture. The perspectives of indigenous population were consistent across the region and conformed to scientific findings[7]. In Theog region, interviewees noted a reduction in snowfall and a shortening of winter, increasing temperatures during the summer, uneven distribution of rainfall and temperatures rising above normal during the winter months. The majority of respondents attributed the major causes of climate change to deforestation, the population explosion and industrialization[8]. In Himalayas there was a widespread perception that the weather is becoming warmer, that water sources are drying up, that the onset of summer and the monsoon season has advanced during last 10 years and that there is less snow on the Himalayan mountains than previously[9].

In Bajaura valley, shorter winter period, reduction in snowfall in winter and increasing temperature during the summer season were among the most visible signs of climate change for the farmers interviewed. Uneven distributions of rainfall and insufficient rainfall during the rainy season were also major signs of climate change. In Lahaul valley, more

Table 1—Farmers perceptions on climate change

Particulars	(Percent multiple response)				
	Fatehpur Valley	Theog Region	Bajaura Valley	Palam Valley	Lahaul Valley
Increasing temp. during summer	88	80	85	90	-
Prolonged summer season	56	48	66	62	-
Short summer season	5	8	10	5	-
Delayed in the onset of rainy season	66	80	85	88	-
Uneven distribution of rainfall	90	96	88	98	-
Insufficient rainfall during rainy season	58	72	77	95	-
Delay in the outset of winter season	92	48	68	45	60
Very low temp. in winter season	-	12	-	10	80
Short winter period	92	88	94	88	80
Temp. above normal during winter	92	88	92	96	15
Reducing snowfall in winter	-	100	100	-	88
High humid weather	66	36	40	75	22
Increasing foggy days in winter	66	52	16	22	-
Increasing cloudy days in winter	56	18	16	15	28
Unpredictable rainfall	66	52	76	65	-
Threat of floods	58	50	88	-	88
High velocity winds	18	-	-	20	-
Mud slides	-	-	-	-	20
High intensity of rainfall	52	-	20	-	-

than 80 % of the farmers interviewed were of opinion that reducing snowfall in the winter and delay in the onset of the winter are signs of changing climate in the mountains. Increasing threat of floods in the valley in the last 4-5 yrs is a sign of changing climate in the valley, as suggested by 88 % of the farmers interviewed. Palam valley farmers reported an unprecedented reduction in rainfall in the region compared to 20 yrs ago. Similarly, the farmers of Loess plateau China believed that the weather had become warmer and drier [10]. All the farmers agreed that the temperature had increased continuously during the period, while the other factors fluctuated more. Other signs of changing climate reported by the farmers were: shorter summer season, more humid weather and increasing number of foggy days in the winter, unpredictable rainfall, higher velocity wind, and higher intensity of rainfall (Table 1).

We found that the farmers' perceptions of climate change corresponded closely with the meteorological record for the state. The agroclimatic database from 1974 - 2009 was used to measure the accuracy of indigenous perception of farmers on climate change. It clearly indicated an increase in the annual mean temperature and a decrease in snowfall especially during September to December and March to May. The increase was more during the Rabi season (October to May) as compared to the Kharif season (June to September) Rainfall showed a decreasing trend at all the elevations, with rainfall reduction greater in mid hill regions (700-1500 m asl), which reflected in sharp decrease in surplus water balance in these regions.

Land use patterns

The land use patterns in the study sites have undergone noticeable changes in both quantity and quality (Table 2). Three quarters of the total land in Fatehpur valley is still under cultivation. The land use patterns of the three identified categories of farmers (marginal, small and large categories) did not exhibit any significant change over the period. Land use patterns of Theog region showed that the area under pasture and grassland and the area under fruits/orchards were reduced in extent by about 22 % and 5 %, respectively over the course of a decade. The percentage decline in area was higher for marginal farmers than for those of small and large farmers. For the farmers of small and large categories, the proportion of cultivable waste land in the total land holdings increased in extent by about 72 % and about 30 %, respectively over the past decade. In Bajaura valley, the area under fruits/orchard cultivation showed a decline of about 22 % during this same decade period (Table 2). The percentage decline in fruit production area was higher for farmers in the marginal category. The land use patterns in Palam valley revealed that size of operational holding

Table 2—Land use pattern of sampled farmers in the selected study sites

(Percent response)

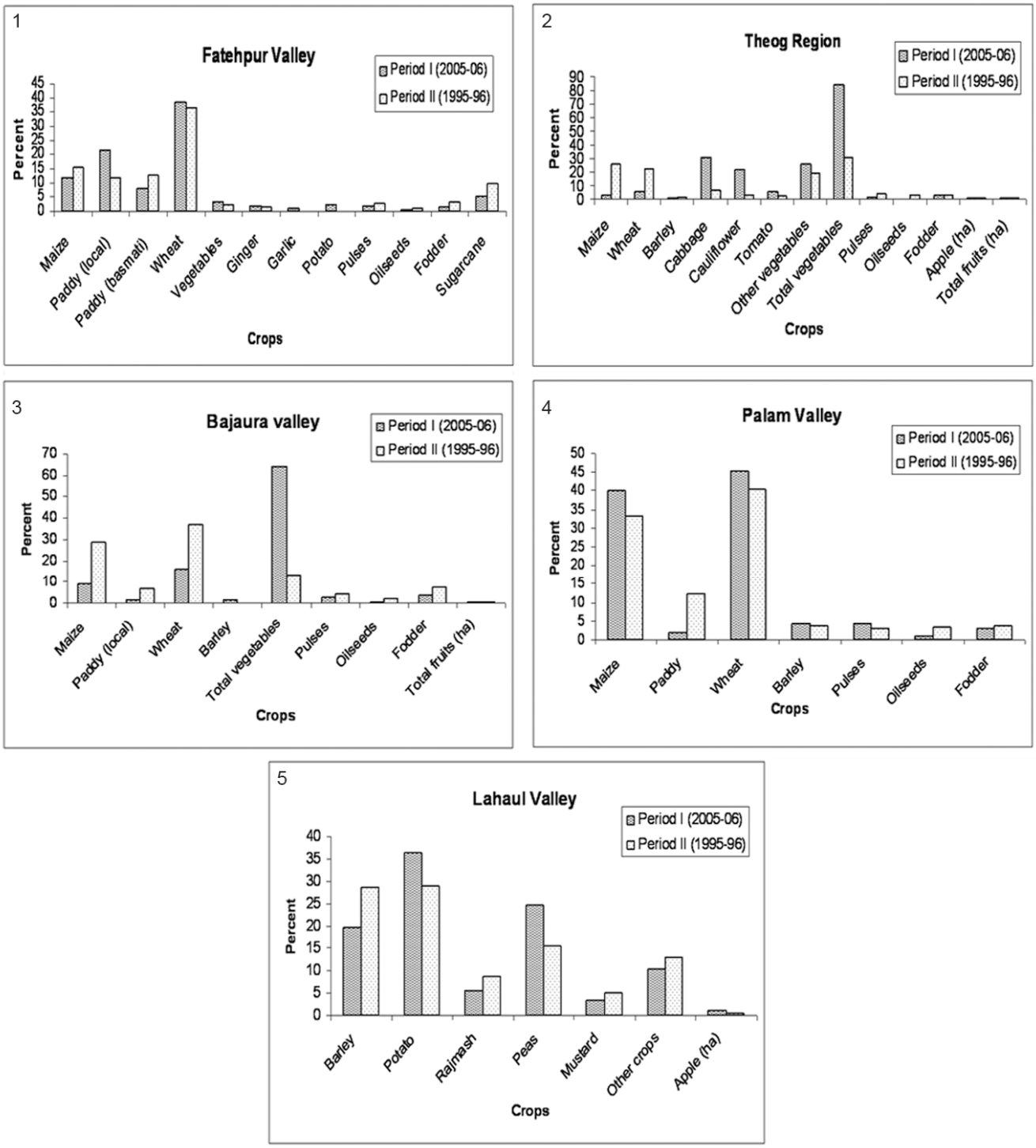
Particulars	Fatehpur		Theog		Bajaura		Palam		Lahaul	
	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II
Operational holding	78.4	78.4	54.6	55.2	74.0	68.0	65.1	74.3	58.9	57.6
Pasture/Grass land	4.2	4.3	15.0	19.3	5.0	5.0	23.9	23.9	16.6	19.1
Orchard	15.5	15.8	21.7	22.8	21.0	27.0	-	-	4.3	1.9
Current fallow	-	-	4.8	0.0	-	-	11.0	1.8	6.3	4.6
Culturable waste Land	1.9	1.5	3.9	2.6	-	-	-	-	13.8	16.8
Total holding (ha)	2.2 (100)	2.1 (100)	2.8 (100)	2.8 (100)	1.1 (100)	1.1 (100)	1.1 (100)	1.1 (100)	2.0 (100)	(1.9) (100)

declined from about 75 - 65 % of the total land holding during the past decade. This might be due to a significant increase in the size of current fallows. The area under pastures and grasslands has remained unchanged across different categories of farmers over this period. In Lahaul valley, a steady increase in the area under fruit production was noted. The proportion of land in orchards in the present scenario increased to 4.34 % from 1.93 % in the past decade. The marginal category farmers have devoted a higher percentage of their land to fruit crops than have those of small and large categories. This is because conditions have now become more favorable for fruit crop cultivation in the valley due to rising temperatures, decreasing snowfall in the winter season and shorter winters.

Cropping patterns

The transition in mountain agriculture was due to a shift of area from traditional crops (e.g. local paddy, maize and wheat) to off-season vegetables, such as cabbage, cauliflower and tomato. Anticipated continuing changes in climate may have significant consequences (in some cases positive, in others, negative) on the development, growth and yield of various crops[11]. Crops of the Fatehpur valley are mainly dominated by food grains (Fig. 1). The area under basmati rice and maize crops showed a decline of about 37 % and 26 %, respectively over the course of a decade, with a significant portion of the former *basmati* rice and maize crop area diverted toward local paddy rice. Vegetable crops like cauliflower, garlic and potato have also been adopted by some farmers. Sugarcane, a cash crop of farmers in the past, registered a decline of about 50 % in its area over recent years. Crops of the Theog region were formerly dominated mainly by food grains; in the past, cereals and pulses together have accounted for more than 62 % of the total area under field crops. In the present scenario (Fig. 2), however, seasonal and off-seasonal vegetables (such as cabbage, cauliflower and tomato) together cover more than 84 % of the area in the valleys. The total area under apples and other fruit crops generally recorded less change over the same period. The decline in area under apples was more for marginal farmers (33.4 %) as compared with small farmers (5.6 %) and large farmers (4.9 %).

Significant changes were observed in the cropping pattern of the farmers of Bajaura valley between the past and present scenarios (Fig. 3). A remarkable increase in the area under off-season vegetables was noted, mainly due to a shift in the area formerly under food grains and fruits (e.g. apple, plum) to off-season vegetable cultivation, with a reduction of over 50% over a the course of a decade. This decline in apple and other fruit production is comparatively higher in the marginal and small categories of farmers. Notably, there was a significant increase in the total cropped area in the present scenario over the past scenario. This might be due to the ability to raise 3-4 crops of off-season vegetables within a year. In the Palam valley no significant shift occurred in the overall cropping pattern over the same time (Fig. 4). However, a shift of paddy crop area to maize production was noted, with nearly 18 % more area diverted to the maize cultivation in the present scenario. The area under oilseeds such as *sarson* is also declined by about 76 %. The farmers were devoting more area to pulses than in the past period. The total cropped area also declined by about 17 %. The present cropping pattern comprising cash crops, mainly potato and peas, in Lahaul valley (Fig. 5) showed an increase of about 8-9 %, whereas the area under various traditional mountain crops like *kuth* (*Saussurea costus* (Falc.) Lipsch), saffron (*Crocus sativus* L.), *kala zira* (*Bunium persicum* Bioss.), buckwheat (*Fagopyrum esculentum* Moench.), hops (*Humulus lupulus* L.) and amaranth (*Amranthus candatus* L.) decreased drastically. The farmers in this valley were devoting less area to crops like barley,



Figs. 1-5—Cropping pattern of Fatehpur valley for period-I and period-II; (2)-Cropping pattern of Theog region for period-I and period-II.; (3)-Cropping pattern of Bajaura valley for period-I and period-II.; (4)-Cropping pattern of Palam valley for period-I and period-II.; (5)-Cropping pattern of Lahaul valley for period-I and period-II.

which had been the main crop of the valley in the past. The area under apples increased from 0.49 hectare per farm in the past to 1.09 hectares in recent times. In particular, the marginal farmers had started fruit cultivation, a new practice compared with the past.

Livelihood options, employment and income

Source of Employment

A shift in the source of employment, from the agriculture sector to various other service sectors, was noted in the study (Table 3). In Fatehpur valley, the percentage of the total work force engaged in the agriculture sector declined to about 57 % in the present period compared with about 87 % in past. The workforce shifted to the service sector both in private and in Government jobs. In the present period about 27 % of the total work force has engaged in the service sector, compared with about 6 % in the past. The percentage of the workforce engaged in business activities and non-agricultural labour also doubled in the present period as compared with the past period. In Theog region the percentage of the workforce engaged in the service sector registered a three-fold increase. The migration of workers from agriculture to non-agricultural activities was greater in marginal category farmers as compared to small and large category farmers. In Bajaura valley in Kullu (Table 3), for example, about 66 % of the workforce was employed in agriculture in the present period as compared with about 76 % in the past period. Employment in other sectors such as business / trade and service sectors increased to the same extent. In the Palam valley, about 60 % of the total workforce was found to engage in agricultural and allied activities in the present period as against about 71 % in past period. The percentage of the workforce employed in activities of labour both in agriculture and non-agriculture increased from about 9 % in the past to about 15 % in the present period. However, the percentage workers engaged in the service sectors in both private and government jobs remained unchanged. In Lahaul valley, the percentage of workforce engaged in agriculture also declined in the present period. Contrary to this, the percentage of workforce employed in government jobs and private jobs in the present period increased by more than 1.5 times than in the past period. The percentage of workforce employed in activities of trade/business and labour also doubled in the present period.

Farm income

The percentage increase in the total income was much higher in small and large farmer categories than for the marginal category farmers. The study on changes in farm income levels (Table 4) showed that in the Theog region the total farm income remained unchanged but in the large category of farmers, the total farm income registered an increase of more than 17 %. The share of food crops in income was reduced from about 11 % to about % and that of fruit crops (mainly apples), from about 59 % to about 33 %. The relative contribution of off-season vegetables also registered an increase of 2-4 times from marginal to large farmers. The livestock sector is also a major contributor towards the total income of the marginal and small category farmers. The total farm income on an average farm in Bajaura valley showed a marginal reduction of about 4 % in the present period. However, across the different categories of farmers, the total farm income registered an increase of about 31 %, 21 % and 20 % in marginal, small and large categories of farmers, respectively.

Fruit crops, mainly apple, provided a major portion of total farm income in past (69.9 %), followed by food (maize (*Zea mays* L.), local paddy (*Oryza sativa* L.), wheat (*Triticum aestivum* L.) and barley

Table 3—Employment pattern of sampled farmers in the selected study sites

(Percent response)

Particular	Fatehpur Valley		Theog Region		Bajaura Valley		Palam Valley		Lahaul Valley	
	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II
Agriculture & Livestock	57.0	86.6	74.5	85.6	65.7	76.4	60.4	70.9	72.3	83.4
Business/ Trade	7.7	3.5	2.8	4.4	7.8	4.9	6.9	4.7	4.8	1.9
Labour	8.3	3.9	-	0.7	-	-	14.9	9.1	4.2	2.8
Private Job	9.4	1.6	8.5	1.8	6.9	4.4	4.5	5.1	3.8	1.9
Govt. Job	17.5	4.5	14.3	7.6	19.6	14.3	10.7	8.1	13.6	8.9
Rural Artisans.	-	-	-	-	-	-	2.5	2.0	1.3	1.1
Total (No./Farm)	4.6 (100)	5.1 (100)	4.7 (100)	4.6 (100)	4.3 (100)	3.9 (100)	4.0 (100)	4.9 (100)	4.8 (100)	5.4 (100)

Table 4—Farm income of the sampled farmers in the selected study sites

Crop	(Percent response)									
	Fatehpur Valley		Theog Region		Bajaura Valley		Palam Valley		Lahaul Valley	
	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II	Period I	Period II
Food Crops	69.35	67.39	7.04	29.92	10.65	27.41	16.37	30.66	8.08	12.81
	(25.6)	(24.9)	(2.7)	(11.4)	(5.0)	(12.4)	(42.6)	(53.8)	(4.2)	(8.8)
Non-food crops	1.121	20.24	3.75	4.72	4.38	2.75	2.18	3.44	0.72	0.96
	(4.1)	(7.5)	(1.5)	(1.8)	(2.1)	(1.2)	(5.7)	(6.0)	(0.38)	(0.66)
Vegetables	58.7	31.8	123.9	33.4	81.6	9.4	-	-	110.6	91.3
	(21.65)	(11.76)	(48.23)	(12.74)	(38.34)	(4.24)			(57.8)	(63.0
Sugarcane	4757	8123	-	-	-	-	-	-	-	-
	(1.8)	(3.0)								
Fruits	81.19	107.78	84.23	155.13	84.23	155.13	-	-	55.75	24.9
	(30.0)	(39.8)	(32.8)	(59.3)	(39.6)	(70.0)			(29.1)	(17.2)
Livestock	45.86	35.32	38.05	38.56	32.04	26.96	19.86	22.92	15.94	14.53
	(16.9)	(13.1)	(14.8)	(14.7)	(15.1)	(12.2)	(51.7)	(40.2)	(8.3)	(10.0)
Oilseeds	-	-	-	-	-	-	-	-	0.250	0.461
									(0.13)	(0.32)
Total Farm Income	271.7	270.66	257.0	261.68	212.91	221.6	38.41	57.01	191.35	144.96
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

*Figures in parenthesis indicate % of total income (Rupees)

(*Hordeum vulgare* L.) crops (12.4 %). However, in the present period, off-season vegetables (38.3 %) along with fruit crops (39.6 %) have been the major contributors to total farm income, with the proportional contribution food crops being reduced from 12.4 - 15 %. The total farm income in Palam valley decreased from Rs. 57,914 - 38,408 (32 %) over the period. The share of food crops in the total farm income decreased from about 54 % to about 43 %. Although the total farm income of the farmers in all categories decreased in the present period, the contribution of livestock to the total farm income increased from about 40 % to about 52 %. In the Lahaul valley, the total farm income increased from Rs. 1,44, 962 - 1,91,351 (32 %) over the period. In the present period, the fruit crops (mainly apple) are contributing about 29 % to total farm income as compared with about 17 % in the past. The share of the food crops was reduced to half in present period (4.2 %) compared with its share in the past period (8.8 %). The horticulture sector comprising of apple (*Malus domestica* Borkh.), stone fruits, viz. peach (*Prunus persica* Batsch.), pear (*Pyrus communis* L. & *P. pyrifolia* L.) , plum (*Prunus domestica* L.) , apricot (*Prunus armeniaca* L.), mango (*Mangifera Indica* L.), etc. share of the gross value output of Himachal has increased from about 25 % in 1999-2000 to about 40 % in 2006-07, whereas crop production has been reduced from about 43 - 30 % during same period[1].

Conclusion

The study attempted to address the impacts of changing climatic conditions on the mountain agriculture as experienced by indigenous farmers of different agro-climatic regions. The study based on premise that any research findings on impact of changing climate on agriculture and farmers should take into account farmers' knowledge of weather/ climate fluctuations vis-à-vis agriculture. The perspectives of Climate Change of indigenous farmers were compared with observed weather changes. The significance of study further compounded in fragile ecosystem of mountains regions when such findings are used to devise the approach towards identifications, monitoring and adaptations strategies for climate change. The study envisaged the scope of reorienting policy plan and calls for adaptations strategies for mountain agriculture.

The study showed that global climate change has impacted mountain people directly. Indigenous peoples perceptions from different elevation zones, ranging from 700 to >3000 m asl, clearly revealed a change in climatic conditions including an increase in mean temperature in both summer and winter, drying up of surface water resources, uneven and insufficient rainfall, an increase in extreme weather phenomena like droughts and floods, a delay in the onset of the winter season, and shorter winters. A remarkable increase in the area under off-season vegetables was

noticed in the cropping patterns of Theog region and Bajaura valley. The contribution of off-season vegetables to the total farm income increased from 4-12 % to 21-48 % in all study sites. In higher elevations, snowfall showed decreasing trends in all the months, reflecting reduced winter periods. In Lahaul valley, the area under apple production increased from 0.49 hectare per farm to 1.09 hectare. Overall, the workforce showed a shift from the agriculture sector to service sectors; in all study sites, there was a decline of the agricultural workforce of 70-86 % in the past period to 57-74 % in the present period. The total farm income in the lower elevation regions decreased, whereas the income in the higher elevation regions of Lahaul and Spiti increased, mainly due to an increase of 12 % from fruit production.

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References

1 Anonymous, *State Agriculture Plan*: Agriculture and net domestic product, Vol.XII, (Department of Agriculture, Shimla, Himachal Pradesh, India), 2009, 16-20

2 IPCC, *Climate Change 2007*. The Scientific Basis, WG I contribution to IPCC 4th assessment report, (Cambridge: Cambridge University Press), 2007.

3 Partap U & Partap T, Apple farming and pollinations issues in Himachal Pradesh, In: *Warning Signals from the Apple Valleys of the Hindu Kush-Himalayas- Productivity Concerns and Pollination Problems*, edited by A B M Shrestha, [International Centre for Integrated Mountain Development (ICIMOD), PO Box 3226, Kathmandu, Nepal], 2002.

4 Surendra PS, Singh V & Skutsch M, Rapid warming in the Himalayas: Ecosystem responses and development options, *Climate and Development,* 2(3) (2010) 221-232.

5 Macchi M, In: *Framework for community-based climate vulnerability and capacity assessment in mountain areas*, (ICIMOD, Kathmandu, Nepal), 2011.

6 Shivakumar MVK, Brunini O & Das HP Impacts of present and future climate variability on agriculture and forestry in the arid and semi-arid tropics, *Climatic Change* ,70 (2005) 31-72

7 Chaudhary P, Rai S, Wangdi S, Mao A, Rehman N, Chettri S & Bawa, KS Consistency of local perceptions of climate change in the Kangchenjunga Himalaya landscape, *Curr Sci,* 101(4)

8 (2011) 504-513

9 Singh J, Effect of Climate Change on Medicinal Plants and Local Perception in Kullu District of Himachal Pradesh, In: *Pre-Congress workshop on Forests and Climate Change*, 17th August, 2011, (Himalayan Forest Research Institute, Shimla, India), 2011.

10 Chaudhary P & Bawa KS, Local perceptions of climate change validated by scientific evidence in the Himalayas, *Biol Lett published online* April 27, 2011, doi:10.1098/rsbl.2011.0269, 2011.

11 Hageback J, Sundberg J, Ostwald M, Chen D, Yun X & Knutsson P, Climate Variability and Land-use change in Danangou watershed, China-examples of small-scale farmers' adaptation, *Climatic Change,* 72 (2005) 189–212

12 Patel HR, Patel VJ & Pandey V, Impact assessment of climate change on maize cultivars in middle Gujarat agro-climatic region using CERES-maize model, *J Agrometeorol,* (special issue), 2 (2008) 292-295

Appendix: 1

QUESTIONNAIRE SCHEDULE

1. GENERAL INFORMATIONS about farmers:
2. INFORMATIONS ON CLIMATE**:**
   - 2.1 What is the altitude of the area (meters amsl) _____
   - 2.2 Agro climatic condition of the area (farmer's perception) __
     - a) Temperature (°C) in winter (months)_____, in spring_____, in summer_____ in rainy season _____
     - b) Humidity (%) in winter_____, in spring_____, in summer _____ in rainy season _____,

2.3 What kind of change do you feel in climate (i. e. temperature, rainfall and humidity) in your area during the past 5-10 years:

a) Increasing temperature during summer (yes / no) (months) _____
b) Prolonged summer season _____
c) Short summer season _____
d) Delay in the onset of rainy season _____
e) Uneven distribution of rainfall _____
f) Insufficient Rainfall during rainy season _____
g) Delay in the onset of winter season (rains) _____
h) Very low temperature in winter season _____
i) Short winter period _____
j) Temperature above normal during winter _____
k) Reducing snowfall in winter _____
l) High humid weather _____
m) Increasing foggy days in winter _____
n) Increasing cloudy days in winter/ summer _____
o) Unpredictable rainfall _____
p) Threat of floods _____
q) High velocity wind _____
r) Mud slides _____
s) High intensity of rainfall during winter _____
t) Other (specify) _____

3. HOUSEHOLD AND AGRICULTURAL INFORMATIONS:

3.1 INVENTORY OF HUMAN RESOURCES: Family members, Literate. Illiterate Workers, Non workers and their age

3.2 OCCUPATIONAL PATTERN, LIVELIHOOD OPTIONS AND CLIMATIC CHANGE:

3.3 LAND USE AND CLIMATIC CHANGE:

3.4 LIVESTOCK PRODUCTION, DISEASES/INSECTS AND CLIMATIC CHANGE:

3.5 CROPPING / PRODUCTION SYSTEM AND CLIMATIC CHANGE:

3.6 PRODUCTION, DISEASES/INSECTS OF DIFFERENT CROPS AND CLIMATE CHANGE: Cereals, Pulses, Oilseeds, Fodder, Vegetable, Fruits and others crops

3.7 YIELD LOSSES DUE TO DISEASES, INSECTS, WEEDS AND OTHER ASSOCIATED FACTORS IN DIFFERENT CROPS RELATED WITH CLIMATIC CHANGE:

3.8 EXTENT OF INPUT USE AND CLIMATIC CHANGE:

3.9 EFFECT OF CLIMATIC CHANGE ON WATER AVAILABILITY IN DIFFERENT CROPS:

3.10 PRODUCTION OF LIVESTOCK PRODUCTS AND CLIMATIC CHANGE:

3.11 CPR AND CPR PRODUCTS:

3.12 INFRA-STRUCTURAL FACILITIES AVAILABLE: