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Original Research Paper

Farmers' Response and Adaptation Strategies to Climate Change in Low-Hills of Himachal Pradesh in India

Nancy Loria† and S. K. Bhardwaj
Department of Environmental Sciences, Dr. Y S Parmar University of Horticulture and Forestry, Nauni Solan-173 230, India
†Corresponding author: Nancy Loria

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ABSTRACT

The study examined the farmers' perceptions regarding climate change, types of adaptation strategies, factors influencing adaptation choices and barriers to adaptation, in the low-hill zone of Himachal Pradesh in India. In low-hill zone, 202 farm households were randomly considered for the study. In the region, 62.4 % of the farm households were of the opinion that temperature has increased during the last 10 years, whereas, 57.9% of the respondents have perceived that there is a decrease in rainfall in low-hills of the state. In this part of the state, people have switched over to off farm jobs to meet their livelihood as perceived by 89.1 percent of the respondents. At farm level, farmers have adopted irrigation, crop diversification, change of sowing/planting dates and crop variety as the strategies to cope up with the changing situation. About 50% of the people have perceived that high cost of adaptation, limited knowledge of adaptation measures, lack of access to technology, labour availability and early weather warnings were the main barriers to climate change adaptation. In the region, adaptation to climate change was influenced by education level, household and farm size, access to irrigation and credit, and number of salaried persons in the household.

INTRODUCTION

Climate change is taking place at a time of increasing demand for food, fibre and fuel and has the potential to irreversibly damage the natural resource base on which agriculture depends. Climate change is likely to intensify high temperature and low precipitation. Its most dramatic impacts have been reported to impact smallholder and subsistence farmers (Mendelsohn & Dinar 2009). Rural areas being natural resource dependant are becoming vulnerable to climate change. Agriculture contributes to 13.7% of the Indian GDP and is the source of employment for 22% of the total population (FAO 2013). About 52% of the India's population is still dependant on agriculture for their livelihood and employment (Joshi et al. 2011). During the recent past, weather patterns all over the world are changing and the state of Himachal Pradesh is no exception to these changes. A significant rise in maximum, minimum temperature and decrease in precipitation has been reported by various workers (Vidya et al. 2015, Bhardwaj & Sharma 2013) in north-western Himalayan region. In the state, about 80 percent of the farmers rely on the rainfed agriculture for their livelihood. Since climatic factors serve as direct inputs to agriculture, any change in them is bound to have a significant impact on crop yields and production. Studies have shown a significant effect of change in climatic factors on the average crop yield (Dinar et al. 1998, Seo & Mendelsohn 2008 and Cline 2007). Therefore, variety of adaptation strategies to mitigate the negative effects of climate change effects and maintain their livelihoods are urgently needed (FAO 2009). Adaptation in the agriculture sector means addressing the negative impacts of climate change and making use of the opportunities that often come with a changing climate. The overall aim of adaptation in agriculture is to reduce farmers' vulnerability and improve their adaptive capacity. Different modern technologies have been developed and introduced at the farm level in order to achieve the Millennium Development Goals (Rosegrant et al. 2008). About 70 % of the population in developing countries like India live in rural areas, where agriculture is their main source of livelihood (IPCC 2007). Therefore, it is reasonable to expect that farmers in developing countries may be less able to adapt to climate change due to credit constraints or less access to adaptation technology. It is necessary that climate change adaptation is not separated from other priorities but is integrated into development planning, programmes and projects (World Bank 2008). Adaptation strategies to climate change will have to be based on sustainable agriculture practices. Such practices are better suited for local climatic variability.

In the low hill zone of Himachal Pradesh, farmers have perceived the changes in climatic parameters (Rana et al. 2013). Adaptation strategies are being implemented at local level in order to enhance their capacity to cope up with such changes. 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. Analysing local adaptation is, therefore, important, as this will be instrumental in finding solutions to address the future uncertainties of climate change in the region. Thus the present study intended to assess the farmers' perception to climate change and the adaptation strategies adopted by farmers at farm level in the low hills of Himachal Pradesh.

MATERIALS AND METHODS

Study area: The study was carried out in the low hills subtropical region of Himachal Pradesh, which occupies about 35% of the geographical area and about 40% of the cultivated area. This region consists of foothills and valley area up to 800 meters above mean sea level. The soils of low hills are shallow and light textured. The major crops of the region are rice, wheat, citrus, mango, litchi, guava, vegetables and barley. The average annual rainfall of this zone is about 130 cm.

Research design and data collection: To conduct the study in the low hills subtropical region of Himachal Pradesh, the two districts namely Kangra and Hamirpur were considered (Fig. 1). In each district two administrative blocks were selected. In Kangra district, Fatehpur and Rait and in Hamirpur, Hamirpur and Bhoranj blocks were selected. A total of 202 farmers was selected randomly from the four administrative blocks. Face to face interviews were conducted with individual farmers using a structured questionnaire, administered in the year 2014, in order to determine the farmers' perceptions to climate variability and change and the adaptation strategies adopted by farmers at farm level. Data were coded and analysed using Statistical Package for Social Sciences (SPSS) plus 21 version. Descriptive statistics based on summary counts of the questionnaire structure were used to provide insights into farmers' perceptions regarding climate change and adaptations adopted. Elements of the survey questionnaire collected information on major components: (1) Perceived changes in specific climatic events; (2) farmers' adaptation strategies to climate change; and (3) important hindrances to adaptation strategies that had been encountered by the farmer over the last 10 years.

Adaptation is a dichotomous dependent dummy-variable in the data. The dummy was determined by assigning a value of one for farmers who indicated that they had taken adaptive measures in response to the negative effects of climate change and a value of zero for farmers who indicated they did not engage in any adaptive measures at all in response to the negative effects of climate change. Logit regression was used to identify the socio-economic factors affecting the farmers' adoption of adaptive strategies, using the functional form of logit model expressed by Gujrati & Porter (2009) as:

$$Pi = 1/1 + e\text{-}(\beta^\circ + \beta_i X_i) \quad ...(1)$$

For simplicity equation (1) can be expressed as

$$Pi = 1/1 + e\text{-}z_i \quad ...(2)$$

Where,

P_i: Probability of adaptation of the i^{th} respondent

$e\text{-}z_i$: stands for the irrational number *e* raised to the power of Zi

Zi: is a function of N-explanatory variables and expressed as:

$$Zi = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \mu_i \quad ...(3)$$

Where,

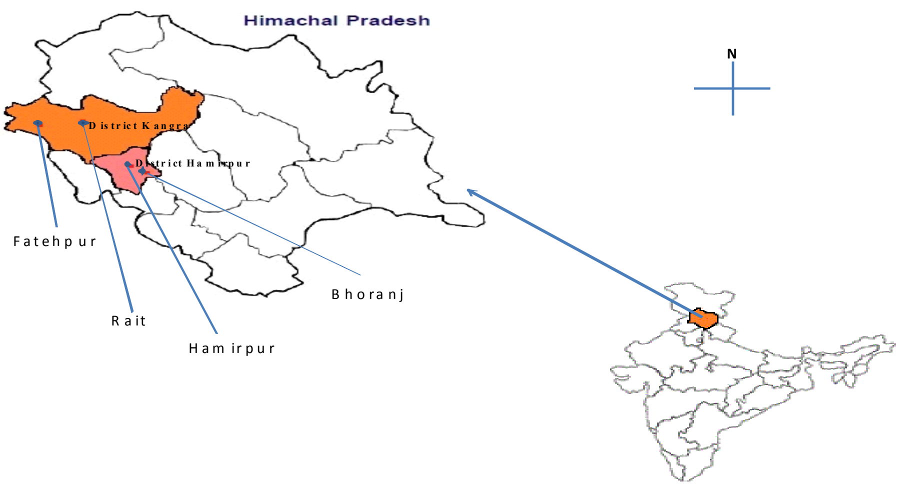

Fig. 1: Study districts showing selected administrative blocks in low-hills area of Himachal Pradesh.

β_0 = Constant term

$\mu_{i=}$ the error term, which has a standard logistic distribution

$\beta_1, \ldots, \beta_n$ = Regression co-efficient

$x_{1,\ldots,} x_n$ = Explanatory variables

The explanatory variables are hypothesized to affect the farmers' adoption decision of an adaptation measure. Based on the review of adoption and adaptation literatures, and past research findings, eight potential explanatory variables were considered in this study and examined for their effect on a farmer's adoption decision of an adaptation option to climate change and variability. Description of explanatory variables and their statistics are presented in Table 1.

A positive and significant variable is interpreted by considering its higher chance of being in that choice group relative to that of reference one. This means that changes in the variable will increase the probability of a farmer to adapt to climate change. A negative and significant sign will mean that the probability of a farmer adapting to climate change is lower than that of the reference point. An insignificant variable irrespective of sign will mean that changes in the variables have no effect on the probability of a farmer adapting to climate change.

RESULTS AND DISCUSSION

Farmers' perception in experiencing climatic events: In the low hills of Himachal Pradesh 62.4% of the respondents have perceived that during the last 10 years the temperature has increased (Table 2). The farmers perception in the region is in line with the findings of Bhutiyani et al. (2007), who, after analysing weather data reported increasing trend in maximum, minimum, mean and diurnal temperature range over the northwestern Himalayan region during the 20th century. In the region, 57.9% of the respondents were of the opinion that the number of rainfall days has decreased and on the other hand, 61.4% of the respondents felt an increase in the rainfall intensity in the region. The results are in agreement with the findings of Dash et al. (2007), Goswami et al. (2006), Lal (2003), Mirza (2002) who have also observed high intensity rains and decrease in total annual rainfall in many parts of Asian countries. In low-hills of Himachal Pradesh the duration of seasons has also been found to change during the last 10 years. In the region, 57.9% of respondents were of the opinion that summer season duration has increased, whereas the duration of winters has decreased as perceived by 49% of people. This finding agrees with the study of Rana et al. (2013), where more than 50% of the farmers experienced long summer and short winter season

Table 1: Description of explanatory variables used to predict farmers adaptation to climate change in low hills of Himachal Pradesh.

Explanatory variables	Mean	Standard deviation	Description
X_1 : Gender of the household head	0.75	0.44	Dummy takes the value one if male and zero otherwise
X_2 : Education level of the household head (Years of schooling)	10.06	3.60	Continuous
X_3 : Household size (Number of family members in household)	6.79	2.05	Continuous
X_4 : Farm size in kanals	23.25	12.36	Continuous
X_5 : Number of salaried persons in the household	2.29	0.86	Continuous
X_6 : Access to irrigation water	0.74	0.44	Dummy takes the value of one if there is access and zero otherwise
X_7 : Access to credit services	0.91	0.29	Dummy takes the value of one if there is access and zero otherwise
X_8 : Access to extension services	0.57	0.50	Dummy takes the value of one if there is access and zero otherwise
X_9 : Membership to CBO's and welfare organizations	0.18	0.38	Continuous

Table 2: Distribution of responses to perceived changes in specific climatic events.

Climatic event	Response %			
	Increased	No Change	Decreased	Do Not Know
Temperature	62.4	34.2	1.5	2
Rainfall	6.4	35.6	57.9	-
Rainfall intensity	61.4	28.2	10.4	-
Summer season duration	57.9	42.1	-	-
Winter season duration	-	38.1	49	12.9

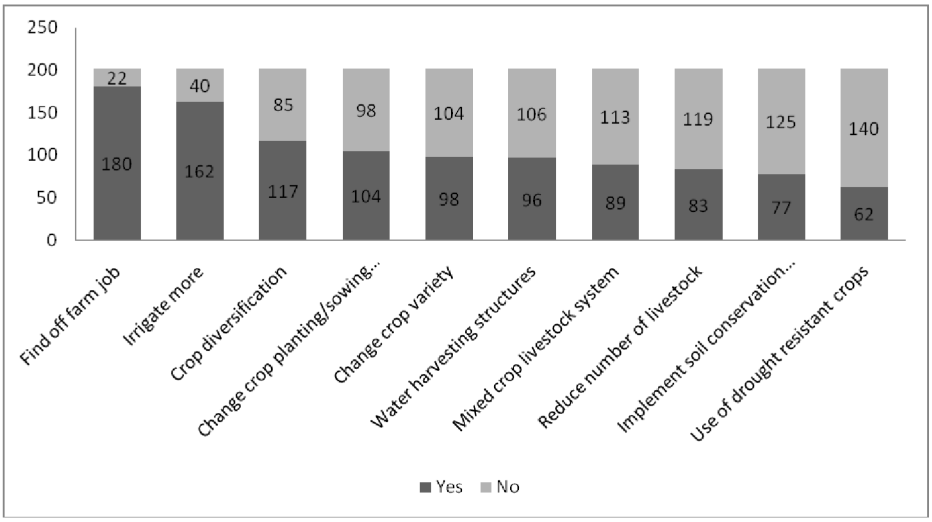

Fig. 2: Farmers' response to adaptation strategies.

in the low hill zone of Himachal Pradesh.

Farmers adaptation strategies to climate change and variability: The majority of the people (89.1%) in the low-hill zone of Himachal Pradesh were of the opinion that under changing climatic situation, off farm activities were being adopted by the people as an alternative to meet their livelihood (Fig. 2). The present shift to off farm activities may be ascribed to low output from the farms. Shift to non-farm activities was also reported by Morton (2007) as an important adaptation strategy in response to climate change. To cope up with the situation of climatic variability, 80.2% of the people considered irrigation as a suitable practice to adapt climate change. This was probably due to less and erratic rainfall in the region. Next to irrigation, crop diversification at the farm was perceived 57.9% respondents as an adaptation to climate change which was followed by change of crop sowing/planting dates (51.5%) and a variety (48.5%), building water harvesting structures (47.5%), mixed crop livestock system (44.1%), adoption of soil conservation practices (41.1%), reducing livestock (38.1%) and use of drought resistant crops (30.7%). Similar kind of adaptation strategies to climate change have also been advocated in other parts of the world (Rosegrant & Cline 2003, Eckhardt 2009, Asfaw & Lipper 2011, Varadan & Kumar 2014).

Barriers to adaptation: In the region, high cost of technologies was perceived (86.6% respondents) as the major barrier to adaptation (Fig. 3). Low income, farm output uncertainty, low access to market resources may be ascribed as the possible reason for not adopting new costly adaptive technologies. This response was followed by limited knowledge on adaptation measures (70.3%), absence of government policy on climate change (68.8%), lack of access to technology (66.3%), labour (64.9%) and early warning information (61.4%), unreliability of seasonal forecast (55%), ineffectiveness of indigenous methods (44.6%), lack of extension services (43.1%) and inability to access improved crop varieties/seeds (41.6%). Lower education level, less interest and backwardness of the area might have resulted in such barriers. The findings indicate a need for further detailed research into the implication of such barriers in order to move towards an improved adaptation and to identify most suitable mean to overcome these barriers. Other barriers to adaptation include government subsidy on farm inputs (38.6%), lack of access to irrigation facilities (26.2%), shortage of land (22.3%), lack of credit facilities (18.8%), insecure property rights (12.4%) and lack of access to water (8.9%). Lack of information on choice of adaptation options and financial resources, shortage of land, poor potential irrigation as well as labour constraints as the factors inhibiting adaptation to climate change effects, were also reported in various studies (Deressa et al. 2008, Amdu et al. 2013, Acquah & Frempong 2011, Kumar et al. 2013).

Determinants of farmers' adaptation: Out of the nine explanatory variables hypothesized to affect farmers' adaptation education level, household and farm size, access to irrigation water and credit and number of salaried persons' in the household were found to be the statistically significant factors (Table 3). The regression model resulted in a positive coefficient (+ 0.298) for education level, which implied that the probability of adaptation to climate change is greater for those who have higher educational attainment compared to less-educated or illiterate farmers. This is probably due to

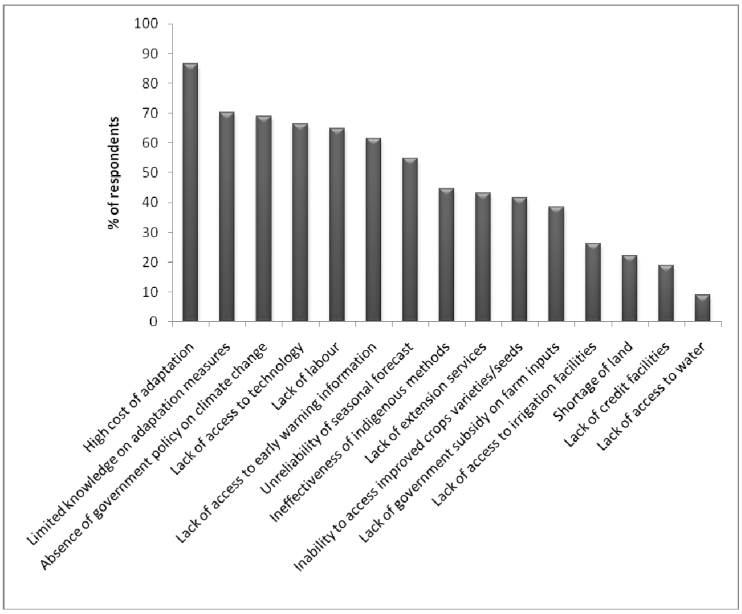

Fig. 3: Household level barriers to climate change adaptation strategies.

the reason that educated farmers have more knowledge, a greater ability to understand and respond to anticipated changes and to forecast future scenarios. Further, they have greater access to information and opportunities than others, which might encourage adaptation to climate change. Several studies also found that education positively and significantly affects the adoption of technology (Adesina & Baidu-Forson 1995, Alam 1995, Maddison 2007, Adeogun et al. 2008, Quayum & Ali 2012).

A positive and significant a coefficient of 1.059 was observed with respect to adaptation strategies based on family size. This may be due to the reason that large family size is generally utilized as labour in agricultural operations. The present perception of farmers is in line with Deressa et al. (2008, 2009), who have also advocated that large family size makes available more labour which can better facilitate the adoption of adaptive measures against climate change effects. Similar reasons for large household size were also reported by Mignouna et al. (2011), Tiamiyu et al. (2009). The present results are in contrary to Apata et al. (2009) who advocated that large household size reduces the probability of adaptation to climate change.

A positive and significant relationship with a coefficient of 0.072 between farm size and adaptation to climate change effects was observed, which indicated that the large farm size encourages the adaptation and discourages diversifying income. The results are in agreement with the findings of Gutu et al. (2012) and Nabikolo et al. (2012) who observed that farmers with large farm size do have a better level of adapting to climate change impacts.

Availability of credit, enhances the probability of a farmer to adaptation as indicated by the positive sign of the coefficient (+ 2.080) and was found to be statistically significant. The result implies the important role of increased institutional support in promoting the use of adaptation options to reduce the negative impact of climate change. Access to credit eases the financial constraints faced by the farmer. The farmer will be in a position to finance adaptation of new technologies such as improved crop variety seed and fertilizer. The positive relationship between level of adaptation and credit availability was also suggested by Gbetibouo (2009), Deressa et al. (2009), Fosu- Mensah et al. (2010), Yirga (2007), Pattanayak et al. (2003).

Highest positive coefficient (4.041) was observed in access to irrigation water (significant at 1% level) implying that access to irrigation have a strong influence in adapting to climate change in the low hill region of Himachal Pradesh. This is probably due to the reason that higher access to irrigation develop more interest of the farmers' in increasing farm productivity and more they are likely to adapt. The present results contradicted the study based on the argument that farmers who have access to irrigation water are more resilient to climate change and are less likely to take adaptation measures (Gbetibouo 2009).

A negative relationship was observed between the number of salaried persons in the household and the level of adoption (coefficient = -2.006) which indicated that salaried people have less interest to use new adaptation prac-

Table 3: Parameter estimates of the logistic regression model.

Variables	Coefficient	Robust standard error	p-value	Exp(B)
Constant	-9.981	3.274	0.002	0.000
Gender	22.400	0.002	0.993	5.349E9
Education years	0.298**	0.140	0.033	1.347
Household size	1.059*	0.412	0.010	2.883
Farm size	0.072**	0.036	0.047	1.075
Number of salaried persons' in the household	-2.006**	0.956	0.036	0.135
Access to irrigation water	4.041*	1.455	0.005	56.906
Access to credit services	2.080***	1.242	0.094	8.007
Access to extension services	-1.181	0.999	0.237	0.307
Membership to CBO's and welfare organizations	-1.565	1.094	0.152	0.209

*Significant at 1% level of significance ; **Significant at 5 % level of significance; ***Significant at 10 % level of significance

tices in the region. This tendency of employed people may ascribe to less return from farming activities in the region which is more or less of traditional type.

Gender, access to extension services and membership to CBO's and welfare organizations, were not statistically significant in the model. In certain ways these results are surprising in light of the theory surrounding their use as development instruments and as climate change adaptation strategies in general.

CONCLUSION

The present study indicated that farmers of the low hills of Himachal Pradesh have also perceived the impacts of climate change in consonance with the scientific studies being conducted by various workers. In the region, farmers have started identifying adaptation practices to combat climate change. Shift to off farm activities, irrigation, crop diversification, change of crop planting/sowing dates and use of suitable crop varieties were the widely used adaptation measures in the region. However, the high cost of adaptation, limited knowledge on adaptation measures, lack of access to technology, labour availability and early weather warnings were the main barriers to adaptation in the region. Adaptation to climate change is being positively influenced by education level, household and farm size, access to irrigation and credit availability.

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