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Farmers' perceptions and adaptation strategies to climate change in Punjab agriculture

SUNNY KUMAR[1] and BALJINDER KAUR SIDANA[2]

Punjab Agricultural University, Ludhiana, Punjab 141 004

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ABSTRACT

Climate change is affecting the performance of agriculture. Farmers are the hardest hit as they have to continuously respond to climate variations. In order to know the farmers' perceptions about climate change and the adaptation strategies the present study collected the primary data from 200 farmers from different agro-climatic zones of Punjab. Multinomial logit model was used to identify the factors affecting the adaptation of climate resilient technologies. The findings revealed that most of the farmers (77%) perceived decrease in seasonal rainfall while 53% of them perceived decrease in rainfall in *rabi* season. Majority of the farmers (83.5% in *kharif* and 93% in *rabi*) perceived that temperature is higher than before. The adaptation choices mostly practiced by sample farmers were laser levelling of the field and improvement in irrigation structures, which was adopted by 30 and 27% of total adoption respectively. The regression model discerned determinants affecting adaptation choices were, viz. age, education, farm size, perception on temperature and extension lectures. Adaptation to climate change is constrained by several factors such as lack of knowledge about technology, lack of finance and credit availability and inadequate trainings and demonstrations about the climate resilient technologies.

Key words: Adaptations choices, Climate, Change, Farmers, Perceptions

Climate variability and change is one of the major sources of risk for farmers in farming (De and Bodosa 2015, Nath and Deka 2010). To reduce climatic vulnerability, climatic adaptation is an effective measure at the farm level; it enables the rural households and communities to reduce adverse effects of climate change (IPCC 2001). Studies show that without adaptation strategies, climate change is generally detrimental to agriculture, but can partly be offset by various adaptation measures at farm level (Smith and Lenhart 1996, Smit and Skinner 2002, Kurukulasuriya and Rosenthal 2003, Hussain and Mudasser 2007, Deressa *et al.* 2009, Birthal *et al.* 2014). The degree to which the agricultural sector is affected by climate change depends on the adaptive capacity of the farming communities (Gbetibouo 2009). A better understanding of farmers' concerns and the manner in which they perceive climate change is crucial to design effective policies for supporting successful adaptation of the agricultural sector. Further, it is also important to have accurate knowledge about the type and extent of adaptation methods being taken up by the farmers. Hence, understanding how farmers perceive changes in climate and what factors shape their adaptive behavior is useful for adaptation research (Mertz *et al.* 2009, Weber 2010). The choice of adaptation methods by farmers depends on various social, economic and environmental factors (Deressa 2007, Bryan *et al.* 2013). This knowledge will ultimately enhance the credibility of policies and their strength to tackle the challenges being imposed by climate change on farmers (Deressa *et al.* 2009).

A great number of studies have been done on farm-level adaptation to climate change across different disciplines in various countries which explored farmers' adaptive behavior and its determinants (Deressa *et al.* 2009, Hassan and Nhemachena 2008, Thomas *et al.* 2007). Despite globally extensive research on adaptation in the agriculture sector to climate change, little work has been done so far in south Asia. Similarly in India, the scope of research linking climate change to agriculture is very restricted (TFCC 2010). In Punjab, very few studies have been conducted on factors affecting adaptation measures to climate change. The present study was designed to understand farmers' perceptions and adaptation strategies to climate change and their determinants.

MATERIALS AND METHODS

To investigate the farmers' perceptions regarding climate change and associated choices of adaptation methods, a selection of the study districts were based on

[1]Research Fellow (e mail: sunnykumar@pau.edu), [2]Assistant Economist (QM), Department of Economics and Sociology (e mail: baljindersidana@gmail.com)

different agro-climatic zones of Punjab namely semi-hilly, i.e. kandi zone, central zone and south-western zone. For the selection of the sample farmers' multi-stage sampling technique was followed. In the first stage two districts, viz. Gurdaspur and SBS Nagar from semi-hilly, Ludhiana from central and Faridkot from south-western zone were selected respectively. Further, one block from each district and two villages from each block was selected randomly. Blocks such as Doraha, Balachaur, Dhariwal and Faridkot were selected from Ludhiana, SBS Nagar, Gurdaspur and Faridkot districts respectively. From each village, 25 farmers were selected randomly making a total sample of 200 farmers. These farmers were interviewed personally about their cropping pattern, inputs used, output obtained and their current and past knowledge of climate change. They were enquired about the ways they have adopted on their farms to mitigate the effects of climate change.

Multinomial Logit model was applied to examine the factors influencing the choice of different adaptation measures applied by the farm households in the study area. It permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Madalla 1983, Wooldridge 2002).

Y_{ij} = 1, If the individual i chooses alternatives j (j=1, 2……, 8 in the present case) =0, otherwise

Further, let $\pi_{ij} = (Y_{ij} = 1)$

where P_r stands for probability. Therefore, $\pi_{i1}, \pi_{i2}, \pi_{i3}, \ldots \ldots \ldots \ldots \ldots \pi_{ij}$ represents the probability that individual i chooses alternative, 1,2, 3……, j, respectively that is alternatives of climate resilient technologies. If these are the only alternatives an individual faces, then, obviously,

$$\pi_{i1} + \pi_{i2} + \pi_{i3} + \ldots + \pi_{ij} = 1$$

The π_s are called as the response probabilities. The above model, if we determine any eight probabilities, the ninth one is determined automatically.

There are eight adaptation options including mix response, which are: change in variety (VAR), improvement in irrigation structure (IIR), laser leveling of the field (LL), zero till wheat (ZTW), direct seeded rice (DSR), change in variety+ laser leveling of the field (VARLL), change in variety + improvement in irrigation structure (VARIIR) and improvement in irrigation structure + laser leveling of the field (IIRLL) (Table 1).

To determine the probability of choosing a particular option, the set of regressors, comprising socio-economic, institutional and perceptions on climate change has been taken in the model (Table 2).

It is expected that there is positive relation between household characteristics such as age, education, farm size, family size, off-farm income and livestock ownership of household and adoption of climate resilient technologies. Likewise, institutional factors such as extension lectures, climate awareness and access to credit have same association with adoption. Information on climate change such as perception on increase in temperature and perception on decrease in rainfall is assumed to be positively related to the adaptation of climate resilient technologies.

Table 1 Percentage distribution of sample farmers across selected choices (n=200)

Adaptation strategies	VAR	IIR	LL	ZTW	DSR	Adoption of sample farmers (No.)	Per cent
VAR	*					13	6.50
IIR		*				19	9.50
LL			*			17	8.50
ZTW				*		17	8.50
DSR					*	15	7.50
VARLL	*		*			19	9.50
VARIIR	*	*				11	5.50
IIRLL		*	*			24	12.00
No adaptation						65	32.50
Total						200	100.00

Multinomial Logit model is given as under:

$$\pi_{ij} = \frac{e^{\alpha_j + \beta_j X_i}}{\sum_{j=18}^{8} e^{\alpha_j + \beta_j X_i}}$$

In this above mentioned equation, j represents the alternatives and is asked to most preferred alternative. In other words, adopter of one technology will attach a different weight to each explanatory variable than other technology adopter. As the model has more than one explanatory variable, X represents a vector of variables and β a vector of coefficients. No adaptation was chosen as base category in the model.

The coefficients of the model provide the information about the relationship (positive or negative) between independent variables and response variable. However, actual magnitude of change and probabilities are not represented by these coefficients. Therefore, to find out the actual magnitude of change, odd ratios or relative risk ratios have been calculated. Relative risk ratios give an idea of how strongly a given explanatory variable may be related with the dependent variable.

Garrett ranking technique was also used to evaluate the constraints or problems faced by the farmers in technology adoption. The orders of merit given by the respondents were converted into ranks by using the following formula:

$$\text{Percentage position} = \frac{100\,(R_{ij} - 0.5)}{N}$$

where, R_{ij}= Rank given for the i^{th} item by the j^{th} individual, N_j = Number of items ranked by j^{th} individual.

The percentage position of each rank thus obtained was converted into scores by referring to the table given by Garrett and Wood Worth (1971). Then for each factor the scores of individual sample farmers were added together and divided by the total respondents for whom scores were added. Thus, mean score for each problem was ranked by arranging them in the descending order.

Table 2 Description of the explanatory variables used in Multinomial logit model

Explanatory variables	
Age of the household (in years)	Continuous
Year of education (schooling years)	Continuous
Farm Size in hectares	Continuous
Extension Lectures (No.)	Continuous
Off farm income (₹)	Continuous
Climate awareness	Dummy takes the value 1 if the farmer has climate awareness; 0 otherwise
Access to credit	Dummy takes the value 1 if the farmer has access to credit; 0 otherwise
Livestock ownership	Dummy takes the value 1 if the farmer has livestock ownership; 0 otherwise
Family size (No.)	Continuous
Perception on temperature	Dummy takes the value 1 if the farmer has perception of increased temperature; 0 otherwise
Perception on rainfall	Dummy takes the value 1 if the farmer has perception of decreased rainfall; 0 otherwise

RESULTS AND DISCUSSION

Farmer level perceptions about climate change

The adoption and successful implementation of new technology by farmers in their ecosystems depend on their tendency to perceive and react favorably towards changes in climate. Hence, all of the respondents were asked a dichotomous ("yes/no" response) question about whether or not they had experienced changes to regional climate. Findings on farmer's perception regarding change in rainfall and temperature have been presented in Table 3.

Table 3 Distribution of respondents according to their perception about rainfall and temperature, Punjab

(Frequency)

Parameter	*Kharif*		*Rabi*	
	Number	Per cent	Number	Per cent
Rainfall				
Increasing	0	0.00	0	0.00
Decreasing	154	77.00	106	53.00
Stayed the same	41	20.50	64	32.00
Don't know	5	2.50	30	15.00
Temperature				
Increasing	171	85.50	186	93.00
Decreasing	0	0.00	0	0.00
Stayed the same	13	6.50	6	3.00
Don't know	16	8.00	8	4.00

Source: Authors' own calculation 2016-17.

The results revealed that majority of the farmers in this area experienced aberrations in the climate. Most of the farmers (77%) perceived decrease in seasonal rainfall while 53% of them perceived decrease in rainfall in *rabi* season. Further, the table revealed that the majority of the farmers (83.5% in *kharif* and 93% in *rabi*) had perceived that temperature was higher than before.

Almost all the farmers perceived that there is an increase in temperature in both summer and winter seasons. These perceptions are matching with the results of trend analysis (Fig 1, 2). According to Fig 1, the mean temperature in *kharif* and *rabi* season shows a significant increase over the period of 1986–2015, while Fig 2 depicts a decrease in *kharif* and *rabi* rainfall over the same period. The uncertainty of the climate makes farming a risky operation, limiting farmers' willingness to invest in it. The riskiness will probably increase with climate change.

Perception of farmers towards effect of climate change on paddy and wheat production

Paddy and wheat dominated the cropping pattern of the sample farmers, therefore only two crops paddy and wheat were studied in detail. The perceptions of farmers regarding effect of climate change on paddy and wheat production have been presented in Table 4. The data revealed that more than 50% of these respondents agreed with the statement that climate change has affected the date of transplantation of the paddy crop and led to delay in crop maturity. Slightly less than 65% agreed and only a few disagreed with the statement that climate change affects the number of irrigations.

The statement that climate change led to change in the time period of fertilizer application was agreed by 63.50% of the respondents and disagreed by 10.50% of the respondents. The quality of grain of paddy and wheat is affected because of climate change was perceived by 61.50% of the respondents and very few (1.50%) disagree with the statement. The whole effect of climate change is on the net returns from paddy and wheat as such, 79.50% agreed and near about one fifth of the respondents had neutral response towards the statement that weather variability affects the net returns of paddy and wheat crop.

Farm-level adaptation strategies and constraints

Farmers who observed variability in the climate were further asked to describe the farm level adaptation measures undertaken in response to weather variability. The various adaptation strategies being used by farmers in response to changing climate are presented in Table 5. The results revealed that laser levelling of the field and improvement in irrigation structure are the most important adaptations in response to climate variability, which was adopted by 30.00 and 27.00% of total sample farmers respectively.

To cope up with climate variability farmers have adopted a wide range of management practices such as change in variety (21.50%), direct seeded rice (7.50%) and zero till wheat (8.50%). In the nut shell, 67.50% of the

Table 4 Distribution of sample respondents according to perception towards effect of climate change on paddy and wheat production, Punjab (Multiple response) (n=200)

Statement	Agree		Neutral		Disagree	
	Number of response	Per cent	Number of response	Per cent	Number of response	Per cent
Whether climate variability has affected transplantation of paddy crop	107	53.50	74	37.00	19	9.50
Delaying crop maturity	113	56.50	80	40.00	7	3.50
Whether the number of irrigations in paddy crop has increased	127	63.50	67	33.50	6	3.00
Whether climate variability has resulted into increased use of fertilizer	127	63.50	52	26.00	21	10.50
Leading to new weeds infestation	65	32.50	101	50.50	34	17.00
More insect pest attack	123	61.50	66	33.00	11	5.50
More diseases in paddy and wheat crop	143	71.50	57	28.50	0	0.00
Quality of grain of paddy and wheat has affected	123	61.50	74	37.00	3	1.50
Whether the net returns of paddy and wheat crop has decreased	159	79.50	36	18.00	5	2.50

Source: Authors' own calculation 2016-17.

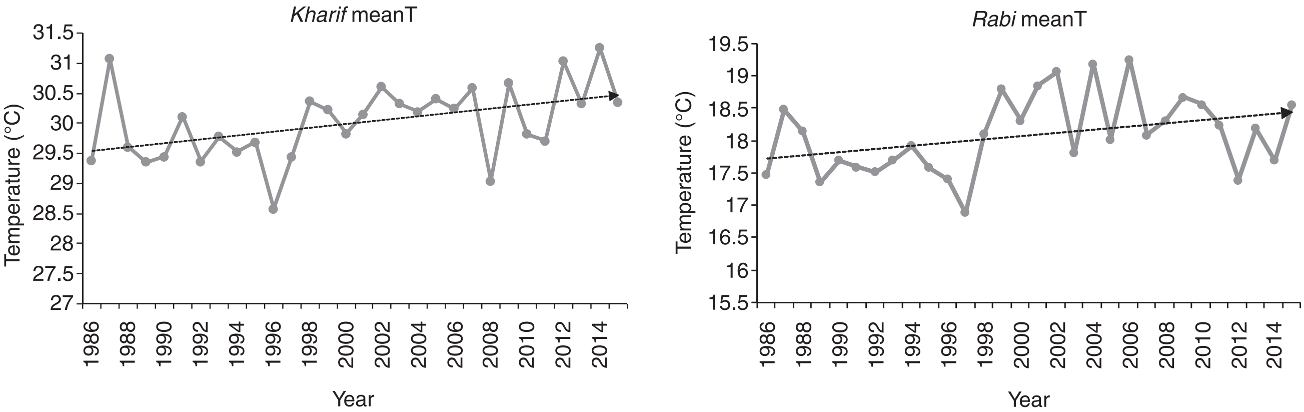

Fig 1 Trend in average temperature during *kharif* and *rabi* seasons in Punjab, 1986-2015.

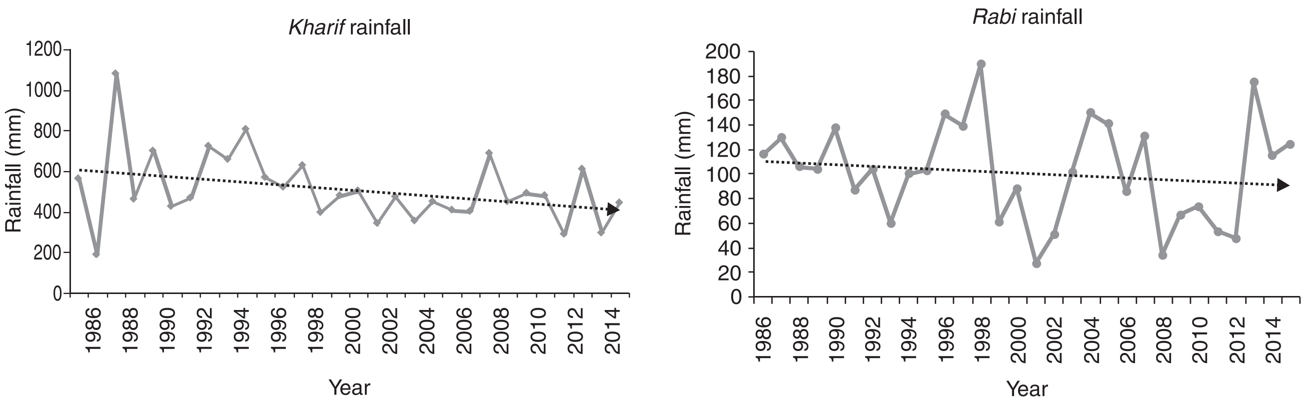

Fig 2 Trend in rainfall during *kharif* and *rabi* seasons in Punjab, 1986-2015.

farm households changed their farming and adopted climate resilient technologies. This stands as evidence supporting a conclusion that farmers of this area were taking actionable steps and changing practices to tackle various, known and unforeseen climatic and environmental changes. Dhaka *et al.* 2010 also found in their study that the majority of the farmers were using various adaptation strategies in response to weather variability. Hence, changing crop varieties, improvement in irrigation structure and laser leveling of the field were the main adaptation methods implemented by farm households.. Researchers from Africa reported that adaptation strategies are implemented on the basis of their farming experiences (Nyong *et al.* 2007, Bryan *et al*. 2009, Mertz *et al*. 2009, Deressa *et al.* 2011).

Table 5 Adoption of climate resilient technologies by sample respondents, 2016-17 (Multiple Response)

Adaptation	Respondents	
	Number	Per cent
Change in variety (VAR)	43	21.50
Improvement in irrigation structure (IIR)	54	27.00
Direct seeded rice (DSR)	15	7.50
Zero till wheat (ZTW)	17	8.50
Laser levelling of the field (LL)	60	30.00
No adaptation	65	32.50
Total sample size	200	

Source: Authors' own calculation 2016-17.

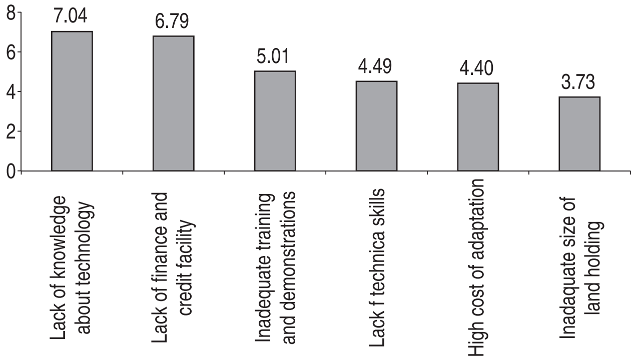

Fig 3 Constraints to climate change adaptation in the study area.

Moreover, the study identified a number of constraints faced by the farmers who perceived weather variability and intended to adapt their farming in the second stage of the adaptation process, but did not adapt their farming in the third stage of adaptation process. The Garrett ranking technique was used for ranking the constraints for non-adoption (Fig 3).The lack of knowledge about technology has been found to be the most important constraint (Garrett's score 7.04) followed by the lack of finance and credit availability. Lack of demonstrations, technical skill, extension lectures and small holding size were other major obstacles in the adoption. Strengthening of agricultural credit and extension for effective transfer of technologies has been found to be the important components to cope with climate variability. Additionally, the linkage between adaptation technologies and farmers' perceptions can be illustrated by the following (Fig 4) schematic framework of farmers' adaptation process in Punjab. For this purpose, Simelton *et al*. (2013)) and Ravi Shankar *et al*. (2013) suggest that scientists, policy-makers and others need to be more in tune with farmers' and extension workers' understandings of how weather is changing in order to improve adaptation policy formulation and implementation. Capacity building at local, national and regional levels is vital to enable developing countries like India to adapt to changing climate.

Factors affecting the adoption of climate resilient technologies

To quantify the impact of various explanatory factors affecting farmers' choice of adaptation methods, the study used multinomial logit regression models. The coefficients (Table 6 and 7) of regression tells us about the direction of effect of independent variables. The relative risk ratios presented in Table 6 and 7 shows the effects of individual explanatory variables on the adoption of various climate resilient technologies, others things being equal. In the following sub-sections, the study describes the impact of various explanatory variables on the probabilities of adopting different adaptation measures in response to variability in climate.

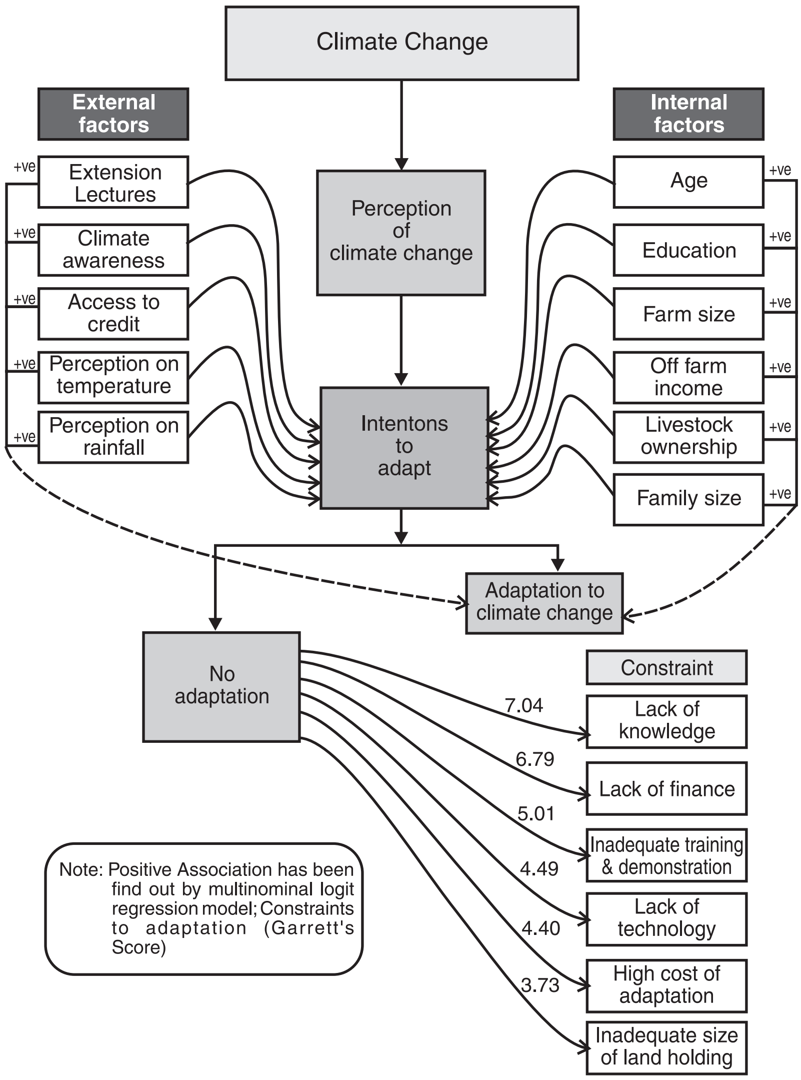

Fig 4 Schematic framework of farmers' adaptation process in Punjab.

Table 6 Parameter estimates and relative risk ratios of farm level adaptations by sample farmers, Punjab, 2016-17

Explanatory variables	VAR		IIR		LL		ZTW	
	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios
Age	0.16**	1.17	0.07	1.07	0.08	1.09	0.13*	1.14
Education	0.28	1.32	0.75***	2.11	0.53*	1.70	0.64**	1.89
Farm size	0.19**	1.21	0.09	1.10	0.004	1.00	0.20**	1.22
Extension lectures	0.78**	2.17	1.00***	2.72	1.11***	3.04	1.05***	2.87
Off farm income	0.00002	1.00	0.00003***	1.00	0.00002*	1.00	0.00002**	1.00
Climate awareness	2.12	8.34	1.06	2.89	1.31	3.72	1.41	4.09
Access to credit	2.62**	13.75	0.87	2.38	1.24	3.47	2.02*	7.54
Livestock ownership	0.21	1.23	0.58	1.79	1.11	3.03	0.46	1.58
Family size	-0.04	0.96	-0.10	0.91	0.44*	1.55	-0.30	0.74
Perception on temperature	2.09	8.12	2.08	8.01	1.33	3.77	2.36	10.59
Perception on rainfall	0.90	2.45	0.82*	2.28	1.94	6.95	1.26	3.54
Constant	-19.58***	3.12e-09	-19.01***	5.54e-09	-20.48***	1.27e-09	-22.05***	2.66e-09
Log likelihood	-247.13							
Pseudo R^2	0.39							
LR chi-square	312.73							
Prob>chi-square	0.00							

Table 7 Parameter estimates and relative risk ratios of farm level adaptations by sample farmers, Punjab, 2016-17

Explanatory variables	DSR		VARLL		VARIIR		IIRLL	
	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios	Coefficients	Relative risk ratios
Age	0.07	1.07	0.28***	1.32	0.20***	1.22	0.10	1.11
Education	0.57*	1.76	0.71***	2.04	0.85***	2.33	0.58**	1.79
Farm size	0.20***	1.22	0.19*	1.21	0.18***	1.20	0.14	1.15
Extension lectures	1.13***	3.09	0.75*	2.11	1.12***	3.07	0.69*	2.00
Off farm income	0.00003***	1.00	0.00002*	1.00	0.00002*	1.00	0.00003**	1.00
Climate awareness	1.63	5.11	1.60	4.94	-0.68	0.51	1.71	5.55
Access to credit	2.76***	15.79	1.35	3.87	1.42	4.16	1.40***	3.04
Livestock ownership	1.82	6.15	-0.58	0.56	1.04	2.84	0.28	1.33
Family size	-0.05	0.95	0.05	1.05	-0.50	0.61	0.64	1.89
Perception on temperature	2.63*	13.87	0.88	2.42	1.40	4.04	2.73*	15.26
Perception on rainfall	0.89	2.42	2.01	7.48	0.92	2.51	-0.44	0.65
Constant	-23.21***	8.29e-09	-28.19***	0.00	-23.85***	4.40e-09	-23.45**	6.57e-09

Note: Base category= no adoption; number of observations (n=200), ***, ** and * denote significance at 1, 5 and 10 per cent levels, respectively. VAR: Change in variety, IIR: Improvement in irrigation structure, LL: Laser leveller, ZTW: Zero tillage wheat, DSR: Direct seeded rice, VARLL: Change in variety+ Laser leveller, VARIIR: Change in variety+ Improvement in irrigation structure, IIRLL: Improvement in irrigation structure + Laser leveller.

Age

The more experienced farmers were more likely to adapt to climate resilient technologies, because experienced farmers have better risk bearing ability, knowledge and information on climate. The coefficients of the age of household has been found positively significant among change in variety (VAR), zero till wheat (ZTW) (Table 6 and 7) and change in variety and laser leveller (VARLL). The relative risk ratio is computed by exponentiating the coefficients for each explanatory variable. The estimated relative risk ratio for age of respondents was 1.17 which means if the age of a respondent is increased by one year, the adoption of new varieties will increase by 1.17 times. Similarly, the increase in the adoption of ZTW, VARLL and VARIIR will increase 1.14, 1.32 and 1.22 times respectively with age. The results are in consonance with the findings of Maddison (2007) and Nhemachena and Hassan (2007). It could be concluded that older farmers with more farming experience are likely to be more aware of past climate events and better judge how to adapt their farming to extreme weather events.

Education of head of household

Educated farmers have more knowledge, a greater ability to understand and respond to anticipated changes, are better able to forecast future scenarios and, overall, have greater access to information and opportunities than others, which might encourage adaptation to climate change. The highly significant coefficient of education of the household head showed that the probability of adapting to changes in climate increases with an increase in the years of schooling (Table 6 and 7). The coefficient of education has been found positive across all adaptation technologies, indicating a positive relationship between education and adaptation to climate change. The results of relative risk ratios implies that a unit increase in the number of years of schooling would result in 1.32 times increase in the adoption of new varieties; 2.11 times increase in the adoption of improvement in irrigation structure, 1.70 times increase in laser leveling of the field, 1.89 times increase in adoption of zero till wheat, 1.76 times increase in adoption of direct seeded rice and 2.04, 2.33 and 1.79 times increase in mix adaptations as well. Similar results have been found (Bryan *et al.* 2013, Deressa *et al.* 2009, Maddison 2007) between education of household head and adaptation to climate change.

Farm size

Farmers with large farm size are likely to have more capacity to try out and invest in climate risk coping strategies. The farm size is positively associated with change in variety because they will be more willing to use part of their land to cultivate new or untried varieties. Larger farm size leads to use of other technologies as well like zero till wheat, direct seeded rice and mix adaptations (Table 6 and 7). Findings of the studies indicate that farm size has both positive and negative effects on adoption, showing that effect of farm size on technology adoption is inconclusive (Bradshaw *et al.* 2004). The various studies (Langyintuo and Mungoma 2008, Vijayasarthi and Ashok 2015) showed that household with smaller farm size may be more willing to adapt technologies that require intensive management.

Extension lectures

Extension services are key sources of information on new agricultural technologies. The coefficients of extension lectures have been found positive across all adaptation technologies, indicating a positive relationship between extension lectures and adaptation to climate change. The estimated relative risk ratio for extension lectures attended by the respondent about DSR technology was 3.09 which means that one per cent increase in lectures attended will lead to increase in adoption of DSR technology by 3.09 times. Similarly, increase in the number of extension lecture would result in 2.11 to 3.07 times increase the adoption of all the adaptation technologies. Ayanwuyi *et al.* (2010) reported that access to extension facilities of households had positive and significant relationship with adaptation of climate change.

Off farm income

Most of the farmers are credit constrained and hence, off-farm income and the wealth status of household are important in financing adaptation through technologies. The implication of this result is that the technology is less accessible to resource-poor farmers because of financial and resource constraints that hinder their ability to adopt the technology. This suggests that more efforts are needed to assist resource-poor farmers so as to increase the probability of climate adaptation. The off farm income of sample households showed positive and significant impact on almost all the adaptation technologies but the magnitude is not so high (Table 6 and 7). Kim *et al.* (2012) found that household income positively and significantly influences the adoption of adaptation to climate change while Gebitobo (2009) explained that wealthier farmers are more interested to adapt by changing planting practices, using irrigation, and altering the amount of land farmed. Further, Nhemachena and Hassan (2007) indicate that per capita income has a positive influence on farmers' decisions to take-up adaptation measures.

Climate awareness

Farmer awareness of changes in climate attributes is important in the adaptation decision making process (Maddison 2007). The analysis revealed that the farmers who have information on climate variability had a significant and positive impact on the almost all the adaptation technologies, although it was not significant.

Access to credit

Credit availability helps farmers to strengthen their financial position and thus they can easily go for new adaptation. The sample farmers reported that access to credit increases the monetary resources of affected farmers and help to meet transaction costs associated with the adaptation options (Okezie *et al* 2011). The coefficients of access to credit have revealed positive and significant impact on the likelihood of using DSR technology (Table 6 and 7). The relative risk ratio of DSR technology showed that a 1% increase in the access to credit would increase the adoption of DSR technology by 15.79 times. The above result implies the important role of institutional support in promoting the use of adaptation options to reduce the negative impact of climate variability. Similar findings have been given by Charles and Rashid (2007) and Apata *et al.* (2009) and Ayanwuyi *et al.* (2010) that access to credit facilities had positive and significant relationship with perception of climate change and adaptation options.

Livestock ownership

The income from the livestock is more fixed and also helps during drought or flood period when crop production may fail. The ownership of livestock is also positively related to the adaptation of climate change (Sofoluwe *et al.* 2011). It could be observed from the analysis that livestock ownership was positive among adoption of all the adaptation strategies, although it was non-significant (Table 6 and 7).

Family size

Large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks. Family size and laser leveling of the field come out to be positively associated with each other, possibly reflecting labour supply (Table 6 and 7). The estimated relative risk ratio for family size of household of respondents for laser leveling of the field was 1.55 which means if the family member of respondents increase by one unit, the adoption of laser leveller will increase by 1.55 times. Findings of the studies of Croppenstedt *et al.* (2003) and Deressa *et al.* (2009) also support our findings of a positive relationship between household size and adoption of agricultural technology or adaptation to climate change.

Perception on temperature

The results indicated that farmers' perception to climate variability is one of the explanatory variables that affect the choice of farmers' adaptation measures. Perception of households' to the increasing temperature was found to be positively and significantly associated with DSR and IIRLL. The relative risk ratios revealed that farmers' who perceived increase in temperature are more likely to increase in adoption of DSR and IIRLL by 13.87 and 15.26 times respectively.

Perception on rainfall

The analysis has shown that the perception of households' to the decreased rainfall has led to significantly increase of IIR, i.e improvement in irrigation structure.

Conclusion

The present study is based on both qualitative and quantitative information about the farmer's perceptions regarding climate change and associated choice of adaptation practices and to identify the main factors affecting their choice of adaptation. Analysis of the observed mean temperature and rainfall of Punjab was carried out to substantiate whether their perceptions match with the reality. This study confirms that majority of the farmers are aware about climate change. In addition, laser leveller and improvement in irrigation structure are the most important adaptations in response to climate variability, which was adopted by 30 and 27 percent of total adoption respectively. The determinants found to be mostly significant are age, education, farms size, perception on temperature and extension lectures.

Even though there exist a good practice of local farm level adaptation by choosing different varieties, improve their irrigation structure, direct seeded rice, zero till wheat and laser leveler of the field, they may not be able to offset the escalating climate change effects. For this purpose and to achieve long term benefits, planned adaption also should be incorporated and implemented by the state government in their development planning.

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