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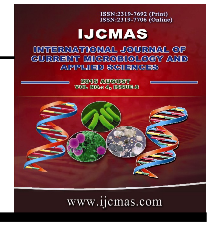

Original Research Article

Assessment of People's Perceptions and Adaptations to Climate Change and Variability in Mid-Hills of Himachal Pradesh, India

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Keywords

Households, Temperature, Rainfall, Extension services

A B S T R A C T

A study based on farm household survey was conducted in mid-hills of Himachal Pradesh to gain insights on people's perceptions and adaptations to climate change and variability. Results of the study indicated that 88.9 % of people perceived rise in temperature of the region while 88.4 % perceived a decreasing trend in amount of rainfall. People's perceptions for both maximum temperature and rainfall were in accordance with results of linear regression analysis of weather data of the period from 1995- 2011 collected from meteorological station in the region. In mid hills people have started responding to climate variability particularly to rising temperature and decreasing and uncertain rainfall by shifting to other crops, varieties, early planting and other cultural measures. Limited knowledge on adaptation measures, lack of access to early warning information, unreliability of seasonal forecast and high cost of adaptation were the main barriers to adaptations in the region. Further, the study identified education of the household head, farming experience, off farm income, access to credit and extension services as factors that enhance adaptive capacity to climate change in the area. Therefore, the study indicated a need for formulating policies to address these factors.

Introduction

Mountains are vital economic and ecological resources, high in biodiversity that provides people with much needed ecosystem services for sustaining livelihoods. They are the foundation for the natural processes of climate regulation and are a vital support for water quality, food security, and flood protection, amongst many others. However, climate change and variability is threatening the long term provision of ecosystem goods and services from the mountain ecosystems, thereby underlining the urgent need for people who exclusively rely on them for their livelihoods, particularly farmers, to come up with ways of adapting.

Adaptations to climate change are preceded by farmers noticing changes in climate and then identifying useful ones for practical use (Maddison, 2006). Agricultural adaptation options encompass a wide range of scales (local, regional, global) and actors (farmers, firms, government). Micro-level options, such as crop diversification, altering the timing of operations; market responses, such as income diversification and credit schemes and institutional changes help in adapting to changing climate. Government responses, such as removal of preserve subsidies and improvement in agricultural markets; and technological developments that involve development and promotion of new crop varieties and advances in water management techniques are encouraging people to adapt to such changes (Mendelsohn, 2001; Smit and Skinner, 2002; Kurukulasuriya and Rosenthal, 2003).

There is a growing understanding that climate variability and change has resulted in serious challenges to development in Western Himalayas because of the dependence of the region's economy on climate sensitive natural resources. In Himachal Pradesh for example, about 80 % of farmers rely on rain fed agricultural for their livelihoods, thereby predisposing themselves to the risks and vagaries of climate and other environmental change drivers. In addition, the mid hill region of Himachal Pradesh is fragile and environmentally sensitive because of predominance of development activities that ignores the imperatives of mountain specificities. The region is expected to experience changing patterns of rainfall, increased temperatures leading to elevated evaporation rates, and flooding. These will in turn lead to greater levels of land degradation, transmission of infectious disease, and loss of surface and ground water potential.

In north-western Himalayan region, a significant rise in maximum, minimum and mean annual air temperatures have been reported by various workers (Vidya *et al.*, 2015; Bhardwaj and Sharma, 2013; Liu and Chen, 2000). Similarly, precipitation has been reported to have decreased in over 68 per cent of India's area over the last century (Kumar *et al.* 2006). Climate and its variability have wreaked havoc on agricultural system in mid-hills of Himachal Pradesh especially due to uneven distribution of rains (Bhardwaj *et al.*, 2010). Moreover, the socio-economic and biophysical effects of climate related hazards, namely, flood, drought, erratic rainfall, pest and disease, hailstorms, and landslides have increased steadily in mid-hills of Himachal Pradesh in recent years. Even though they are exposed to these hazards and have a low adaptive capacity, farmers have survived and coped by making tactical responses (adaptations). However, these local adaptations have not been valued and documented so far, and hence, recognizing and documenting the local adaptation strategies is an important entry point to strengthen the resilience of local people to climate change. Analyzing local adaptation is, therefore, important to inform policy for future successful adaptation of the agricultural sector to the impact of climate change.

The present study focussed on assessment of adaptation strategies adopted by farmers at farm level and factors that drive the process of adaptation. The study captured the extent of farmers' awareness and perceptions to climate variability and change, different types of adaptation strategies and factors affecting adaptation.

Materials and Methods

Profile of the study area

The study area consisted of mid-hill (800-1600 m above mean sea level) regions falling in two districts namely Kullu and Solan of Himachal Pradesh in North Western Himalayas. The region has mild temperate climate with annual average precipitation amounting to 1150 mm. The soils vary from sandy loam to loam in texture. The area has a steep and rugged terrain which amplifies biophysical and socioeconomic vulnerability of the communities. Overall, the Mid Hill region occupies about 33% of the geographical area and 53% of the cultivated area of Himachal Pradesh State.

Research design and data collection

In order to collect primary data on farmers' perception of climate variability and change and types of adaptations they have adopted to these changes, a total of 275 farm households were considered at the selected sites of mid-hills in Solan and Kullu districts during the year 2014. Two administrative blocks were selected from each of the two districts, namely Kullu and Naggar in Kullu district and Solan and Kandaghat in Solan district (Fig. 1). Households falling within an altitudinal range of 800 to 1600m amsl were randomly selected from the four administrative blocks to constitute the sample and data collected from the household heads using a pretested questionnaire. Data were coded and analyzed by using SPSS 16. Descriptive statistics based on summary counts of the questionnaire structure were used to provide insights into farmers' perceptions of climate change and variability and adaptations adopted. Logit regression was performed to assess factors determining adaptations adopted by the farmers. The model specification was worked out as per the guidelines provided by Gujarati (2004). Its empirical specification that was estimated is presented below, albeit in reduced form.

$$Yi=\beta 0+\beta 1X1+\beta 2X2+\beta 3X3+\beta 4X4+\beta 5X5+\beta 6X6+\beta 7X7+\beta 8X8 \quad \text{.................................(1)}$$

Where Yi is a dichotomous dependent variable (farmer using any climate change adaptation technology or not, specified as yes=1, otherwise = 0). β0 is the Y- intercept whereas β1- β8 is a set of coefficients to be estimated. X1-X8 are explanatory variables hypothesised, based on theory and related empirical work, to influence farmers' adaptation to climate change. Description of explanatory variables and their expected sign is presented in table 1.

Further, equation 1 can be rewritten as;

$$\text{Logit } (p) = \log (p / 1- p) = \beta 0+\beta 1X1+\beta 2X2+\beta 3X3+\beta 4X4+\beta 5X5+\beta 6X6+\beta 7X7+\beta 8X8 \text{.......(2)}$$

Where p is probability that Y= 1 i.e. p = probability (Y= 1). In terms of probability, equation 2 translates into;

$$p=\exp(\beta 0+\beta 1X1+...\beta 6X6+\beta 7X7+\beta 8X8)/1+\exp(\beta 0+\beta 1X1+...\beta 6X6+\beta 7X7+\beta 8X8 \text{.......(3)}$$

In addition, secondary data on maximum and minimum temperature and rainfall from meteorological stations in the study area was collected from the department of environmental science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan to supplement the analysis on climate variability and change. The data was tested for linear trend using linear regression.

Results and Discussion

Temperature and precipitation changes

In mid-hills of Himachal Pradesh, 88.9 % of the people were of the view that temperature has increased in the region (Table 2). Interestingly, only 2.3% of the people perceived that there was no change in temperature whereas only 5.5% were of the view that temperature has become uncertain in the region. The statistical record of temperature data from the study area between 1995 and 2011 showed a significant ($p < 0.05$) increasing trend for maximum temperature with a coefficient of determination (R^2) of 0.46. However, the change was not significant for minimum temperature ($R^2 = 0.03$, $p > 0.05$) as shown in figure 3. The results are in consonance with the findings of other workers who have reported an increasing trend of temperature in the region (Vidya *et al.*, 2015; Bhardwaj and Sharma, 2013; Negi *et al.*, 2012).

In this region 88.4 % of people also perceived that rainfall has decreased (Table 2). In mid-hills of Himachal Pradesh, only 9.1% of the people were of the opinion that rainfall has become uncertain in the region. In addition, rainfall season was perceived as starting late by 69.8 % of the farmers and stopping early by 70 % of them while 26.5 % and 26.2 % respectively, were uncertain about the starting and stopping of the rain season. These perceptions allude to great variability in amount and distribution of rain in mid-hills of Himachal Pradesh. Indeed, a great number of farmers suggested a decreased and erratic rainfall due to recent incidents of failure of rain seasons in the region in recent years. The results are in line with findings of other workers who reported variability in amount and distribution of rainfall in mid-hills of Himachal Pradesh (Vidya *et al.*, 2015; Bhardwaj and Sharma, 2013 and Vishwa *et al.*, 2013). The famers' perceptions of precipitation are in accordance with rainfall statistical data from weather stations in the region whose linear regression analysis results indicated a significant ($p < 0.05$) decrease in amount of rainfall with time ($R^2 = 0.19$) as shown in figure 4. Similar studies several other parts of India indicate that most farmers perceive temperature to have became warmer and rainfall reduced over the past decade or two (Vedwan, 2006; Sahu and Mishwa, 2013; Bantilan *et al.*, 2013; Jodha *et al.*, 2012; Shashidahra and Reddy, 2012; Varadan and Kumar, 2014).

The main adaptation options adopted by farmers in the face of increased temperature in the region include change of crop variety (61.6%), planting early maturing crops (50%), change of planting dates (47.4%) and practicing mixed cropping (39.9%) as shown in table 3. Despite perceived increase in temperature and consequent dry condition, only 32.5% designated planting of drought resistant crops as an adaptation strategy. Other adaptation options that were not widely adopted by farmers in the region include irrigation (18.7%), reusing water (32.8%), use of water harvesting schemes (31%), changing from crops to livestock (4.9%) and reducing the number of livestock (5.6%).

Out of the total farmers who have adapted to changing climatic situation like rainfall, 52.4% have gone for early maturing crops, 52.4% build water harvesting schemes, 40% irrigate more, 47.4% change planting dates, 39.9% mixed cropping and 33% implement soil conservation techniques (Table 3). Farmers have also adopted growth of drought resistant crops (32.5%), mix crops and livestock (32.8%), change from crops to livestock (4.9%) and reduce number of livestock (5.6%).

Interestingly, adaptations induced by perceptions of changing rainfall patterns seem to differ from those induced by changing temperature. While adopting a new crop variety is the main strategy used to adapt to increasing temperature, building water-harvesting schemes is a popular adaptation strategy to those experiencing the effects of decreased precipitation. The high percentage of farmers who has adopted change of crops as an adaptation strategy against changes in temperature can be explained by pronounced rise of temperature in higher altitudes. Studies on climate change show that rise in temperature will be felt more in higher altitudes (IPCC, 2014; Liu and Chen, 2000). Consequently, rising temperature in mid-hills of Himachal Pradesh has gravely affected chilling requirements of apples growth thereby forcing farmers to replace apple with other crops like pomegranate, kiwi and vegetables which require relatively low temperatures. Similar findings by Vedwan (2006) while working in Himachal Pradesh indicated that some crops like maize, wheat and lentils are now growing at higher altitudes where they could not grow before.

Use of harvesting water structures as a popular adaptation strategy against reducing rainfall can be attributed to pronounced inter-seasonal and annual monsoon rainfall variability in the mid-hills of Himachal Pradesh. Population pressure and concomitant development activities have also been putting pressure on existing water sources as also reported by Singh and Kandari (2012) and Mall *et al.* (2006).

In the region of mid-hills of Himachal Pradesh, the level of adaptation to the changes in temperature and precipitation is low and farmers are susceptible to socio-economic and biophysical vulnerabilities of climate change. The low adoption level of adaptation strategies in the region maybe ascribed to high cost of adaptation, low socio-economic status of farmers, steep and hilly slopes, lack of space for water harvesting due to hilly terrain and lack of information on climate change impacts and adaptation options. Similar findings on barriers to adaptation to climate change have been reported in other studies (Nabilokolo *et al.,* 2012; Juana *et al.,* 2013; Fosu-Meusah *et al.,* 2010; Acquah-de and Onumah, 2011).

Barriers to adaptations

In mid-hills of Himachal Pradesh, high cost of adaptation was perceived by the people as one of the barriers to adaptation to climate change (Table 4). This perception was followed by limited knowledge on adaptation measures (93.8%), lack of early warning information (87.2%), unreliability of seasonal forecast (88 %), lack of access to technology (89.1 %), lack of labour (72%), steep terrain (79.9 %) and poor communication infrastructure (65%). Similarly, 34% of the respondents cited lack of access to water as barrier to adaptation. Lack of extension services (47.4%), improved crops/seeds (50%) and irrigation facilities are also perceived as main barriers to adaptation. The data further indicated that the barriers to adaptation in the region can be categorised as personal, institutional and technological. In the region it was observed that educated people adapted in a better way, compared to uneducated ones. Similarly, wealthy people were noticed to have more capability to adapt than those with less income. Moreover, institutional factors such as access to extension services and information source as well as access to institutional credit have a strong positive influence on adoption of adaptation practices. In the same vein, technological factors such as genetically improved varieties, efficient and reliable weather forecasting stations and cheap and affordable irrigation facilities have a high level of influence on adaptation adoption. Similar studies have found a strong positive relationship between adoption of adaptation practices and wealth, education, knowledge, access to extension services, information source and institutional credit, availability of genetically improved varieties, irrigation facilities and efficient and reliable weather forecasting services (Satishkumar *et al.*, 2013; Ravi *et al.*, 2011; Idrsi *et al.*, 2012; Deressa *et al.*, 2008; Onyeneke and Madukwe, 2010).

Factors determining farmers' adoption of adaptation strategies to climate change and variability

Results of logistic regression to test effects of farming experience of the household head, level of education of the household head, annual off-farm household income, annual on farm household income, household size, gender of the household head and household access to credit and extension services on farmers' adaptation to climate change and variability indicated that the eight predictor model provided a statistically significant improvement over the constant only model, X^2 (8, N = 275) = 286.772, p = 0.00. The Nagelkerke R^2 indicated that the model accounted for 88 % of the total variance. The correct prediction rate was about 95 %. The Wald tests showed that farming experience, education, off farm income and access to credit and extension services significantly predicted the farmers' adaptation status (Table 5). However, household size, on farm income and gender of the household head were not significant.

It is evident that there is a positive relationship between farmers' adaptation strategies to climate change and variability and level of education of household head, with the odds of farmer adapting increasing by a factor of 1.010, for every unit increase in level of education (coefficient = 0.237; odds ratio = 1.010). This implies that higher level of education leads to an increase in the probability of adopting new technologies. It increases one's ability to receive, decode, and understand information relevant to making innovative decisions. The role of education in enhancing adaptive capacity was also highlighted by Acquah-de and Onumah (2011) from their work on determinants of farmers' adaptation to climate change and variability in western Ghana.

The relationship between farmers' adoption of adaptation strategies to climate change and variability and off and on farm incomes was positive, implying a higher level of household adaptation with increased incomes. However, off farm income was significant, with the odds of farmer adapting increasing by a factor of 1.010 for every unit increase in off farm income (coefficient = 0.010; odds ratio = 1.010; $p < 0.05$) while on farm income was not significant, with the odds of farmer adapting increasing by a factor of 1.001 for every unit increase in on farm income (coefficient = 0.001; odds ratio = 1.001; $p > 0.05$). Off farm income is more reliable than on farm income since it is not affected by climate change and variability like the later. It is therefore more instrumental in influencing the households' wealth, thereby enhancing risk bearing capacity of the people. Thus, households with higher income and greater assets are in better position to adopt new farming technologies. Strong positive relationship between farmers' adaptation strategies to climate change and variability and off income was also noticed by Sofoluwe *et al.* (2011) and Lyimo *et al.* (2010).

Farming experience got a positive coefficient and an odds ratio of 36.593, implying that the odds of farmer adapting increases by a factor of 36.593 for every unit increase in farming experience. In other words, farmers' adaptation to climate change and variability is contingent upon years of farming and the adaptation increases with increase in farming experience. This is because experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices. Similar studies by Nhemachana and Hassan (2007) on farmers' adaptation strategies to climate change and variability in South Africa, Zambia and Zimbabwe indicated that experienced farmers have an increased likelihood of using portfolio diversification, changing planting dates and changing the amount of land under production.

Access to credit also got a positive coefficient of 2.748 and an odds ratio of 15.61. This means that there is a positive relationship between access to credit and farmers' adoption of adaptation strategies. Farmers' in the region who access credit are 15.61 times more likely to adapt than those who do not. This can be ascribed to the fact that any fixed investment requires the use of owned or borrowed capital. Similar studies by Fosu-Mensah *et al.* (2010) indicated that adoption of technology requires large initial investments, which generally get hampered by lack of borrowing capacity.

The coefficient of farmers' access to extension services was 2.861 which translated into an odds ratio of 17.475, implying a positive relation between farmers' access to extension services and adoption of adaptation strategies. Further, farmers accessing extension services are 17.475 times more likely to adapt compared to those who do not have access to such services. This is because access to extension services enhances the efficiency of adoption of new technologies by exposing farmers to new information and technical skills.

It also enhances access to climate information which may increase the likelihood of uptake of adaptation techniques by the farmers. These findings are corroborated by similar studies by Gbetibouo (2009) in South Africa which indicated that farmers with access to extension services are likely to perceive changes in climate because extension services provide information about climate and weather. Consequently, such farmers adopt appropriate adaptations to climate change and variability.

Moreover, results showed that there is a positive relationship between farmers' adoption of adaptation strategies and gender of household head with male headed households being 1.915 times more likely to adapt compared to female headed households (coefficient= 0.650; odds ratio= 1.915). However, the relationship was not significant ($P > 0.05$). This indicated that gender of the household head has an influence on farmers' decision to adopt adaptation practices Similar findings have been reported by Okonya *et al.* (2013). In most of the developing countries, women have lesser access to critical resources like land, cash and labour which undermines their ability to carry out labour-intensive agricultural innovations.

However, in some other cases female headed households could more likely take up climate change adaptation methods. This is possible in situations where men are based in towns and much of the agricultural work is done by the women. Thus, in this case, women have more farming experience and information on various management practices and how to change them, based on available information on climatic conditions and other factors such as markets and food needs of the households.

Household size registered a coefficient of -0.360 and an odds ratio of 0.698 implying that the odds of farmer adapting decreases by a factor of 0.698 for every unit increase in household size.

Table.1 Description of explanatory variables used to predict farmers' adaptation to climate change in mid-hills of Himachal Pradesh

Variable	Description	Expected sign
X_1	Education level of the household head (Years of schooling)	+
X_2	Household size (number of family members in household)	+ / -
X_3	Off farm income (annual income from nonfarm activities)	+
X_4	On farm income (annual income from farming activities)	+
X_5	Farming experience (household head number of years of farming)	+
X_6	Gender of household head (1= male; 0= female)	+
X_7	Access to credit (1= yes; 0= Otherwise)	+
X_8	Access to extension services (1= yes; Otherwise= 0)	+

Table.2 People's perception (%) on changes in weather quantity in mid-hills of Himachal Pradesh

People's perception		
	Temperature	Rainfall
Do not know	0.8	0.4
Decreasing	2.5	88.4
No change	2.3	1.8
Increasing	88.9	0.4
Uncertain	5.5	9.1

Table.3 People's perception (%) on adaptation options in response to changes in temperature and precipitation in mid-hills of Himachal Pradesh

Adaptation options	Perception of weather elements	
	Temperature	Precipitation
Change crop variety	61.6	32
Change planting dates	47.4	47.4
Mixed cropping	39.9	39.9
Plant drought resistant crops	32.5	32.5
Plant early maturing crops	50.4	50.4
Mix crops and livestock	32.8	32.8
Build water harvesting scheme	31	52.4
Practice reuse of water	32.8	32.8
Implement soil conservation techniques	-	33
Irrigate more	18.7	40
Change from crops to livestock	4.9	4.9
Reduce number of livestock	5.6	5.6

Table.4 People's perception (%) to barriers for adaptation in mid-hills of Himachal Pradesh

Adaptation Hindrance	% of respondents
Lack of access to early warning information	87.20
Unreliability of seasonal forecasts	88.00
Lack of labour	72.60
High cost of adaptation	95.60
Lack of access to improved crops/seeds	50.40
Ineffectiveness of indigenous methods	76.30
Lack of government subsidy on farm inputs	56.90
Limited knowledge on adaptation measures	93.80
Absence of government policy on climate change	82.10
Lack of extension services	47.40
Inaccess to water	34.30
Shortage of land	6.90
Insecure property rights	1.80
Inaccess to irrigation facilities	69.00
Inaccess to technology	89.1
Steep Terrain	79.90
Poor communication infrastructure e.g. roads	65.00

Table.5 Determinants of farmers' adaptation to climate change in mid-hills of Himachal Pradesh

Explanatory variable	Estimated coefficient	S.E of coefficient	Odds ratio	P value
Farming experience	3.600	0.741	36.583	0.000***
Education	0.237	0.102	1.268	0.020**
Annual off-farm income	0.010	0.004	1.010	0.17**
Annual on-farm income	0.001	0.003	1.001	0.827
Household size	-0.360	0.211	0.698	0.088
Gender	0.650	0.630	1.915	0.302
Credit access	2.748	0.795	15.610	0.001***
Extension access	2.861	0.822	17.475	0.000***
Constant	-17.912	3.253	0.000	0.000***

Note: ***, ** indicates significant at 1% and 5% level of significant, respectively

Figure.1 Map of the study area showing selected administrative blocks in mid-hills of Himachal Pradesh

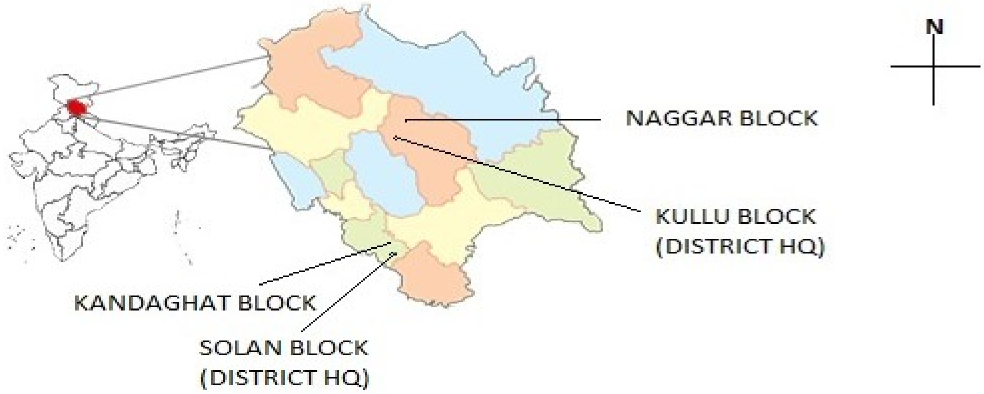


Figure.2 Trend of maximum temperature data for Solan and Kullu districts in mid-hills of Himachal Pradesh

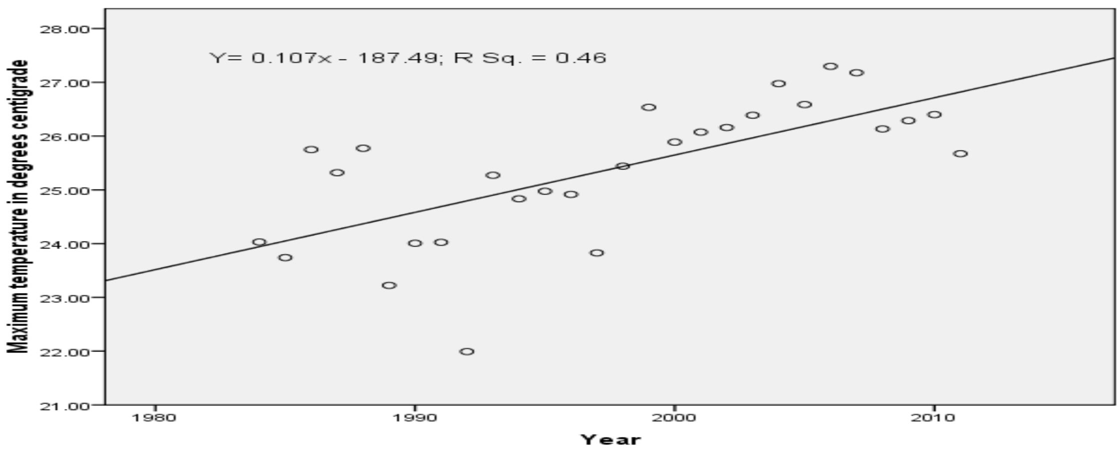


Figure.3 Trend of minimum temperature data for Solan and Kullu districts in mid-hills of Himachal Pradesh

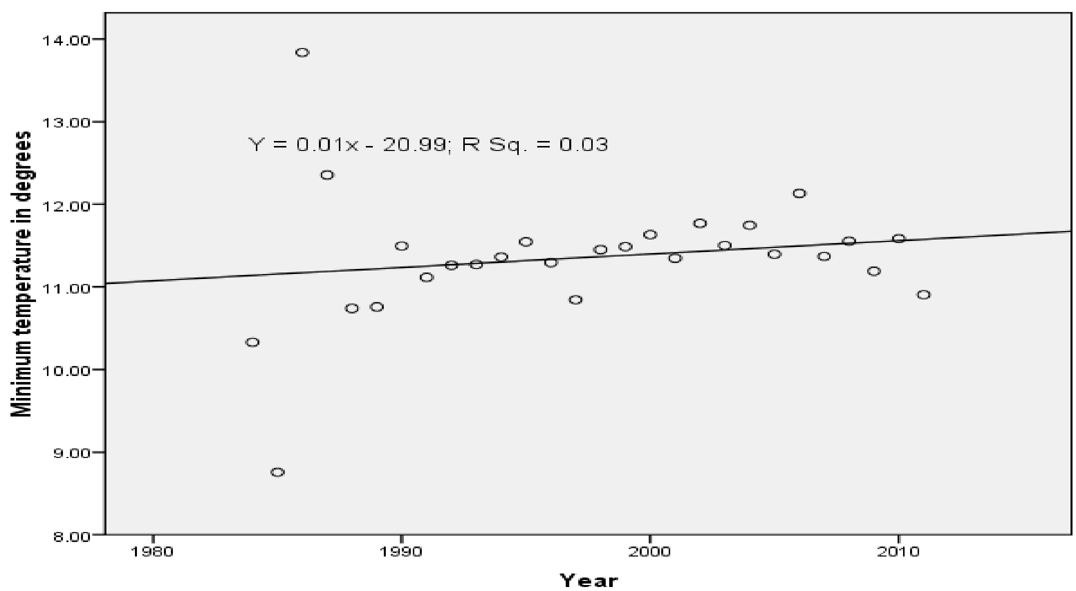
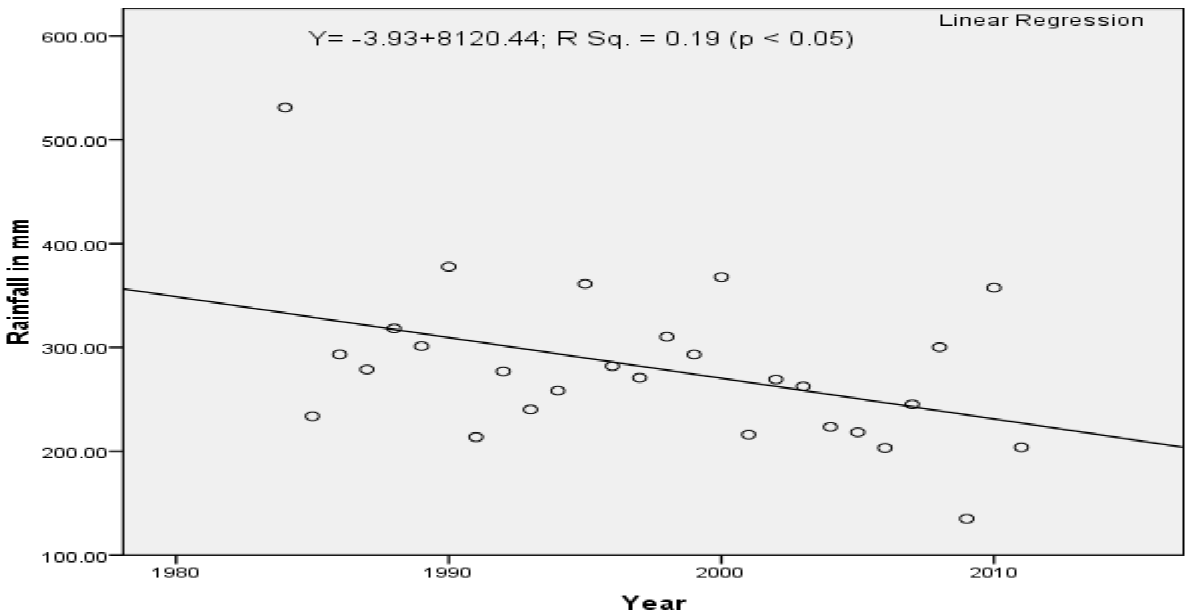


Figure.4 Rainfall distribution trend in mid-hills of Himachal Pradesh



This may be explained by the fact that households with many family members might have diverted part of their labour force to off-farm activities in an attempt to earn income to ease the consumption pressure imposed by a large family size. Similar findings have also been reported by Tizale (2007). However in other cases and as also reported by Tekelwold *et al.* (2006), household size acting as a proxy to labour availability and influence the adoption of a new technologies by reducing availability of the labour constraints.

Studies on farmers' perception regarding climate change indicated that the mid-hills of Himachal Pradesh have become warmer and drier due to less rainfall. In the region the rising temperature and reducing rainfall is affecting agriculture and is becoming a matter of serious concern. Changing climate situations have brought forth new problems and questions the solutions to which have been generated by combining farmers' ingenuity and their trial and error efforts like shifting to new crops and their varieties, changing planting dates and by adopting rain water harvesting technologies among others. However, factors such as education of the household head, farming experience, off farm income, access to credit and extension services influenced farmers' adaptive capacity and hence these need to be addressed in the region.

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