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Determinants of adoption of climate change adaptation strategies in cotton in Palnadu district of Andhra Pradesh

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Abstract

Climate change poses a serious threat to agriculture, especially in developing countries like India where, farming is highly dependent on climate-sensitive resources. Cotton, a key commercial crop, is particularly vulnerable to irregular rainfall, rising temperatures, and pest infestations which contributes to the low yield. These challenges can be addressed by the adoption of climate change adaptation strategies. However, the rate of adoption is very low. Hence a study was designed to identify and analyze the determinants of adopting climate change adaptation strategies among cotton farmers in the semi-arid Palnadu district of Andhra Pradesh using a binary logistic regression model. A total of 180 cotton farmers including 60 adopters and 120 non-adopters across six villages in three major cotton-growing mandals were surveyed for the agricultural year 2023-24. The results revealed that access to institutional credit, trainings on climate change, Government subsidies, non-farm income and education level of the farmer significantly increased the likelihood of adoption of climate change adaptation strategies. Conversely, the age of the farmer negatively influenced adoption. The study emphasized the need for targeted policy interventions, including strengthening adequate credit access, providing training on adoption of climate change adaptation strategies, providing financial subsidies and promoting non-farm income through MSME.

Keywords: Climate change adaptation, cotton farmers, logistic regression, socio-economic factors, Palnadu district, credit access, training, government subsidies, agricultural resilience.

1. Introduction

Climate change poses a significant threat to agriculture, particularly in developing countries like India where the sector is heavily dependent on monsoon rainfall and climate-sensitive resources (IPCC, 2022) [2]. Cotton, one of the most important commercial crops in India, is grown as a rain fed and semi-arid crop. In India, there are nine major cotton growing states: Punjab, Haryana, Rajasthan, Maharashtra, Madhya Pradesh, Gujarat, Telangana, Andhra Pradesh and Karnataka. Andhra Pradesh contributes to 4 per cent to the country's total cotton production and ranks 8th position in area and production (crop outlook reports Andhra Pradesh ANGRAU 2023-2024) [6], mirrors the national trends in climate vulnerability and declining productivity.

Despite the heavy dependence on climate, cotton farmers in Andhra Pradesh face a multitude of challenges that constrain productivity and profitability. These include difficulties in accessing quality seeds and fertilizers, limited reach of extension services, high input costs, declining soil fertility, lack of market information, pest attacks, and erratic weather conditions. Additionally, institutional bottlenecks, such as delays in the distribution of inputs, weak credit support, and inadequate post-harvest infrastructure, exacerbate the situation.

Cotton, being a rain fed and semi-arid crop is particularly vulnerable to climate changes. Cotton farmers have been encouraged to adopt climate change adaptation strategies to cope with these challenges. These include selection of drought resistant seed varieties, adjustments in sowing dates and improved water and nutrient management (Sahu and Mishra, 2013; Tripathi and Mishra, 2017) [4, 7]. However, the rate of adoption is very low.

The area under cotton cultivation in Andhra Pradesh has shown a marked decline over the years from 8.21 lakh hectares producing 26.50 lakh bales in 2014-15 to 4.22 lakh hectares yielding 7.37 lakh bales in 2023-24. Productivity has also declined from 570 kg/ha in 2014-15 to 297 kg/ha in 2023-24. (Season and Crop Reports, 2015-16; 2023-24) [5]. The area and production under the cotton is declining in spite of many measures taken by the Government and also development and dissemination of proven technologies/climate change adaptation practices by the research stations, which need a critical enquiry. Hence a study was designed on "Determinants of Adoption of Climate Change Adaptation Strategies in Cotton in Palnadu

District of Andhra Pradesh".

2. Materials and Methods

The state of Andhra Pradesh was selected for the study due to its significant role in India's cotton production Palnadu district was purposively selected as the specific study location. Formed in 2022, Palnadu holds the second-largest area under cotton cultivation in the state, with 65,347 hectares, 2.04 lakh bales of production, and a productivity of 170 kg/ha in the year 2023-24 (Season and Crop Report, 2023-24).

In Palnadu district three mandals Veldurthi, Amaravathi, and Durgi were purposively selected based on their extensive cotton cultivation during 2023 Kharif season (karshak.ap.gov.in Kharif 2023). From each mandal, two villages with the highest area under cotton were selected. From each village, 30 cotton-growing farmers were randomly selected, including 10 adopters and 20 non-adopters of climate change adaptation strategies. Thus, the total sample size comprised 180 farmers.

The data pertaining to the study were obtained through survey method and enquiries were made with the help of pre-tested structured questionnaires. The present study pertains to the agricultural year 2022-23.

A binary logistic regression model was used to determine the factors that influence the adoption of climate change adaptation strategies. The use of binary logistic regression model, which gives the maximum likelihood estimates, overcomes most of the problems associated with linear probability models and provides estimators that are asymptotically consistent, efficient and Gaussian. The binary logistic regression model based on the cumulative logistic probability function is computationally easier to use than the probit models and was used in this study (Pindyck and Rubinfeld, 1981) [3]. The theoretical model is given as follows. The cumulative logistic probability model is specified as:

$$\text{Ln}\,(P_i/(1-P_i)) = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ldots\ldots\ldots \beta_{10} X_{10} + e_i.$$

Where,

P_i = probability of farmer's adoption of climate change adaptation strategies

$1-P_i$ = probability of not adoption of climate change adaptation strategies

β_0 = intercept

β_i (1,2,3……10) = Regression Coefficients)

X_i (1,2,3……10) = Independent Variables

Ln $(P_i/(1-P_i)$ = in log-odds ratio

e_i = error term.

The binary logistic model is used to determine the effect of the explanatory variables on farmer's adoption of climate change adaptation strategies in Palnadu district. The dependent variable is a binary variable representing the adoption of climate change adaptation strategies (1) and otherwise (0). Independent variables included are farmer socio-economic characteristics such as access to institutional credit, access to market information, access to trainings on climate change, irregular climatic patterns, government subsidies provided, non-farm income of the farmer, age of the farmer, educational level of the farmer, farm size. For this study above equation is expressed implicitly as

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + u_i$$

Where,

Y = Adoption or non-adoption of climate change adaptation strategies (1 if yes, 0 if no)

X_1 = Access to institutional credit (if, yes=1 or no = 0)

X_2 = Access to market information (if, yes=1 or no = 0)

X_3 = Access to trainings on climate change (if, yes=1 or no = 0)

X_4 = Irregular climatic patterns (if, yes=1 or no = 0)

X_5 = Government subsidies provided (if, yes=1 or no = 0)

X_6 = Non-Farm income (Rs)

X_7 = Age of the farmers (years)

X_8 = Education level of the farmer (1= Illiterate, 2= Primary, 3= Secondary,

4= Intermediate, 5 =Degree, 6= Post Graduate)

X_9 = Farm size (hectares)

b_1, b_2……..b_{10} are parameters corresponding to estimated variables coefficients. u_i is the error term and consists of unobservable random variables.

3. Results and Discussion

For analysing the determinants of adoption of climate change adaptation strategies a binary logistic regression model was used. In the model, adoption of climate change adaptation strategy was used as a dependent variable. Marginal effects were also calculated to express the probability of adoption of climate change adaptation strategies.

Table 1: Determinants of adoption of climate change adaptation strategies in cotton crop in the study area

Variables	dy/dx	Standard Error	p- values
Access to institutional credit	0.411***	2.512	0.005
Access to market information	0.0267	1.150	0.366
Access to trainings on climate change	0.179**	1.905	0.042
Irregular climatic patterns	0.034	1.234	0.278
Govt subsidies provided	0.438***	2.165	0.008
Non-farm Income	0.164**	1.657	0.020
Age of the farmer	-0.010***	0.143	0.005
Education level of the farmer	0.221***	2.345	0.000
Farm size	-0.045	1.863	0.348
Pseudo R^2	0.88		
Log likelihood	-13.320		
Number of observations	180		

Note: *** significant at 1 per cent level of significance and**significant at 5 per cent level of significance

Access to institutional credit: Access to institutional credit showed a positive relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 1 per cent. The marginal value of 0.411 denoted that with one unit increase in the access to credit, the probability of adoption increased by 41.1 per cent. Farmers are being provided with the credit facilities like crop loans, kisan credit cards which are sufficient for the cultivation of crops. But the adoption of climate change adaptation strategies like use of drought resistant varieties, application of micro nutrients, drip irrigation, mulching *etc* requires additional money as the initial costs of installation is high. Hence if the adequate credit facilities are provided the farmers will be able to adopt the climate change adaptation strategies effectively.

Access to trainings on climate change: Access to trainings on climate change showed a positive relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 5 per cent level. The marginal value of 0.179 denoted that with one unit increase in the access to trainings on climate change the probability of adoption increased by 17.9 per cent. Few training programs were organised in the study area by Department of Agriculture and KVK's. Cotton farmers who have attended the training programmes on climate change have knowledge about the causes and impacts of climate change on the crop and they are adopting the strategies to some extent. Farmers will better adopt the strategies if they are provided with the practical guidance on how to use the strategies through exposure visits to real situations where the climate change adaptation strategies worked against the climate changes in the crop.

Govt. subsidies provided: Govt. subsidies provided showed a positive relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 1 per cent. The marginal value of 0.438 denoted that with one unit increase in the Govt. subsidies provided the probability of adoption increased by 43.8 per cent. In the study area Department of Agriculture is providing inputs like seeds, fertilizers and electricity to some farmers on subsidy. But the tenant farmers are not getting any subsidies. As subsidies lower the financial burden on the farmers, the adoption of climate change adaptation strategies will be higher if the cotton farmers are provided with the required inputs like micro nutrients, plant protection chemicals, components of drip and plastic mulches.

Non-farm income: Non-farm income showed positive relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 5 per cent. The marginal value of 0.164 denoted that with one unit increase in the non-farm income the probability of adoption increased by 16.4 per cent. Some of the sample farmers were earning income from different non-farm sources *viz.*, carpenter works, building construction works, mineral water plants, small shops, hotels and private jobs and investing on the adoption of climate change adaptation strategies. The adoption will be higher if they are provided with non-farm income sources through establishment of MSME, cottage industries, vermi compost unit, mushroom production which may improve their financial condition and support them with the supplementary financial resources.

Age of the farmer: Age of the farmer showed negative relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 1 per cent. The marginal value of -0.010 denoted that with one year decrease in the age of the farmer the probability of adoption increased by 10 per cent. Older farmers tend to be more risk-averse and conservative in their decision-making, which reduces their willingness to adopt new or unfamiliar practices. Additionally, they often have a shorter planning horizon and may prioritize immediate returns over long-term resilience, making them less inclined to invest in climate adaptation measures that yield benefits over time. Physical limitations and reduced participation in extension activities or training programs may also hinder older farmers from adopting labor-intensive or technically demanding practices.

Education level of the farmer: Education level of the farmer showed a positive relationship with the probability of adoption of climate change adaptation strategies and was found statistically significant at 1 per cent. The marginal value of 0.221 denoted that with one year increase in the education level of the farmer the probability of adoption increased by 22.1 per cent. Educated farmers are better equipped to evaluate the costs and benefits of new practices, understand extension messages, and participate effectively in training programs or institutional networks. They are also more likely to seek out information proactively, interact with service providers, and make informed, future-oriented decisions. As a result, they are generally more open to innovation and better prepared to implement complex or knowledge-intensive adaptation strategies.

Several factors influence the adoption of climate change adaptation strategies among farmers. Access to credit enables farmers to overcome financial constraints and invest in adaptation technologies. Training on climate change enhances awareness, technical skills, and confidence in new practices. Government subsidies lower the cost of adoption and encourage uptake by providing financial incentives. Non-farm income increases financial stability, allowing farmers to take on the risks and costs associated with adaptation. In contrast, older farmers tend to adopt less due to risk aversion, shorter planning horizons, and lower openness to innovation. Finally, education plays a critical role, as more educated farmers are better at understanding climate information and are more likely to adopt modern, knowledge-intensive practices.

4. Summary and Conclusion

The findings of the study highlight several key factors influencing the adoption of climate change adaptation strategies among cotton farmers. Access to institutional credit, training on climate change, government subsidies, non-farm income, and the education level of the farmer were found to significantly encourage adoption. These factors enhance farmers' capacity to understand, invest in, and implement adaptive practices.

Conversely, the age of the farmer had a negative impact on adoption, suggesting that older farmers may be more resistant to change or less inclined to adopt new practices due to risk aversion or limited exposure to information.

The findings underscore the need to strengthen credit support systems, organize regular training programmes on climate change adaptation strategies, provide the required inputs for the establishment of drip irrigation and mulching (plastic mulches) and non farm income sources through MSME like establishment of to promote the adoption of climate change adaptation strategies.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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