

## Perception and Adaptation Strategies of Farmers to the Impact of Climate Change-a Case Study in Karnataka

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**Abstract** Agriculture is the major sector of India and is influenced by climate. Indian agriculture is negatively affected by climate change. Adaptation is identified as one of the options to reduce the negative impact of the change. This study identified the adaptation techniques employed by farmers and analyse factors that determine the adaptation techniques among farmers in the study area. Biprobit model and binary logit regression model were used to identify factors that influence the farmers perception about climate change and adaptation strategies followed by farmers to the adverse effect of climate change re-

spectively. The analysis of perception of farmers to climate change revealed a high increase in temperature and decrease in rainfall. The result showed that nine adaptation methods were employed by the farmers. The results revealed that farm experience, education and climate information were positively significant on perception of rainfall and temperature. Moreover, the analysis of factors affecting adaptation to climate change indicates that, use of drought tolerant, crop diversification, integrated farming system and soil conservation techniques compared to the rest of explanatory variables has more significant impact on adaptation. It is recommended that policy makers should enlighten the farmers more on the danger of climate change to productivity of crops and livestock and provide necessary logistics to support various alternative course of action.

**Keywords** Climate change, Perception, Adaptation, Biprobit, Logit.

### Introduction

Agriculture is the most important sector of the economy in India and it is highly dependent on climate. Change in climate impacts cropping patterns, water availability and to some extent productivity of crops as well [1]. Climate change is any change in climate over time that is attributed directly or indirectly to human activity that alters the composition

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**Table 1.** Perception of changes in rainfall of total farmers (n=120).

Sl. No.	Statements	Response of total farmers (n=120)			
		Agree	%	Disagree	%
1	Number of rainy days (more than 2.5 mm) were more	0	0	120	100
2	Amount of rainfall was more	0	0	120	100
3	There was change in the onset timing of rainfall	92	76.67	28	23.33
4	More dry spells	120	100	0	0
5	There were changes in rainfall during crop growth (Jul–Oct)	108	90	12	10
6	There was no changes in the rainfall pattern	4	3.33	116	96.67
7	There was deficit rainfall	118	98.33	2	1.67

of the global atmosphere in addition to natural climate variability observed over comparable time periods [2]. An increase in maximum temperature has an adverse effect on the crop yields whereas increase in minimum temperature had a favorable effect on crop yield. However, it was not sufficient to fully compensate the damages caused by the rise in maximum temperature. The projections of climate impacts towards 2,100 have suggested that with significant changes in temperature and rainfall, the rice yield will be lower by 15% and wheat yield by 22%. Coarse cereals will be affected less, while pulses will be affected more than cereals which affects the food security in India [3]. Decrease in yields of cereals, horticultural crops, livestock production and loss of employment, all associated with decreased income of farmers were the most immediate economic impact of drought due to reduction in rainfall. Malnutrition is also reported due to changed food preferences [4]. Thus in the long run, agriculture and agricultural practices will have to adapt to the climate change to ensure food security for human survival.

Adaptation is identified as one of the policy options to reduce the negative impact of climate change [5, 6]. Adaptation to climate change refers to adjustment in natural or human system in response to actual or expected climatic stimuli or their effects which

**Table 2.** Perception of changes in temperature of total farmers (n=120).

Sl. No.	Statements	Response of total farmers (n=120)			
		Agree	%	Disagree	%
1	There is increase in temperature	116	96.67	4	3.33
2	Experienced more extreme temperature	118	98.33	2	1.67
3	Experienced less extreme temperature	2	1.67	118	98.33
4	Experienced scorching sunshine	116	96.67	4	3.33
5	Summer is getting hotter	108	90	12	10
6	Winter is getting colder	56	46.67	64	53.33

moderates harm or exploits beneficial opportunities [7]. Steps should be taken to encourage and facilitate their adaptation behavior to climate change which can go a long way reducing their vulnerability [8]. The knowledge of adaptation methods and factors influencing the choice of adaptation methods could enhance policy towards tackling the challenges climate change is imposing on Indian farmers. This is because share of agriculture in employment was 48.9% as per National Sample Survey Office (NSSO) in 2011–12 [9]. It is reported that the small and medium rainfed farmers were highly vulnerable to climate change and to a larger extent the small and medium rainfed farmers adopted cropping mechanisms for climate change compared to large farmers [10]. But information on farmers perception and factors influencing choice of adaptation methods by farmers in Karnataka has been limited. This study investigates the perception of farmers to climatic variable changes, adaptation methods and factors influencing the choice of adaptation methods.

## Materials and Methods

### Selection and description of sample size

The village were selected purposively for the study.

**Table 3.** Results of the seemingly unrelated biprobit model of farmers perception of climate change in the climate. Log likelihood= -27.52, Number of observation=120, Athrho= -0.2772, Rho= -0.2234, chi2 (1)= 3.7462, prob>chi2= 0.052, \*\*\*Significant at 1% level, \*\*significant at 5% level, \*significant at 10% level.

Variables	Perception of rainfall				Perception of temperature			
	Co-efficient	Standard error	Z-value	P>[Z]	Co-efficient	Standard error	Z-value	P>[Z]
Age	-0.0707	0.1710	-0.41	0.679	0.2061	0.2326	0.89	0.376
Farming experience	0.2314	0.1109	2.08	0.046**	0.5657	0.3051	1.85	0.074*
Education	0.4706	0.1575	2.99	0.003***	0.6160	0.2461	2.50	0.012**
Extension contact	0.3797	0.7334	0.52	0.605	-1.1940	1.6387	-0.73	0.466
Climate information	3.1390	1.5490	2.03	0.043**	3.4880	1.96	1.77	0.077*
Irrigation	-0.6806	0.7934	-0.86	0.390	0.8840	0.8425	1.05	0.294
Constant	-7.384	5.873	-1.26	0.209	-16.762	9.382	-1.79	0.073*

The sample villages were selected from Bangalore north taluk of Bangalore Urban district which comes under the eastern dry zone of Karnataka viz., Seetakempanahalli, Shanubhoganahalli, Dibburahalli and Itgalpura.

#### Survey design

Primary data of 120 farmers were collected through personal interview by pre-tested schedule thirty farmers from each village were selected.

#### Analytical tools

A probit model is used to study the determinants of farmers perception about climate change and bivariate probit model was employed in the study. The dependent variables are dichotomous with  $Y_1=1$  for yes, if farmers perceive scarcity of rainfall and 0 otherwise. The other dependent dichotomous variable was defined as  $Y_2=1$  for yes if farmers perceive increase in temperature and 0 otherwise. The general model is a seemingly unrelated biprobit model with perception about climate change (Y) as a function of a vector of explanatory variables (X) [11].

It is assumed that there is an underlying response variable  $I^*$  defined by the regression relationship [12].

$$I_i = \beta_1 + \beta_2 X_i$$

In practice,  $I_i$  is unobservable and what is observed is a dummy variable Y defined by  $Y=1$  if  $I_i^* > 0$  (There is increase in temperature/ and or decrease in rainfall due to climate change = yes)  $Y=0$  otherwise.

Given the assumption of normality, the probability that  $I_i^*$  is less than or equal to  $I_i$  can be obtained from the standard normal cumulative distribution function (CDF) as :

$$P_i = P(Y=1/X) = P(I_i^* \leq I_i) = P(Z_i \leq \beta_1 + \beta_2 X_i) = F(\beta_1 + \beta_2 X_i)$$

Where  $P(Y=1/X)$  means the probability that an event occurs given the value (s) of the X, or explanatory, variable (s) and where  $Z_i$  is the standard normal variable, i.e.,  $Z \sim N(0, \sigma^2)$ . F is the standard normal CDF, written explicitly in the present context as:

$$F(I_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{I_i} e^{-\frac{z^2}{2}} dz$$

$$= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1 + \beta_2 X_i} e^{-\frac{z^2}{2}} dz$$

Now to obtain information on  $I_i$ , the utility index, as a well as on  $\beta_1$  and  $\beta_2$ , we take the inverse of above

**Table 4.** Adaptation strategies followed by farmers to climate change (n = 120).

Sl. No.	Adaptation measures	Adapted	%	Not adapted	%
1	Use of drought tolerant varieties	108	90.00	12	10.00
2	Practicing crop diversification	112	93.33	08	6.67
3	Cultivating short duration crops	77	64.16	43	35.84
4	Integrated farming system	106	88.33	14	11.67
5	Practicing crop rotation	72	60.00	48	40.00
6	Crop insurance	0	0	120	100.00
7	Soil conservation techniques	110	91.67	10	8.33
8	Off-farm employment	68	56.67	52	43.33
9	Practicing intercropping	28	23.33	92	76.67

equation to obtain:

$$I_i = F^{-1}(I_i) = F^{-1}(P_i) \\ = \beta_1 + \beta_2 X_i$$

where,  $F^{-1}$  is the inverse of the normal CDF.

Logit model is used to examine the adaptation measures taken by the farmers against climate change [12]. Adaptation is a dependent dummy variable in the data. The dummy variable was assigned a value of 1 for farmers who indicated that they had taken adaptation measures in response to negative effects of climate change and a value of 0 for farmers who indicated they did not engage in any adaptation measures at all in response to the negative effects of climate change. Different strategies are practiced by various farmers, which enhance the farmers adaptation to climate change. However, adaptation strategies to climate change effects also depend on the socio-economic characteristics of the farmers. For instance literate farmers may take different adaptive measures compared to those who are illiterate. Moreover, annual family income, farm size, farming experience and contact with extension service agents influence the farmers use of adaptive measures to adjust to environmental degradation and severe weather

events resulting from climate change effects. Regardless of the strategies applied by any farmer, it is predicted that taking adaptive measures reduces the negative effects of climate change on farm production, household income and farmer livelihoods.

Logit models guarantee the estimated probability increases and never cross the range of 0 to 1 economic factors affecting the farmers adoption of adaptive strategies, using the functional form of logit model expressed by Gujarati et al. [12] book as:

$$P_i = 1/1 + e^{-(\beta_0 + \beta_1 X_i)}$$

For simplicity above equation can be expressed as  $P_i = 1/1 + e^{-Z_i}$

where,  $P_i$ : Probability of adaptation of the  $i^{\text{th}}$  respondent

$e^{-Z_i}$ : stands for the irrational number e raised to the power of  $Z_i$

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

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \mu_i$$

where,  $\beta_0$  = Constant term

$\beta_1, \dots, \beta_n$  = Regression co-efficients

Therefore,  $Z_i = \beta_0 + \beta_1 (\text{AGE}) + \beta_2 ((\text{FRMEXP}) + \beta_3 (\text{EDU})) + \beta_4 (\text{FARMSZ}) + \beta_5 (\text{CO-OP}) + \beta_6 (\text{CREDT}) + \beta_7 (\text{FMSZE}) + \mu$ .

Where AGE, FRMEXP, EDU, FARMSZ, CO-OP, CREDT and FMSZE indicates age, farming experience, education, farm size, co-operative membership, credit and family size respectively.

## Results and Discussion

Perception of farmers about changes in precipitation

It is evident from the results that almost all farmers

**Table 5.** Estimates of binary logit regression model based on farmers adaptation strategies to climate change effects (n=120). Log likelihood=63.47, McFadden  $R^2=0.595$ , \*\*\*indicates significant at 1% level, \*\*indicates significant at 5% level and \* indicates significant at 10% level.

Variables	Coefficient	Standard error	Z-statistic	Probability
Age	-0.001	-0.00057	1.726	0.092*
Farming experience	0.188	0.196	1.903	0.336
Education	0.177	0.1031	1.7161	0.096*
Farm size	0.838	0.3812	2.1977	0.036**
Co-operatives	2.445	1.001	2.4425	0.015**
Credit	0.821	1.039	0.790	0.430
Family income	1.454	0.805	1.806	0.071*
Constant	-8.552	4.875	-1.754	0.079*

agreed about the changes in the precipitation (Table 1). All the farmers agreed that the number of rainy days were less as well as amount of rainfall was also less. About 76.67% of the farmers agreed that there was a change in onset timing of rainfall. All the farmers agreed that the dry spells were more. Around 90% of the farmers said that there were changes in rainfall during the crop growth. Among 120 farmers, 116 farmers agreed that there were changes in rainfall pattern for the past 15 years. Among 120 farmers, 118 farmers agreed that there was deficit rainfall.

#### Perception of the farmers about the changes in the temperature

Almost all the farmers have opined that there was change in the temperature (Table 2). Among 120 farmers, 116 farmers agreed that was increase in temperature. Among all the farmers 118 farmers said that they experienced more extreme temperature and two farmers said they experienced less extreme temperature. 116 farmers experienced the scorching sun shine. Among all the farmers 118 farmers said that summer is

getting hotter whereas 56 farmers said that winter is getting colder.

#### Probit model for farmers perception about climate change

Biprobit model has been applied to identify factors that influence the farmers perception about changes in precipitation and temperature during the past fifteen years (Table 3). The explanatory variables are age, farming experience, education, extension contact, access to climate information and access to irrigation.

The results revealed that the variable farming experience is positive and significant at 5% level and 10% level in case of perception of farmers about rainfall and temperature of the farmers respectively. This indicates that as the farming experience increases the farmers are more exposed to the changes in both rainfall and temperature over the years.

The variable education is positive and significant at 1% and 5% level for perception of farmers about rainfall and temperature of the farmers respectively. Education seems to increase the probability that the farmer will perceive long-term changes in rainfall and temperature. The educated farmers are more likely to perceive that rainfall has a significant declining trend over the long run and that temperature has significantly increased over the past fifteen years.

Information about climate through radio, television and other medias is positive and significant at 5% and 10% level in case of perception of farmers about rainfall and temperature respectively. This indicates that access to climate information increases the knowledge about climate change and such farmers are more likely to perceive changes in rainfall and temperature.

Farmers with more farming experience, education and access to climate information are more likely to perceive changes in rainfall and temperature. Such farmers are able to recognize that the temperatures have increased and there has been a reduction in quantity of rainfall.

Adaptation measures followed by the farmers to the adverse effects of climate change

The farmers have taken several adaptation measures in crop production, soil and water conservation practices in response to the changes in the climatic parameters. The details are presented in Table 4.

An overwhelming majority of respondent farmers indicated that they had employed at least one of the identified adaptive strategies, with only a few indicating no adoption of any of the adaptive strategies included in the study. This stands as an 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.

The findings of the binary logit regression model (Table 5) indicate that age is negative and significantly (at 10% level) related to farmers adaptive strategies to climate change effects. This implies that the probability of adaptation significantly decreases the older a respondent farmer. It can be predicted that such farmers have less interest or less incentives in taking climate change adaptation measures. Perhaps older farmers do not see the necessity to adapt to climate change effects. Moreover, these older farmers may be more set in their ways, interested in following traditional methods familiar to them rather than adopting modern farming techniques.

The regression model results explained that education is positive and significantly (at 10% level) related to adaptation strategies to climate change effects. This implies that the probability of adaptation to climate change is greater for those who have higher educational attainment compared to less-educated or illiterate farmers. It is obvious that 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.

There is a positive and significant (at 5% level) relationship between farm size and adaptation to cli-

mate change effects. Specifically, results show that increase in land holding size increases the probability of farmers adoption of adaptive strategies to climate change. The reason behind this result may be the large farmers were using modern technologies to climate change adaptation.

Involvement in cooperatives is positive and significantly (at 5% level) related to adoption of adaptation strategies, implying that the probability of adaptive strategy adoption is higher for those farmers who have membership and contact with different cooperatives enterprises compared to farmers not participating in such coordinated actions and groups. We interpret this observation as an indication that membership and engagement in a cooperative encourages farmers to engage in a united strategies orientation, farmers involved in cooperatives share knowledge and innovation ideas, discuss problems and challenges with others and engage in collaborative decision-making.

The result of the logistic regression shows positive and significant (at 5% level) relationship between family income and adoption of adaptive strategies to climate change effects. This implies that farmers with high income are more likely to adopt adaptive strategies than farmers with lower incomes.

## Conclusion

Farmers adapted to climate change by using different methods, of which the major ones are included in this study. Those who did not use any of the methods identified lack of information on adaptation methods and lack of capital as major constraints to adaptation. Of the estimated binary logit model, age, education, farm size, member in co-operatives and family income had greater significant effect on the decisions of the farmers to adopt some of the methods such as use of drought tolerant, crop diversification, integrated farming and soil conservation techniques. The analysis of the farmers perceptions of climate change indicates that most of the farmers in the study area were aware that temperature is increasing and the level of rainfall is declining.

The analyses of factors that influence farmers

adaptation to climate change in the study area suggest a number of different policy options. These options include creating awareness of climate change and appropriate adaptation methods, facilitating the access to credit, encouragement of livestock ownership and creating opportunity for off farm employment and conducting research on the use of new crop varieties that are better suited to farmers new climatic conditions.

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