Climate change in Kashmir valley: Is it initiating transformation of mountain agriculture?

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Abstract

Background/Objectives: Climate change has profound impacts on Himalayas, non availability of both data and models to estimate its impacts was a major problem. Therefore, apart from key climate variables, farmer's perceptions in mitigating the climate change formed the major source of information and objective of the current study.

Methods/Statistical analysis: The study is based on both primary and secondary data collected from 270 respondents during 2013-14 and 2014-15 spread over north, central and south Kashmir which was further classified into low to mid (L-M) and mid to high (M-H) altitudes. Group discussions/interactions in each selected village between the farmers, scientists and experts from concerned departments formed an important part of the survey. Averages and percentages were worked out to analyse the data.

Results: The rise in temperature was prominent in first and last quarters of the year. This trend seemed to help the temperate mountain farming scenario owing to extended summers favouring increased cropping intensity and adopting advanced technological mix in the study area. This was supported by the introduction of paddy cultivation in southern elevations of Kulgam district, being only a dream a few years before. The annual averages revealed a considerable decrease in the day^{-1} rainfall (-19.44%) and average number of rainy days month^{-1} (-24.10%) during period-I over period-II. The variation in the magnitude in different quarters, revealed steeper decrease in winter season (Oct-Dec and Jan-Mar) compared to summer season (Apr-Sep). Important and unambiguous perceptions about climate change perceived by the farmers were increased temperature, long summers, short winters, less snowfall and highly uncertain weather conditions, which triggered since late 1990s. These perceptions are in conformity with the inferences drawn from dynamics of temperature and rainfall during last three decades. (170 words)

Conclusion: The study concludes that climate change has initiated in this region which is supported by macro-evidences, demanding a serious effort for its mitigation through awareness programmes designed as per farmer's perceptions for better pay-off in long run.

Keywords: Climate Change, Adaptation, Temperate Region, Farmer Perceptions

1. Introduction

Climate change is now a phenomenon of global concern for its likely impacts on general human welfare. Warning signals indicates that its occurrence could even reverse the progress in human development achieved over the last decade [1], severity of which could add millions to the existing lot of poor. Even political instability was feared [2] due to possible mass migration leading to resource stresses. Its occurrence in terms of increase in temperature, widespread melting of glaciers and rising sea level is explicit [3, 4] and is causing irreversible imbalances in ecosystems globally. About 20 to 30 per cent of plant and animal species assessed [5] so far are likely to be at increased risk of extinction if increase in global average temperature exceeds 1.5 to 2.5°C. Similarly, there has been six times increase in the number of floods and four times increase in other weather-related disasters each year than in 1980s [6].

Climate change is also feared to widen or bring about economic disparity between the regions/nations, as the regions with their economies tied to natural resource base such as agriculture, forestry and water (developing economies) are disproportionately vulnerable to climate change [7]. Confirming this, the UNDP estimates reveal that over 90 per cent of those (people) affected by climate disasters annually from 2000 to 2004 globally was from the developing world [1]. Many other studies have also shown concern over the ultra-vulnerability of developing regions to climate change due to their overdependence on natural resources, especially on agriculture [8,9,10,11,12] and their lack of adaptive capacity [13, 14, 5].

Climate change is having remarkably profound impacts on the Himalayas as well [7], a glacial melt of which forms a source of perennial rivers such as the Indus, Ganges, and Brahmaputra, feeding hundreds of millions of people across South Asia [15]. Asian sub-continent, especially the Himalayan region including the Tibetan Plateau in south Asia, has quiet often been reported as the most sensitive region to climate change as the warming and its impact here will be more significant than the global average of 0.74°C over the last 100 years [16, 17, 18, 19]. The resultant deglaciation across the 2,400 kilometers of the Himalayan range is feared to aggravate the risk of glacial lake outburst floods (GLOFs) [20] and pose threats to more than 40 percent of the world's population [21]. Nevertheless, it is also claimed that an exact understanding of the future evolution of the climate in the Himalayan region is hindered by the fact that the available global/regional models do not perform adequately due to the extreme topography of the region [19].

1.1 Evidences of impact on agriculture in climate sensitive regions

The overdependence of developing economies on natural resources such as land (agriculture), forests and water renders them the most vulnerable to climate change. There are plenty of research evidences highlighting the potential losses to agricultural yields and incomes in these regions. A decreased agricultural productivity between 2.5 to 10 per cent by 2020 [14] and by 4.5 to 9 per cent in major crops within next three decades [22] are only the indicators. Similar other findings have projected a net revenue loss up to 25 percent depending upon the scenario [10, 11, 23, 1]. Referring particularly to the fate of developing economies, a food policy report by IFPRI cites that climate change will cause yield declines for the most important crops in developing countries [9].

In the most threatened south Asia, the net cereal production under the most conservative climate change projections till the end of 21st century will decline by at least 4 to 10 per cent [18]. Similarly, in the Indian context, the yield losses for rice and wheat (without accounting for carbon fertilization) is feared to vary between 32 to 40 per cent and 41 to 52 per cent, respectively, leading to a decline in agricultural production (AGDP) by 1.8 to 3.4 per cent during later half of this century under different climate change scenarios [24]. Pertinently, the yield losses in major crops in India will also be associated with the potential variability in annual monsoon rainfall - accounting for 70 per cent of total annual precipitation during crucial months of Kharif season [25]. It is worthy to note that this season alone accounts for India's half of food grain production and 65 per cent of its oilseed production [26, 27, 28]. India is already a home of 320 million (28%) people living below poverty line suffering from food insecurity and malnutrition. The consumption rate of this chunk of population is feared to fall further-estimated at about 18 per cent [29].

1.2 Advantaged temperate regions

Amid the extensive pessimistic views about the consequences of climate change, there are optimistic views as well, though limited to certain geographical regions. To a great relief, the impacts of climate change are understood not to be distributed evenly around the world. There are evidences that the tropical regions and low to mid-latitudes are more vulnerable [5, 18] than the temperate regions (with mono-cropping) which are expected to reap the benefits from climate change through increased length of growing period (LGP) [8, 9]. The strategies can be adjustment in sowing time, breeding of resilient plant varieties and improvement in agronomic practices [30]. The increasing shift towards fruit and vegetable farming in north-western mountainous state of Himachal Pradesh, especially on higher altitudes was attributed, partly to the climate change [31, 32].

Furthermore, agricultural output is also likely to be supported by the concentration of atmospheric carbon (CO_2) through the process of carbon fertilization [33, 34, 35, 36, 37] though it should be considered in the context of level of temperature, moisture, farm resources and nature of pests [38, 39]. To sum-up, the effect of climate change on different crops and locations can be either positive or negative, depending on its agro-climatic setting. With growing knowledge and new data, many of the unfolding impacts are coming up indicating that the aggregate impact of climate change is yet to be ascertained, as the losses somewhere will be offset by the gains elsewhere.

In this backdrop, monitoring the pace and pattern of agricultural performance amid the shadows of climate change assumes a great significance, as this sector has an unparallel role in providing food and livelihood security to the farming community in general and hill farmers in particular. In Himalayan region, agriculture sector forms a major occupation contributing about 45 per cent to the total regional income of the inhabitants [31]. Owing to the specificities and imperatives of hill agriculture, however, the shrinking crop land is a major concern for managing the food and livelihoods of most of the farmers [40, 41]. The bundle of their concern swells given the threat posed by climate change. In this backdrop, it is therefore worthwhile to focus our research on agricultural performance in different climate change scenarios, and devise the alternatives accordingly. Equally important, however, is to identify the directions of changes in climate in advance, and the awareness and preparedness of a farmer (the most vulnerable section of the society) to fight such changes. The present study attempts to estimates the trends/ directions of climate change (if any) and the perceptions of the farmers about this change with its potential impact on the Hill farms in temperate region of Jammu and Kashmir which is supposed to benefit from the climate change.

2. Material and Methods

The study uses both primary and secondary data. The secondary data on macroclimatic variables since 1980 was collected from Meteorological Section of the Division of Agronomy, SKUAST-K, Shalimar. The present data is based on the average of raw data (daily temperature/ rainfall), collected from five different locations, one each in district Anantnag, Baramulla, Kupwara, Budgam and Srinagar. To facilitate proper comparison, this data was classified into two sub-periods (from 1980 to 1995 and 1996 to 2011) each of 16 years. This classification was based on the elementary analysis of the data, which revealed that the changes in the patterns of temperature and rainfall were more prominent since mid 1990s. To have a view about the climate change on ground level, the farmers were sampled out from three districts namely, Kupwara, Budgam and Kulgam, from northern, central and southern Kashmir, respectively. For comprehensive study, three villages forming a cluster of village, one each from low to mid (L-M) and mid to high altitudes (M-H) were selected from each district .The regions were differentiated as per the variations in the climate and crop choices between low to mid (L-M) and mid to high altitudes (M-H). A final sample of 270 households, with 45 respondents from each cluster of villages was drawn and included for comprehensive study. Age of the respondent was considered as an important determinant for recording the observations on climate change. A preliminary survey of the study area was undertaken to ascertain the availability of the respondents in all age categories, required to have complete information/ perceptions for at least for the past 60 years

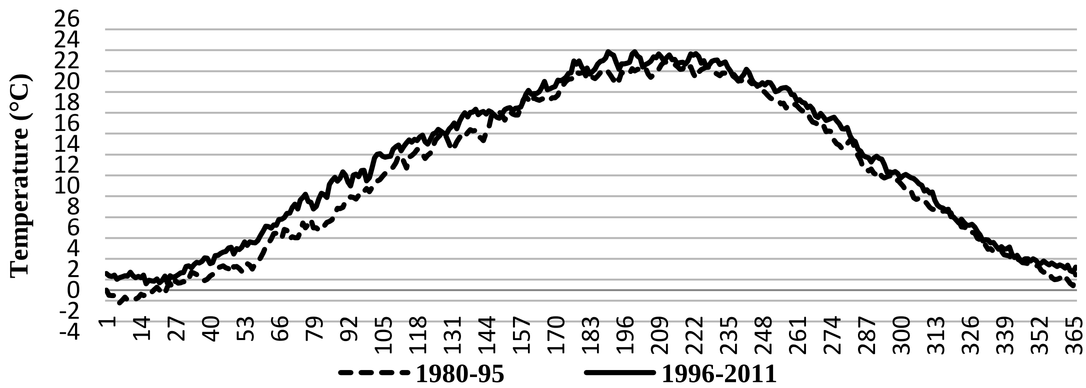
The selected farmers were later classified into four age groups viz. A) 80-100: B)60-80: C) 40-60: D) 20-40 years. This was done to facilitate the recording of information on the kind of adaptations taken up by the respondents from time to time in response to the climate change. For example, a 90 or a 100 year old respondent was asked to provide information about the farming system / climate that was in vogue about 60 or 80 years back when he was just 20 years of age and also about how did the people respond to that kind of a situation. The similar pattern of questioning was followed to have the required information collected from other respondents which helped us to develop a database for about 80 years, which formed the base to estimate the change in climate and the transformation/adaptations that took place in agriculture. Group discussions/interaction in each village between the farmers, scientists, experts from Agriculture, Horticulture, Animal Husbandry departments and village heads was an important part of the survey. Simple averages and percentages were worked out to analyse the data. The study was conducted during the year, 2013-14 and 2014-15, under a UGC sponsored project, Rajiv Gandhi Chair, in contemporary studies on Livelihood and Food security.

3. Result and Discussion

3.1 Dynamics of macroclimatic variables

Annual average temperature and rainfall are the two macroclimatic variables exclusively considered in this study. The trends revealed a marked shift in the valley's climate. The valley has witnessed not only a change in the magnitude of temperature and rainfall, but its distribution over the years as well. Such changes, however, are very crucial and indicative to the performance of agriculture which is highly climate sensitive. The forehand evidence of change in temperature over the period from 1980 to 2011 is depicted in Fig. 1. As is evident from the figure, the curve representing average daily temperature for the period 1996-2011 lies above the other curve throughout the year, reflecting an increase in the average daily temperatures. A close look at the figure shows that average temperature on the first day of year has increased from about 0°C to 2°C during the period. Though there is a clear gap between the curves through their entire length, it seems, however, to be little wider in first 100 days of the year.

Figure 1. Marked increase in daily average temperature round the year



Such tendency in temperature becomes clearer from the data presented in Table 1, which depicts the absolute and relative changes in the temperature (maximum, minimum and average) in each quarter over the period of time. A look at yearly average figures in last column reveals an increase of about 1.20°C (10.81%) in the average temperature during the period (from 11.06°C in 1980-95 to 12.06°C in 1996-2011).

Table 1. Variations in average temperature during 1996-2011 over 1980-85

Time period	Temperature (°C) during different quarters					
		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Average
Period-I	Max	7.40	21.68	26.25	13.54	17.23
(1980-95)	Min	-2.28	8.10	13.37	0.36	4.90
	Avg.	2.56	14.89	19.81	6.95	11.06
Period-II	Max	9.91	23.47	27.60	15.18	19.05
(1996-2011)	Min	-1.13	8.71	13.87	0.39	5.47
	Avg.	4.39	16.09	20.73	7.79	12.26
Change (%)	Max	34.04	8.25	5.14	12.10	10.57
	Min	(-)50.30	7.57	3.71	8.57	11.62
	Avg.	71.50	8.07	4.66	12.01	10.81

Quarterly breakup reveals that the maximum temperature during first quarter (January to March) has increased by about 34 per cent in the period-I over the period-II compared to merely 8.25, 5.14 and 12.10 per cent in successive quarters. The average minimum temperature during the same period has also increased by about 50 per cent in the first quarter compared to meagre increases in the successive quarters, respectively. Consequently, the overall average of maximum and minimum temperature during the first quarter reflected an increase of 71.50 per cent compared to 8.07, 4.66 and 12.01 per cent in second, third and fourth quarter, respectively.

This table supports the argument arised from Fig. 1 that rise in temperature has been more prominent in early part of the year. Assuming this to be true, such a trend seems to favour the temperate mountain farming scenario in Kashmir valley, as the rising temperatures in this quarter of the year means shortened winter and stretched summer, or say an increased length of growing period (LGP). Through technological mix, farmers can therefore avail the benefits of increased LGP by increasing their cropping intensity, raise their income and employment as well. Increased LGP is also expected to widen the crop choice at higher elevations with shorter LGP than in plains. This is in consonance with the introduction of paddy cultivation in southern elevations of Kulgam district, which was only a dream few years before (Table 5). The table also reveals that last quarter (October to December) of the year ranks second in terms of increased temperature. These two quarters with maximum temperature change extending from October to March, (winter season) a dormant period for crop growth in most parts of the valley. The increase in temperature during these quarters may, therefore, pave way for double cropping in cereals or more in case of vegetables in most parts of the valley.

The trend in average daily temperature during different quarters has been presented in Fig. 2, which reveals a gradual increase during the three recent decades. However, the increase seems to be little prominent in later half of the curves (1996/97 onwards). The results thus are in tune with the earlier findings, which reveal that the increase is more prominent in extreme end curves (Jan-Mar and Oct-Dec) compared to the middle quarter curves.

Similarly, the trends depicted by magnitude and distribution of rainfall during the period 1980-2011 were analysed, and are presented in Table 2 and Fig.3. The pattern of rainfall was examined through total rainfall recorded per day and the number of rainy days. The yearly averages reveals that there has been a considerable decrease in the daily average rainfall (-19.44%) and average number of rainy days per month (-24.10%) during period-I over period-II. The variation in the magnitude in both cases in different quarters, however, reflects that the decrease has been steeper in winter season (Oct-Dec and Jan-Mar) than in summer season (Apr-Sep). The trends in rainfall pattern over the period of time have more explicitly been shown in Fig. 3.

The Fig. 3 compares the average distribution of rainfall (as percentage of annual rainfall) over different months of the year in two different time periods. The figure reveals that March has remained a peak rainy month in both periods, though the months around it too witness more rainfall as compared remaining part of the year. There is moderate rainfall of 6 to 8 per cent during June to September, and least (around 4%) during October to December. A significant variation over the period could be seen in the average distribution of rainfall over the months. As is evident from the figure, the quantum of rainfall in peak month (March) has not only reduced from above 18 per cent during period-I to just below 14 per cent during period-II, but the peak also tends to move towards February. The obvious decline in rainfall during March to May can have serious implications on the performance of Kharif crops in valley, as these months coincide with the timing of sowing/transplanting of important crops/vegetables. Similarly, July, the pre-harvest season for Kharif crop, used to receive about 10 per cent of rainfall during the period-I and then would decline to about 6 per cent during August (the harvesting season); whereas during the period-II, the July level continues till ending August, and then declines to 6 per cent in September. What can be the impact of disturbances in the distribution and magnitude of rainfall during two crucial seasons on the crop performances is, however, to be ascertained.

Figure 2. Trends in temperature changes since 1980 (Quarterly averages)

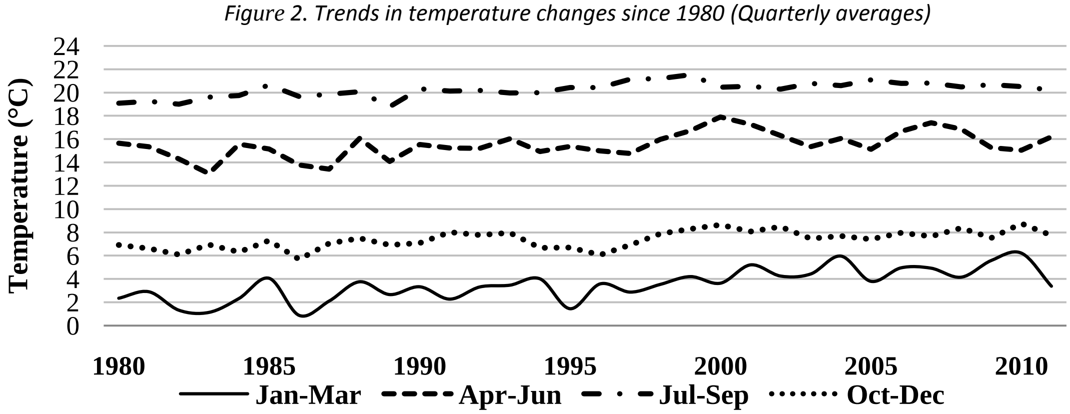


Figure 3. Changing distribution of rainfall (% of total) over months during the period

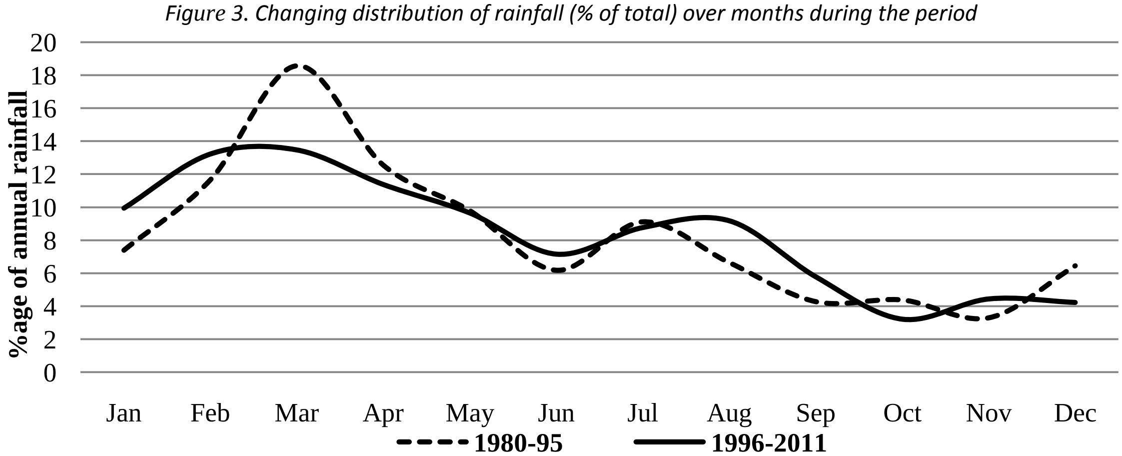


Table 2. Quarter-wise trends in rainfall

Quarter	**Period-I** (1980-95)	**Period-II** (1996-2011)	
	Magnitude	Magnitude	Variation*
Average rainfall (mm/day)			
Jan-Mar	4.76	3.67	-22.95
Apr-Jun	3.58	2.91	-18.96
Jul-Sep	2.48	2.38	-4.09
Oct-Dec	1.80	1.21	-32.36
Average	3.15	2.54	-19.44
Average number of rainy days (per month)			
Jan-Mar	20.58	15.19	-26.21
Apr-Jun	21.46	18.13	-15.53
Jul-Sep	20.73	17.21	-16.98
Oct-Dec	12.92	8.06	-37.58
Average	18.91	14.63	-24.10

*Variation in terms of per cent change in quantity over 1980-95

3.2 Farmer's perception on climate change

The variations in temperature and rainfall are bound to be associated with the transitions in other macro and microclimatic parameters having direct or indirect bearing on agriculture. People in general and farmers in particular will clearly perceive such changes in their routine life. The ensuing discussion focuses on such changes in climatic parameters as temperature, precipitation, snowfall, etc, over last two to three decades and their impacts on agriculture as perceived by farmers.

Being an elongated process, it was logical to target the older (senior) farmers of the communities to gather the observations about climate change vis-à-vis farming. So a brief background information regarding the resource possession of farmers, cropping pattern followed, employment and income derived and their experience in farming was collected from the selected farmers and presented in Table 3. It can be seen that the respondents were falling within the age group of 57 to 63 years with lifelong experience in farming, and were well versed with the long term transformations in farming. The table reveals that average holding size was too small (ranging from 0.41 ha in low to mid altitude of central Kashmir to 0.66 ha in mid to high altitudes of north Kashmir). Farming seems to be quiet diversified in each region as fruits, vegetables, fodder and oilseeds have competed substantially with cereals for land resource, though cereals were the dominant crop.

Also, livestock rearing was one of the significant economic activities of the respondents; as rearing around two animals would give them around 25 thousand rupees a year and much more than 100 days of employment. The cash income from agricultural land including horticulture figured more than one lakh rupees except in low to mid hill areas of central Kashmir where it was only about 70 thousand rupees, obviously because of just 3 per cent of gross cropped area under horticulture.

The collective but impressive figures for employment and income derived from agriculture and livestock together reflects farming as a dependable livelihood activity. Since farming is highly climate sensitive, this community will, therefore, notice the changes (if any) earlier than the non-farming community in the society.

In order to substantiate the level of knowledge about changing climate and its consequence on agriculture, a group discussion involving senior farmers and village heads was carried out. The conclusions drawn so far have been summarized in Table 4. There was a general consensus among farmers that significant changes could be observed in various climatic factors since past two decades. A routine warm and humid summer with pinching heat was, was a common perception of farmers. Also, the summer season seems to be stretched as early summer (March/April) and late summer (September/October) which used to be relatively cooler than they are now. Farmers also reported frequent, hailstorms, scattered, stormy and damaging rains during higher temperature. At times, such rains cause terrific rich soil loss on slopes and even washes away the juvenile plants. The quantitative and qualitative damage to fruits and crops are often irreversible.

Similarly, the winds in early summers were reported to cause great damage to the flowering fruit trees (e.g., almond, pears, apple, peach, etc.). Farmers from the uplands in central Kashmir related the decline in almond plantations (since 1980s) to this very phenomenon, because almonds came in flowering earlier than other fruit trees. Similarly, the farmers in plains reported 100 per cent damage to the strawberry crop due to hailstorm at harvesting stage for consecutive three years (2003-05). Farmers also reported uncertainties in today's weather. Sudden rainfall even during sunshine and a dip in temperature, and gentle but prolonged rainfall at times causing floods is amazing. The important point here is that such events would occur very rarely during their childhood, but have become a normal affair now and is feared anytime anywhere, the farmers said.

Winter has also borne a change, and is no more a winter as it used to be in the past. Winter and snowfall in Kashmir valley were synonymous. Farmers recall the days by pointing towards the hills which would remain snow-clad round the year. Late snowfall of 1-3 feet compared to early fall of 7-8 feet in mid to high altitudes 2-3 decades earlier are the clear signs of climate change. Good sunny days, occasional rains and less snowfall during early winters cause severe water scarcity in the kharif season. Sunshine and less snowfall has, however, increased the length of growing period (LGP), thereby allows the raising of second crop in a year. Farmers from plains in central Kashmir reported sowing of vegetables seeds/seedlings in early winters, which get enough time and temperature to germinate/stand before the snowfall, though to ensure a good germination most of them use low-cost low-lying poly-houses. Reports from mid to high altitudes of south Kashmir also reported extended hotter days enabling them to cultivate paddy since recent past, though not on large scale. However, farmers in general showed lot of concern for the least snowfall since past two decades as it affected agriculture, especially paddy yields to a greater extent.

Table 3. Background information of selected farmers

Particulars	**North**		**Central**		**South**	
	L-M	M-H	L-M	M-H	L-M	M-H
Total land (ha)	0.57	0.69	0.42	0.67	0.52	0.57
Average holding size (NSA)	0.55	0.66	0.41	0.64	0.51	0.50
Gross cropped area	0.81	0.95	0.64	1.00	0.68	0.65
Paddy	32.10	42.11	48.44	34.00	38.24	32.31
Maize	-	3.16	-	4.00	7.35	10.77
Vegetables	14.81	16.84	25.00	12.00	8.82	6.15
Fodder	11.11	14.74	10.94	8.00	8.82	4.62
Oilseed	13.58	4.21	12.50	18.00	4.41	4.62
Horticulture	28.40	18.95	3.13	24.00	32.35	41.54
Gross income ('000')	131.28	106.52	69.73	101.23	137.24	154.44
Employment (Man days)	166.20	150.06	158.87	142.06	162.94	164.97
Livestock Population	1.21	1.39	1.67	2.34	1.18	1.22
Gross income ('000')	24.60	23.57	22.90	24.87	28.96	23.12
Employment (Man days)	120	135	150	210	120	126
Total farming (gross) income	155.88	130.09	92.63	126.10	166.20	177.56
Total farming employment	286.20	285.06	308.87	352.06	282.94	290.97
Non –agricultural land	0.02	0.03	0.01	0.03	0.01	0.07
Sample size (households)	42	45	35	38	44	37
Average age of respondent (yr)	57.22	62.67	62.09	59.95	58.56	61.34

Note: (1) Area under crops is the percent of gross cropped area; (2) Income and employment is an approximation by farmers on recall basis; (3) L-M: low to mid altitudes and M-H: mid to high altitudes.

3.3 Farmers' adaption measures and transformation process

Rural economy on the whole is under transformation and so is the farm economy. To get a reasonable input from the farmers' experience, they were asked to recall the changes with possible causes and consequences, they have ever observed. Some surprising revelations came forth from most parts of the study area, especially from higher reaches, which have been summarized in Table 5. As shown, the broad changes were reported to have occurred in net cultivated area, cropping pattern, cropping intensity, gross farm income, employment derived, women involvement and capital formation. Results reveal that there has been a negative change in net cultivated area over the years. These changes, however, are commonly due to the legal division of ancestral land among legatees. Very few farmers have also reported an addition to their farm sizes either due to land purchases and/or land reclamation or a negation due to land sale and/or water logging.

Shift in cropping pattern has been the interesting change. A significant proportion of farmers have reported a shift from field crops to fruits and vegetables across the selected area, citing different reasons. About 46 percent of these have cited strictly the economic (commercial) reasons behind the shift, whereas about 17 per cent farmers have cited climatic factors as drivers of shift. Inadequate irrigation facilities due to land degradation or otherwise and disinterest among younger generations in farming, as reported by about 7 per cent of farmers, has also led to a shift towards fruit farming. Cropping intensity too, was reported to have changed positively as viewed by about 23 percent farmers, 17 percent of whom relate it exclusively to technological advances whereas 6 percent have cited climate change as a factor. Farmers have observed extended growing seasons allowing them to perform early sowing/harvesting and double cropping. Similarly, all the farmers have witnessed increased farm income due to yield increases since recent past. Introduction of fruit farming has enhanced product prices and increased income-employment opportunities, in both males and females, owing to some specific operations performed by women folk in fruit cultivation and its post harvest operations. There has also been a net addition to capital formation in terms of farm tools needed in orchards, like sprayers and water pumps. The mechanisation has decreased the net labour requirement in crop lands, e.g. paddy and maize, and might have led to capital formation through maintaining owned tractors and other improved tools/machinery.

Among all, the shifts in cropping pattern and increased cropping intensity are the two extraordinary transitions observed during the course of investigations which were attributed partly to the changing climate and partly to the economic reasons by the respondents. For example, a significant proportion of farmers throughout the study area have partially shifted from cereals to fruit farming (mainly apple), and the most frequently cited reason was low productivity in cereals as compared to fruits (Table 6). Low productivity in cereals (maize and rice) was primarily due to climatic factors like inadequate rainfall/drought and dry irrigation canals during summers due to less snowfall, and can as such be regarded as climate change induced shifts in farming. Climate induced transformations were reported from all locations at all altitudes, though with higher frequency in north and south Kashmir than in central Kashmir. Farmers from central Kashmir also reported some other types of transformations like 'paddy to vegetables' and 'almonds to other fruits'. Though shifting to vegetables is purely on economic considerations, shifting from almond to other fruits is, however, primarily climate induced. About 50 percent of such farmers attributed this trend to sudden surfacing of stormy winds in early spring since recent past which blow away the flowering of the plants leading to frequent crop failures, whereas about 28 percent farmers have cited an economic reason behind this.

Increased length of growing period (LGP) is yet another manifestation of climate change observed by farmers, which has prompted introducing new crops at some locations. For example in mid altitudes of central Kashmir farmers are now raising peas on their paddy fields as rabi crop, which 20 per cent farmers attribute to awareness and/or economic reasons, and 14 per cent to increased LGP. Similarly, in high altitudes of south Kashmir, farmers have been able to introduce orchards and paddy in their fields due to warmer climate. Farmers however, remarked that apple orchards and paddy are not that lively as in mid altitudes. Paddy fields even gave minimal yield as compared to the lower belts, but still better to have something than nothing, said 27 percent farmers in case of apple orchards and 8 percent in case of paddy growers. Their views are validated by the fact that many farmers have reported a preponed fruit development in apple (especially Pink-bud stage) by more than a weak many times during last decade (especially in the absence of rains).

Climate change has had its impact on livestock sector as well, as lack of moisture due to inadequate snowfall causes poor grass growth in pastures in uplands rendering the Gujjar communities helpless regarding feeding their livestock. They have now maintained small herd size, said 83 percent of farmers. The grazing areas in foothills have been protected by government agencies, which is another cause of maintaining low herd size. To sum up, climate change has casted its shadow on farming communities, though some have benefitted from it while others have lost. However, it is the gradual adaptation process which forces the farmers to switchover between options to remain in farming.

*Table 4. Farmers' observations on climate change and impacts on agriculture**

Parameter	Group observations
Summer	
Temperature	Significantly warmer and pinching; Too hot in early and late summers (March-April and Sep. - Oct.) during sunshine as compared to pleasant past summers; Weather uncertainty prevails. *Causes moisture stress and increased demand for irrigation.*
Rainfall	No particular pattern; Rains either heavy, fast and short-lived or gentle but prolonged one, unlike in the past. *Fast rains cause surface erosion, especially on slopes, whereas the prolonged one cause water logging/floods in plains.*
Humidity	Generally more humid causing sweating even in cloudy hours. *Encourages diseases/insect infestation.*
Winds	More frequent and intense than past. *Causes physical damage to crops/ plantations, and even washes away flowering in early summers (March-April) causing crop failure*.
Extreme events	Hailstorm: Usually scattered; Bit frequent than in past. *Causes huge crop losses*.
Winter	
Temperature	More sunny days than in past, however, cooler nights. *Increased on-farm working period; double cropping possible in mid to high altitudes; Cultivating new crops possible at many places; Frost injuries due to severe chill in few crops.*
Rainfall	Occasionally in early winters (Nov. – Dec.) and not assured in late winters (Feb-March) as compared to mostly late winter rains in past. *Lowers productivity of rain-fed rabi crops.*
Humidity	Mostly dry in plains, *causing poor germination of rabi crops*.
Winds	Less likely, as in past (almost unchanged).
Extreme events	Very occasional windstorm/hailstorm in early winters.
Snowfall	No particular pattern, usually in late winters; Generally less snowfall; Does not stick (melt) for long causing water stress in kharif crops. In past it used to cover plains till late winters. *Severe consequences on irrigated crops. Water level in rivers remains low and canals are dry during (mid to late) summers in case of little or no snow cover on hills.*
Additional comments	Farmers in general realize a change in climate and are pessimistic about the future agriculture though optimistic about technologies.
	A widely held view that winters have shortened whereas summers have protracted.
	Some new (flora and fauna) species could be seen while as some have vanished.

*Based on group discussions held with village heads, elderly farmers, field officers of development departments and scientists in each sampled village

Table 5. Observed transformation in agriculture and causes in selected areas over recent past

Particulars	**Trends**	**Causes**	**Response** (%)
Net cultivated area	Decreased overtime, with very few exceptions	Fragmentation land purchase/sale land reclamation water logging	98.34 18.26 05.81 01.66
Cropping pattern	A significant shift from crops to fruits and vegetables, and change in crop choice observed *(see details in Table 5)*	Economic reasons Climate change Other*	45.64 17.43 07.05
Cropping intensity	Increased	Technological advances Increased LGP(climate change)	16.59 06.22
Gross farm income	Increased	High prices and yield per unit of land/Orchards	100.00
Employment derived	Decreased in crop land; increased opportunities in horticulture	Mechanization Labour requirement more in horticulture.	92.16 95.43
Women involvement	Decreased in crop land, Increased in fruits and vegetables.	Do -	26.97 95.43
Capital formation	Increased	Mechanization, horticulture	100.00

* Others include 2nd generation issues, lack of irrigation and land degradation.

Table 6. Location specific agriculture related changes and causes

Location	**Farmers observations**	**Perceived causes**	**Response** (%)*
North			
L-M	Maize field converted to orchards	Low productivity due to less rainfall/economic	78.57 (42)
M-H	Maize fields converted into orchards	-do-	59.52 (45)
	Water level/flow in canals and Water reservoirs** decreasing	Low snowfall in up-hills	86.47 (45)
Central			
L-M	Partial shifting from paddy to vegetables	Economic, awareness	37.14 (35)
	Partial shifting from paddy to fruits	Water scarcity	22.86 (35)
	Peas follow paddy (in rabi) wherever feasible	Increased LGP	14.29 (35)
		Economic, awareness	20.00 (35)
M-H	Almonds replaced by walnut, apples, pear	Early winds affected almond yield	50.00 (28)
		Economic	28.57 (28)
	Maize replaced by apples, plum, peach, pear	Economic	15.79 (38)
	Paddy replaced by - do-	2nd generation problems, Economic	20.00 (35)
South			
L-M	Paddy replaced by apples	Water scarcity	52.27 (44)
		Economic, awareness	40.91 (44)
	Maize replaced by apples	Low productivity, economic	70.45 (44)
M-H	Orchards (apple) introduced on maize or reclaimed fields	Probably temperature increase and LGP	27.03 (37)
	Paddy introduced (very recently)	Do -	08.11 (37)
	Maize productivity declines or even fails (High altitudes)	Lack of moisture, Low rains and loss of fertile soil layer due to fast rains	77.78 (18)
	Low herd size maintained (High altitudes)	Protected grazing land, insufficient grasses on uphill pastures due to low moisture (snowfall)	83.33 (18)

*Figures in parentheses represent sub-sample. **Water reservoirs or storage tanks (Sar in local parlance) are an efficient and effective water harvesting practice in mid altitudes of Lolab valley. There are more than 50 sars in the area and each occupying 1 to 3 hectares of land each irrigating around 25 hectares of paddy fields. Sars are public property and introduced in the area during 1960s[?]. Occasional de-siltation is done by the government to ensure maximum water storage. However, farmers observe that due to low snowfall in upper reaches storage is minimal. Still these sars irrigate fields continuously for three months once the natural flow in canals exhausts. These sars have pushed the productivity levels in local paddy variety to about 7 t/ha (200 percent increase over adjacent areas).

4. Conclusion

Climate change is a phenomenon of worldwide concern for its negative consequences on general human welfare. It can disturb ecosystems, and cause mass destruction through devastating floods, droughts, storms and alike. It poses a potential threat to the survival of poor communities with inadequate knowledge and resources to fight it. Since the (biological growth of) living beings, especially plants, is highly climate sensitive, agricultural predominant economies are most threatened. Amid the climate change, therefore, the livelihood of millions of farmers in these economies is at stake and so is their food security. At the same time, however, agriculture is also expected to benefit from the climate change in certain agro-climatic regions (temperate regions) by creating favourable growing environment for many crops. Similarly, yield level of few crops may also increase by the process of carbon fertilization. This way, losses on one side are expected to be offset on other. Nevertheless, knowledge about the occurrence and directions of changes in climate can minimize the losses considerably through prompting early adaptation and mitigation strategies.

In this backdrop, this study is an attempt to have an insight in to the occurrence of climate change in the Kashmir valley through two approaches: 1) by examining the long term trends in macroclimatic variables, and 2) by practical/actual feelings and perceptions of people, especially farmers, who are perhaps the first to experience the changes. Through farmers' experience, the study also attempted to examine the major transformations in agricultural composition in relation to climate change. It was found that farmers are well advanced regarding the knowledge about climate change and its impacts on agriculture. A significant proportion of them related recent changes in agriculture directly to climate change, besides changing economic and technological scenarios.

The major changes they named were conversion of maize/paddy fields into orchards and introducing peas as rabi crop in many areas in low to mid altitudes, and introducing paddy and fruit crops in mid to high altitudes. Decreasing herd size by tribals in upper reaches was also attributed partly to the climate change which led to the poor growth of grasses in upland pastures. Some important and unambiguous perceptions about climate change among farmers are the increased temperature, long summer, short winter, less snowfall and highly uncertain weather, triggered since late 1990s. Long summers for them means extra farming season, which permits raising another short duration crop in low to mid altitudes; thereby increasing land efficiency, income per unit of land and employment.

Farmers' perceptions are in conformity with the inferences drawn from dynamics of temperature and rainfall during last three decades. An increase in average temperature of the year by 1.20°C (10.81%) during past fifteen years over the 1980s level has been observed. Moreover, confirming farmers' argument, the average temperature during winter has increased more rapidly than in summer, indicating a shortened winters or longer summers (growing period). Similarly, the trends in rainfall pattern did show a considerable decrease in the magnitude of yearly rainfall and the number of rainy days as well. Also, the distribution of rainfall over different months of the year too has changed, and the change has been more significant during March and August, the crucial months for Kharif crop. The possible impact of the disturbances during the crucial seasons on the crop performance needs to be ascertained. It can therefore be concluded that climate change has initiated in this region. It is not only the feel of public, but supported by macro-evidences as well. The climate sensitive agriculture and agriculturists are at stake and therefore, is a serious concern. The policy implications that came out of the study could therefore be;

- to validate the apprehensions of climate change and its projections based on the evidences from empirical research and reliable data-base on various climate related variables.
- to develop an adaptation process to offset the negative impacts of climate change through appropriate technological and agronomical packages and suitable crop mix. These packages need to be developed by conducting location specific research for improved crop planning to push growth without compromising on ecology and environment of the area and at the same time mitigating climate change.
- development of reliable technologies for weather forecasts to help farmers to overcome the diseconomies of weather uncertainties.
- the accelerated adaptation process may be ensured through capacity building programmes, imparted through designated institutions in the area , creating proper infrastructural facilities, required for the purpose and providing financial assistance to such institutions.

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