Indian Journal of Agricultural Economics
Volume 78, Number 3, July -September 2023

Climate Resilient Farming and Food Security of Farmers: A Study of Different Flood Hazard Zones of Assam

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ABSTRACT

The present study has made an attempt to explore if the area expansion under climate-resilient farming assists food security of the farmers using primary data collected from farm households in five different flood hazard zones of Assam. Though increase in total cultivated area, crop diversity index, access to irrigation and extension services, degree of flood hazardousness was associated with greater proportion of land devoted for climate-resilient farming, but the share of climate resilient crop area in total land under cultivation was meagre across the farm households in the study area. Hence, besides improving the spread of irrigation policies should focus on disseminating the knowledge of climate resilient agricultural practice and its benefits among the farmers of different landholding size by training them through enhanced extension services.

Keywords: Extreme events, agriculture, farmland, irrigation

JEL: Q15, Q54

I

INTRODUCTION

The alarming weather and climate extremes are pervasive in nature, posing a huge threat to agriculture and the global food security (Duchenne-Moutien and Neetoo, 2021; Cai *et al*., 2016). Serious projections can be seen in literature about the impact of climate change on agricultural yield (Tabari, 2020; Rahman and Rahman, 2020; Mandal and Singha, 2020; Ziervogel and Ericksen,2010). Achieving the target of food security for all has become more challenging due to declining average size of land holding on the one hand and deterioration of natural resources such as soil quality, ground water on the other (Guha and Mandal, 2021) beside climate change upsetting agriculture (Fuglie, 2021; Muluneh *et al*., 2017). There is urgent need to address the problem of food insecurity on a global scale with 8.9 per cent of the world's population suffering from hunger (UNICEF, 2020). With more than 200 million undernourished people, India alone is home to the largest number of hungry people of the world (FAO, 2019). Unquestionably, the future demand for food is expected to increase significantly due to population growth, changing dietary patterns, and urbanisation. To meet such growing food demand and achieve food and nutritional security, diversifying our food production beyond staples like paddy and wheat is crucial (Mayes *et al.,* 2012; Rasul, 2016). Coarse cereals, pulses and other climate resilient crops can play a significant role in this regard (Pingali *et al.,* 2017; Abraham and Pingali, 2020). With the increasing frequency and intensity of extreme

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weather events, viz., droughts, floods, heatwaves, and storms the conventional agricultural practices often fails to ensure stable crop production (Srinivasarao *et al.*, 2020; Abhilash *et al.,* 2021). Implementing climate-resilient cropping practices helps farmers adapt to extreme events and maintain sustainable food production systems (Rao, 2016, Wiebe *et al.*, 2019). Climate-resilient cropping practices are projected to contribute towards long-term higher productivity, income and food security of farmer in the face of climate change (Joyce *et al*., 2016; Escarcha *et al*., 2020). Ismail *et al.* (2013) reported the contribution of submergence-tolerant paddy cultivation to food security in flood-prone rainfed lowland areas. Several scholars have recommended diversification of crops, improved water management, conservation agriculture, agroforestry and intercropping, climate-informed decision-making, adoption of climate-smart practices in enhancing food security (Lipper *et al*., 2014; Acevedo *et al*., 2020; Zakari *et al*., 2022). By implementing climate-resilient cropping practices, farmers can adapt to the changing climate, reduce risks, enhance agricultural productivity and improve food security (Lipper *et al.*, 2014; Amoak *et al.*, 2022; Zakari *et al*., 2022). One of the strategies to deal with flood and other external threats in agriculture as recommended in the literature is crop diversification (Harwood *et al*., 1999; Mandal, 2010). Rukhsana *et al.* (2021) found that diversified crop rotation process augments food security.

Agriculture is sensitive to both changes in weather and variations in climate. Weather variability is one of the key factors influencing agricultural land use and production (Tao *et al.*, 2008; Lobell and Field, 2007). Heal and Millner (2014) claimed that weather variability has a severe problem that necessitates immediate attention. The impact of climate fluctuation and change on the food production and food security around the world was further discussed by Iizumi and Ramankutty (2015). In India, Khanal and Mishra (2017), Aryal *et al.* (2018) empirically validated the threat of weather extremes on food insecurity, suggested to adopt suitable food crop portfolio choice in response to mitigate the changing environmental hazards. However, the climate resilient cropping practices discourses the entwined challenges of food security and issues of climate change (Aryal *et al.*, 2018; Lipper *et al.*, 2014; FAO, 2013). Undoubtedly, several attempts have been made so far in assessing the role of climate resilient farming on food security across countries, with few studies in the Indian context. A study by Mandal *et al*. (2023) has tried to assess the food insecurity of Northeast India in the face of extreme weather events. However, there is dearth of studies on examining if climate resilient farming assists farmers' food security, with farm level data in Assam. This study is an attempt to bridge such gap in literature. Greater vulnerability of conventional farming to extreme events and climate variability has been discussed in previous studies (Lee, 2021; Goh, 2011; Kansanga *et al*., 2019). With the presumption that devotion of greater landmass under climate resilient cropping helps in protecting farm output from extreme events and climate variability thereby minimising the damage of crop under cultivation and hence food security of farmers, the present study aims at assessing the share of climate resilient crop area in the total area under cultivation and its determinant using farm level primary data collected from five different flood hazard zones of Assam. The results of our analysis indicate that there is substantial scope for enhancing area under climate resilient crop with improved access to irrigation and extension services.

The rest of the paper are divided into four different sections. Section II gives a description of the study area, data, sample. Section III illustrates the empirical model applied in the study while section IV covers the results and discussion. The conclusion and policy recommendations of the study covered in final section of the paper.

II

DATA, SAMPLE AND METHODOLOGY

The present study is based on primary data, collected using multistage random sampling method from different flood hazard areas of Assam. Based on the frequency of flood inundation using satellite data, the Flood Hazard Atlas of Assam State (2016) has categorised the flood hazard areas of the state into five different classes based on areas those experienced flood number of times flood occurred during 1998 to 2015 viz., very low (1-4 times); low (5-8 times); moderate (9-12 times); high (13-15 times); and very high (16-18 times). Given such classification, the researcher in the present study has applied the same classification and selected the villages from where the data were collected.

In the initial stage seven districts were selected from each of the six agro-climate regions having different degrees of flood hazardness. Thus the districts identified were Tinsukia from Upper Brahmaputra Valley Zone, Dhemaji from North Bank Plain Zone, Dhubri from Lower Brahmaputra Valley Zone, Morigaon and Nagaon from Central Brahmaputra Valley Zone; while Karimganj from Barak Valley Zone, and Karbi Anglong from Hill Zone. Having identified the districts, in the second stage Agricultural Development officer (ADO) circle were selected from respective sampled districts of the study area. Thus, two non-contiguous ADO circle were selected from each distrct of the study area thereby figuring a total of 14 ADO circles. In the third stage minimum of three non-contiguous villages were selected from each of the sampled ADO circles of the study area, thereby resulting in a total of 42 villages of different degree of flood hazardousness. Given the vastness of the universe of the study and time and resource constraint for individual reseacher, present study randomly selected 7-9 per cent of farm households with minimum 10 households from each of the sampled village in the final stage, thereby resulting a sample of 764 farm households for the study.

Description of the Variables and Summary Statistics

Table 1 provides an overview of the variables used in the study along with their summary statistics. On average, the farm households in the study area consist of 5 members with the average age of household head of 47 years. The farming heads

TABLE 1: SUMMARY STATISTICS

Non-Categorical Variable (1)	Unit (2)	Mean (3)	SD (4)	Min (5)	Max (6)
Family Size (FS)	No. of Person	5	2.45	1	15
Age of farming head of the household (Age)	Years	47.00	10.63	18	76
Year of Schooling of farming head (YoS)	Years	8	3.17	0	15
Experience in Farming of farming head (Exp)	Years	18.72	9.93	2	50
Cropped Area under climate resilient crops (Area_climate)	Hectares	1.08	1.15	0	22.01
Cropped Area under Conventional crops (Area_Con)	Hectares	2.74	2.24	0	16.55
Cropped area under cultivation (Area)	Hectares	3.81	2.99	1	22.32
Categorical Variable					(Per cent)
Access to irrigation (Irri)	Yes = 1				32.85
Access to institutional credit (Credit)	Yes = 1				35.73
Access to extension services (Extension)	Yes = 1				21.47
N = 764					

Source: Survey Data, 2021
Note. No. stands for Number

have completed 8 years of schooling on an average with average experience of 18.72 years in farming. The mean landmass under cultivation in the study area was 3.81 hectares. The area under climate resilient cropping[1] was 1.08 hectares of land on an average while it was 2.74 hectares for conventional cropping.[2] Such result reflects the relatively smaller share of land under climate resilient cropping in total landmass under farming in the study area. Nearly 32.85 per cent of farm households in the study area were having access to irrigation facilities (Irri) facility while, around 35.73 per cent of households have access to institutional credit (credit). Nearly 21.47 per cent of farm households seen to have access to extension services (Extension) such as knowledge and information sharing, training and capacity building, on-farm demonstrations and advisory and consultation services.

III

EMPIRICAL MODEL

With to the objective of determining the factors influencing the share of climate resilient crop area in a diverse cropped portfolio across the different degree of flood hazardousness, a linear regression model is not suitable as dependent variable lies between zero and one (Guha and Das, 2020). In such case, a censored regression model (i.e., Tobit model) is most suitable because it uses all observations usually the limit is zero for non-cultivation of climate resilient crop group (Amemiya, 1984; Foster and Kalenkoski, 2013).

The proportion of climate resilient crops out of total cultivated land area (Y_c) was used as a dependent variable in the model. The function of Y_c was defined as:

$$Y_c = f\ (CDI, X)$$

Where, CDI stands for crop diversification index[3], X is the vector of different households and farm characteristics.

The model can be reported as:

$$Y_{ci}^* = X_i\beta_i + \varepsilon$$

Where, Y_{ci}^* is the latent variable; X_i is the vector of independent variables. β_i is the vector of coefficients to be estimated. ε is the error term assumed to follow a normal distribution with mean 0 and constant variance σ^2. i stands for i-th household. The observed dependent variable (Yc) is linked to the latent variable Yc_i^* as per following formulation:

$$Y_c = Y_c^* \text{ if } Y_c^* > 0$$

$$Y_c = 0 \text{ if } Y_c^* \leq 0 \text{ and left-censored}$$

The estimates the coefficients (β) of the linear regression equation while accounting for the censored observations in the dependent variable. The independent variables listed in Table 2 were anticipated to be positively significant with regressand barring area under conventional cropping. The estimation of the Tobit model has been performed using maximum likelihood estimation (MLE) techniques, which find the parameter values that maximize the likelihood of obtaining the observed censored data given the model.

IV

RESULTS AND DISCUSSION

From the regression result as reported in Table 2, it can be seen that the estimated coefficient of the degree of flood hazardousness is found to be positive and significant which indicates that degree of flood hazardousness was associated with greater proportion of land under climate-resilient crops. The possible explanation for such result may be fact that a high degree of flood hazardousness urged farmers to dedicate greater proportion of landmass under climate-resilient crops to reduce the crop damages from extreme events that augments their food security.[4] Such result is consistent with the findings of Ismail *et al.* (2013); Sam *et al.* (2021). The total area under cultivation seems to have a significant positive association with the proportion of land under climate-resilient crops. Thus, a one-hectare increase in the crop area (area) was associated with a 0.021 percentage point increase in the proportion of the area under climate resilient crops implying farmers with large landholding were more inclined towards resilient farming, possibly because of economies of scale effect. The coefficient of CDI is found to be positively significant with the proportion of area under climate-resilient crops, implying more diversified portfolio was associated with larger proportion of landmass under climate-resilient crops. Contrasting observations were made by Acevedo (2020); Lipper (2014) that diversified crop portfolio tends toward resilient cropping. The access to irrigation facilities is seen to be positive significant predictor of the proportion of area under climate-resilient crops. Such result implies that better access to irrigation assisted farmers in expanding the area under the climate resilient crops in the study area. Similarly, positive significant result of access to extension services implies that the availability of extension services helped farmers to initiate climate resilient farming practices. Similar observation was made by Ghosh (2019) while addressing the issue of national food security and climate-smart agriculture. The experience of farmers seems to have significant positive determinant of the proportion of area under climate-resilient crops. The veteran farmers in the study area might be more acquainted with agricultural vulnerabilities from extreme events from their past learning by doing experiences, so tried to avert such risk by devoting greater proportion of their farmland under climate resilient crops.

TABLE 2: DETERMINANTS OF PROPORTION OF AREA UNDER CLIMATE RESILIENT CROPS (Y_C)

Independent Variables/Others (1)	Coefficient (2)	Robust S.E. (3)
Flood Hazard zone	0.020***	0.004
Area	0.021***	0.002
Area_Con	-0.030***	0.003
CDI	0.354***	0.035
Irri	0.064***	0.013
Credit	-0.016	0.012
Extension	0.177***	0.015
Age	-0.001	0.001
YoS	0.001	0.002
Exp	0.002**	0.001
Constant	-0.069	0.049
F (11, 752) = 153.08		
Prob > F = 0.000		
Pseudo R^2 = 1.6603		
Log pseudo likelihood = 213.54		
Number of observations (N) =764		

Source: Authors' estimation from survey data, 2021

The overall significance is established so far as the value of F statistic is concerned and the model seems to exhibit better fit to the data so far as value of the pseudo R^2 is concerned (Table 2).

V

CONCLUSION

The present study has made an attempt to explore if the area expansion under climate-resilient farming assists food security of farmers using primary data collected from farm households in five different flood hazard zones of Assam. Though increase in total cultivated area, crop diversity index, access to irrigation and extension services, degree of flood hazardousness was associated with greater proportion of land devoted for climate-resilient farming, the share of climate resilient crop area in total land under cultivation was meagre across the farm households in the study area. Hence, besides improving the spread of irrigation policies should focus on disseminating the knowledge of climate resilient agricultural practice and its benefits among the farmers of different size of landholding by training them through enhanced extension services. It is likely to encourage the farmers of different land holding size to dedicate greater area under cultivation towards climate resilient crops, thereby enhancing their food security. The caveat of the present study is its failure to take account of nutritional indicators assessing the farmers' food security. In addition, the study could not cover longitudinal information on the consequences of climate resilient farming at farm level.

NOTES

1. Climate-resilient crops have enhanced tolerance to biotic and abiotic stresses. They are intended to maintain or increase crop yields under stressful conditions viz. flood, droughts, higher average temperatures and other climatic conditions (Zohry and Ouda, 2022). In the present study, the climate resilient crops are those which are flood tolerant. Such crops in the present study were selected using cropping season and tolerance capacity. Crops such as Rape and Mustard, Maize, Summer Vegetables, pulses: Black Grams and Rajmah, and *Boro* (Summer) paddy which are gaining relatively low concentration among farmers considered for present study.
2. In the present study major crops included in conventional crops are winter paddy (traditional), winter paddy (hybrid), autumn paddy, Jute, *Bao*.
3. Crop Diversity Index (CDI) = [1- Hrischman Herfindahl Index]. Normally, ($0 \leq CDI \leq 1$) farms are said to be more diversified if the value is closer to 1 and opposite if the value is closer to 0.
4. Food security in the present context defined with the presumption that devotion of greater land area under climate resilient cropping helps in protecting farm output from extreme events and climate variability thereby minimising the damage of crop under cultivation and hence ensuring food security of farmers.

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