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Factors Influencing Adoption of Climate Resilient Agricultural Technologies in Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Andhra Pradesh, climate change may negatively impact crop yields and variability, especially in rainfed agricultural areas, which account for 46 per cent of the total cultivated area. Besides drought-prone areas like the districts in the Rayalaseema region of Andhra Pradesh, even the state's coastal districts are prone to cyclones and floods. In this context, farmers have to adopt Climate Resilient Agricultural (CRA) technologies to mitigate the negative impacts of climate change. Certain factors influence the farmer's decision to adopt these technologies. In this context, this study investigated the factors influencing the adoption of CRA technologies in the Srikakulam and Anantapur districts of Andhra Pradesh by employing a logistic regression model. Primary data was collected from 300 purposively selected farmers comprising of 240 adopters and 60 non-adopters from both the districts. The results revealed that education (6.2%), farming experience (7.8%), family size (5.1%), annual farm income (4.8%), access to climate information (9.8%) and access to extension contact (16.5%) significantly influenced the adoption of CRA technologies in Srikakulam district. Similarly, in Anantapur district age of the farmer (0.7%), education (6.6%), annual farm income (5.2%), access to climate information (9.0%), access to extension contact (17.6%) and membership in organisation (7.1%) significantly influenced the adoption of CRA technologies. Therefore, the results indicated that it is necessary to set up an appropriate institutional structure to provide climate information, extension services and non-formal education to farmers on the benefits of CRA technologies for the wide spread adoption of CRA technologies.

Keywords: Adopters; climate change; CRA technologies; determinants; logistic regression model; non-adopters.

1. INTRODUCTION

A region's agricultural acreage, crop production and yield are all influenced by its climate. Throughout the world, there is significant concern about the impact of climate change on agriculture, as temperature and precipitation are two major climatic events that impact crop productivity [1,2]. In general, developing countries like India bear much impact because of their heavy agricultural dependence. Studies revealed that over the years, there has been significant warming due to increased temperatures in India (Kothawale *et al.*, 2010). Further, mean warming in India will increase by 1.7–2°C by 2030s and 3.3–4.8°C by 2080s under the Coupled Model Intercomparison Project Phase-5 (CIMP-5), Representative Concentration Pathways (RCP) 6 and 8.5 Scenarios. Precipitation will increase from 4 to 5 per cent by the 2030s and from 6 to 14 per cent towards the end of the century (2080s) compared to the 1961–1990 baseline [3]. In Andhra Pradesh, maximum and minimum temperatures are predicted to increase by 1.3 to 2°C and 1.83 to 2.17°C by 2050, with an average temperature increase of about 1.0°C [4]. An increase in temperature of 2°C and precipitation by 7 per cent will result in a loss of about 8.4 per cent of total net revenue [5]. Empirical evidence indicates that due to climate change, the productivity of Indian agriculture will be reduced by the end of this century [6,7,8,9].

In Andhra Pradesh, 62.17 per cent of the total working population depends on agriculture and allied activities. The contribution of agriculture under the primary sector to the State Gross Value Added for the year 2020-21 Advance Estimates (AE) is 15.50 per cent at current prices (Agricultural Statistics at a glance – Andhra Pradesh 2020-21). As around 46 per cent of the gross sown area in Andhra Pradesh is under rainfed conditions, climate change will adversely influence crop yields and variability. Building climate-resilient agriculture is acknowledged as the primary means to adapt and mitigate the negative impact of climate change due to its potential to guarantee sustained yield and farm income [10].

In this context, the Indian Council of Agricultural Research (ICAR) initiated the National Innovations on Climate Resilient Agriculture (NICRA) project in 2011 to equip farmers with the necessary coping skills to manage the effects of climate change. A wide range of Climate-Resilient Agricultural (CRA) technologies have been promoted to combat the adverse effects of climate change and ensure sustainable yields. They will sustainably boost agricultural productivity and strengthen the agriculture systems' resistance to climate change on several levels. These technologies include growing drought and flood-tolerant varieties, implementing water and soil conservation measures, introducing new crop varieties and changing planting dates, using crop insurance mechanisms, and irrigation practices.

Various factors, including how farmers perceive climate change, the size of their farms, the household, and socioeconomic, geographic, and institutional factors, influence these adoption decisions [11,12]. Understanding the factors influencing farmers' decisions to adopt CRA technologies is crucial to helping private individuals and policymakers plan for the agriculture sector's future adaptation to climate change [13]. With this background, the current study entitled "Factors influencing the adoption of Climate Resilient Agricultural Technologies in Andhra Pradesh" has been formulated to identify the variables and determine the degree to which they affect farmers' choices.

2. MATERIALS AND METHODS

2.1 Study Area and Data Collection

Srikakulam (flood-prone) and Anantapur (drought-prone) districts of Andhra Pradesh were purposively selected for the study where there is implementation of CRA technologies under the NICRA project through Krishi Vigyan Kendras (KVKs). From each district, 150 farmers (120 adopters and 30 non-adopters) were selected, thus constituting a total sample of 300 respondents (240 adopters and 60 non-adopters).

The requisite primary data was collected by personally interviewing the sample farmers using a pre-tested schedule. The primary data regarding farmer details, land holding size, capital resources, yield, annual farm income, access to extension contacts, credit sources to the farmers, and perception on climate change were collected.

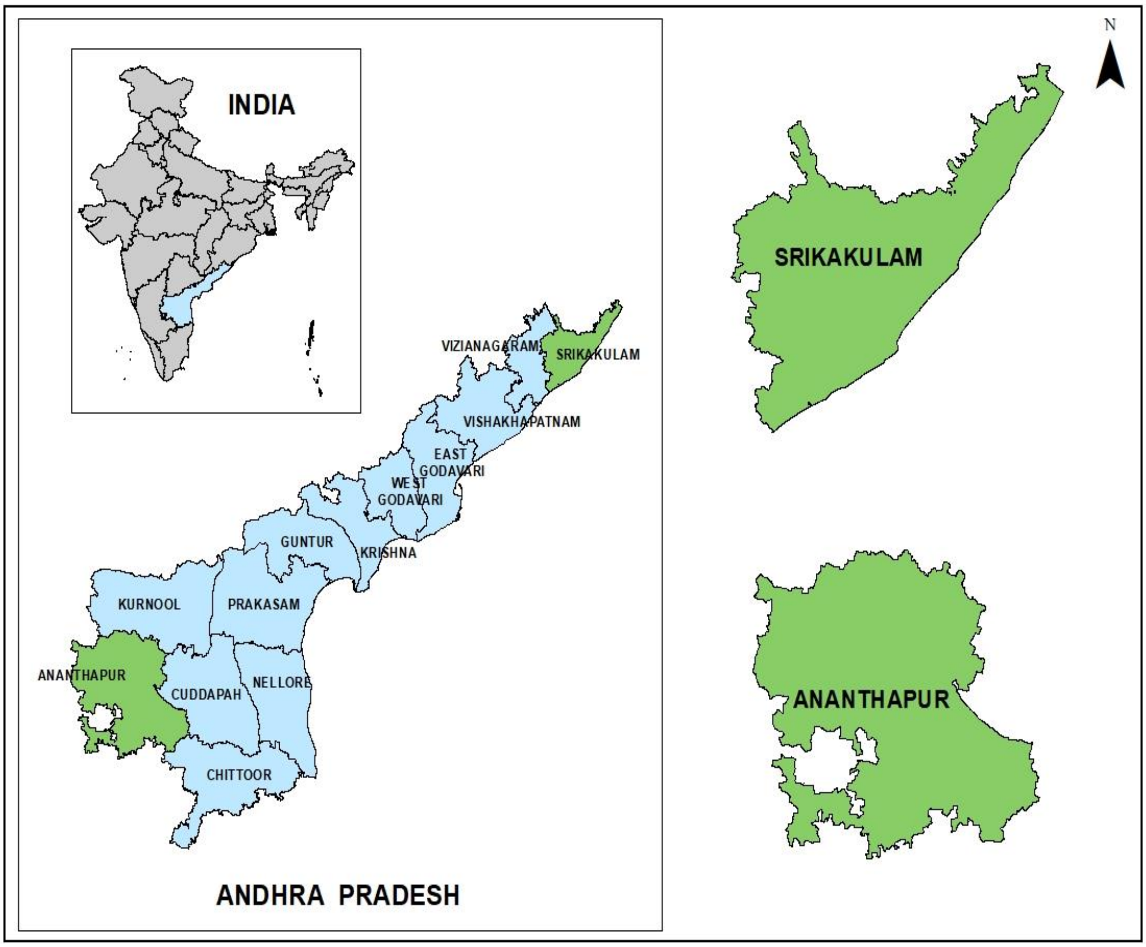

Fig. 1. Map indicates study area

2.2 Analytical Tools Used

Determinants of adoption of CRA technologies was analysed by using binary logistic regression. The logit model assumes that the random variable Z_i predicts the probability of adoption. The basic model of the logit estimation [14] was given below.

$$p_i = F(Z_i) = F(\alpha+\beta X_i) = \frac{1}{(1+\exp Z_i)} \qquad (1)$$

Where,

F (Z_i) the standard normal density function for the possible values of the index Z_i
p_i = the probability of adoption of CRA technologies
X_i = set of explanatory variables
α = regression intercept, and
β= a vector of coefficient. Where, i = 1, 2, 3, ..., n

Where p_i is the probability of adoption of CRA technologies, given X_i (the explanatory variables) and are parameters to be estimated. The log odds of the probability that an individual is willing to adopt CRA technologies is given by

$$Z_i = \log\left(\frac{Pi}{1-Pi}\right) = \alpha + \beta_i X_i + \ldots \beta_n X_n + \mu_i \qquad (2)$$

Where:

i = 1, 2 …. N are observations
Z_i = the natural logarithm of choice for the i^{th} observation
X_n = the n^{th} explanatory observation
β_n = the n^{th} vector of covariates
μ_i = the error or disturbance term.

For this study, the above equation is expressed implicitly as

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + u_i$$

where,

Y = Adoption of CRA technologies (1- adopter, 0-non-adopter)
X_1 = Age of the farmer (in years)
X_2 = Education (years of schooling)
X_3 = Farming experience (in years)
X_4 = Family size (in number)
X_5 = Farm size (in acres)
X_6 = Average annual farm income (in Rs)
X_7 = Perception on climate change (1-yes, 0-otherwise)
X_8 = Access to extension contact (1-yes, 0-otherwise)
X_9 = Membership in organization (1-yes, 0-otherwise)
X_{10} = Access to credit (1-yes, 0-otherwise)

$b_1, b_2 \ldots b_{10}$ are parameters corresponding to estimated variables' coefficients.

u_i is the error term and consists of unobservable random variables.

Marginal effect of a continuous independent variable on the probability. The marginal effect is

$$\frac{dp}{db} = f(bX)b$$

where,

p = the probability of adoption of CRA technologies
b = slope coefficients
X = value of explanatory variables

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

Table 1 depicts the descriptive statistics of sample respondents in Srikakulam district. From the table, the average age of the adopters was 47 years, while that of non-adopters was 48 years. The average number of years of schooling for adopters is 14 years, more significant than that of non-adopters (9.30 years). This indicates that a large section of adopters had a high education level compared to non-adopters in the study area. Adopters (27 years) have more farming experience than non-adopters (23 years). The average family size of adopters and non-adopters is similar in the study area. Non-adopters (3.81) had higher average land holdings than adopters (3.14 acres). Adopters had a higher mean score of 0.73, indicating more access to climate information than non-adopters (0.27). A high mean score of 0.79 for adopters represents a high level of extension contacts, while non-adopters had a relatively low mean score of 0.13. Adopters had a relatively high mean score of 0.57 and 0.89 compared to non-adopters (0.40, 0.37) for access to credit and membership in the organisation, respectively.

Table 1. Descriptive statistics of sample respondents in Srikakulam district

Variables	Srikakulam district			
	Adopters (n=120)		Non-adopters (n=30)	
	Mean	SD	Mean	SD
Age of the farmer	46.68	7.80	47.77	8.44
Education	14.10	5.56	9.30	6.52
Farming experience	27.43	11.19	22.77	13.33
Family size	3.07	1.13	2.57	0.73
Farm size	3.14	1.71	3.81	1.76
Access to climate information	0.73	0.45	0.27	0.45
Access to extension contact	0.79	0.41	0.13	0.35
Membership in organization	0.57	0.50	0.40	0.50
Access to credit	0.89	0.31	0.37	0.49

Table 2 represents descriptive statistics of sample respondents in Anantapur district. From the table, we can see that the average age of the adopters and non-adopters is 40 and 53, respectively, which indicates that adopters were relatively younger than non-adopters in the study area. Adopters (14 years) had a higher level of education than non-adopters (9 years). Both adopters and non-adopters had similar experiences in farming at 23 and 22 years, respectively. Adopters had a higher average family size of 3.81, while non-adopters had a lower average family size of 2.87. Adopters had a higher average total farm size of 4.29 acres, while non-adopters had a relatively lower average farm size of 3.34. Adopters had a higher mean score of 0.76, 0.87, 0.86 and 0.85 compared to non-adopters for access to climate information, access to extension contact, membership in the organization and access to credit facilities, respectively.

3.2 Determinants of the Adoption of CRA Technologies

Logistic regression was used to analyse the determinants for adopting CRA technologies, and the results were presented in Tables 3 and 4.

3.2.1 Age of the farmer

In the Anantapur district, the farmer's age showed a negative relationship and was found statistically significant at a 1 per cent level of significance (LOS). The negative coefficient indicated that age and the farmer's decision to adopt had a negative relationship. The marginal value of -0.007 for this variable indicated that the probability of adoption decreased by 0.7 per cent with a year increase in the farmer's age. Younger farmers were more inclined to adopt CRA technologies than older farmers. As the farmers grow older, there is an increase in risk aversion and a decreased interest in the adoption of CRA technologies. The results were similar to Uddin *et al.,* [15] and Akrofi-Atitianti *et al.,* [16].

3.2.2 Education of the farmer

The respondents' Education showed a positive relationship with the adoption of CRA technologies and was found statistically significant at one per cent LOS. This indicated a positive relationship between the education and adoption decisions of farmers. The marginal values for this variable, 0.062 and 0.066, denote that the probability of adoption increased by 6.2 and 6.6 per cent, with a one-year increase in farmers' Education in Srikakulam and Anantapur districts, respectively. The farmers with higher levels of Education had a higher capacity to adopt CRA technologies, and the knowledge and skills accumulated over the years of formal Education may give them an eagle's eye for progressive pathways. This finding was consistent with Mazhar *et al.,* [10] and Deshmukh *et al.,* [17].

3.2.3 Experience of the farmer in farming

The farmer's experience in farming showed a significant positive relationship with the adoption of CRA technologies in the Srikakulam district and was statistically significant at one per cent LOS. The positive coefficient indicated that the farmer's experience in farming and the adoption of CRA technologies had a positive relationship. The marginal value of 0.078 for this independent variable indicated that the probability of adoption increased by 7.8 per cent with a year increase in the farmer's experience in farming. More experienced farmers were likelier to adopt CRA technologies than less experienced farmers. The results were similar to Denkyirah *et al.,* [18] and Fadina and Barjolle [19].

Table 2. Descriptive statistics of sample respondents in Anantapur district

Variables	Anantapur district			
	Adopters (n=120)		Non-adopters (n=30)	
	Mean	SD	Mean	SD
Age of the farmer	40.28	9.04	53.37	8.25
Education	14.58	4.86	9.50	6.37
Farming experience	23.51	12.57	21.97	10.83
Family size	3.81	1.24	2.87	0.82
Farm size	4.29	2.08	3.34	1.66
Access to climate information	0.76	0.43	0.27	0.45
Access to extension contact	0.87	0.34	0.13	0.35
Membership in organization	0.86	0.35	0.23	0.43
Access to credit	0.85	0.36	0.37	0.49

Table 3. Determinants of the adoption of CRA technologies in Srikakulam district

Variables	Co-efficient	Std. Error	P-Value	dy/dx
Age of the farmer	-0.074	0.002	0.319	-0.002
Education	2.034	0.017	0.000	0.062***
Farming experience	2.578	0.017	0.000	0.078***
Family size	1.666	0.020	0.014	0.051**
Farm size	-0.482	0.012	0.238	-0.014
Annual farm income	1.572	0.015	0.002	0.048***
Access to climate information	3.201	0.044	0.028	0.098**
Access to extension contact	5.409	0.044	0.000	0.165***
Membership in organization	1.101	0.033	0.316	0.033
Access to credit	0.380	0.037	0.756	0.011
Log likelihood	-15.05			
Pseudo R^2	0.80			
Number of observations	150			

*Note: *** and ** indicates statistical significance at 1% and 5% respectively*

Table 4. Determinants of the adoption of CRA technologies in Anantapur district

Variables	Co-efficient	Std. Error	P-Value	dy/dx
Age of the farmer	-0.287	0.002	0.003	-0.007***
Education	2.610	0.017	0.000	0.066***
Farming experience	-0.771	0.024	0.423	-0.019
Family size	0.491	0.018	0.494	0.012
Farm size	0.306	0.007	0.286	0.007
Annual farm income	2.069	0.013	0.000	0.052***
Access to climate information	3.558	0.034	0.010	0.090**
Access to extension contact	6.971	0.042	0.000	0.176***
Membership in organization	2.812	0.029	0.017	0.071**
Access to credit	-1.222	0.038	0.424	-0.030
Log likelihood	-12.23			
Pseudo R^2	0.84			
Number of observations	150			

*Note: *** and ** indicates statistical significance at 1% and 5% respectively*

3.2.4 Family size

The family size of respondents significantly and positively influenced the probability of the farmers' adoption at 5 per cent LOS in the Srikakulam district. The co-efficient showed a positive correlation between family size and adopting CRA technologies. The marginal value of 0.051 implied that the probability of adoption increased by 5.1 per cent with every one per cent increase in family size. The results were aligned with the findings of Kassa *et al*., 2022.

3.2.5 Average annual farm income of the farmer

Respondents' average annual farm income showed a significant positive influence with the adoption of the CRA technologies at one per cent LOS; this showed a positive correlation between farmers' adoption decisions and their average annual farm revenue in both the districts. This variable's marginal values of 0.048 and 0.052 revealed a 4.8 and 5.2 per cent increase in the chance of adoption of CRA technologies with the increase in the average annual income in Srikakulam and Anantapur districts, respectively. Farmers were likelier to adopt CRA technologies because of higher yearly farm incomes and yield. The results obtained were similar to the findings of Kumar *et al*., [11] and Sisay *et al.,* [20].

3.2.6 Access to climate information

Access to climate information had a statistically significant positive relationship with the adoption of CRA technologies at five per cent LOS in both districts. This suggested a beneficial association between farmers' adoption decisions and access to climate information. A marginal value of 0.098 and 0.090 showed a 9.8 and 9.0 per cent increase in the likelihood of adoption of CRA technologies. Farmers with access to climate information were more likely to adopt CRA technologies. Similar results were reported by Balew *et al.,* [21] and Sardar *et al.,* [22].

3.2.7 Access to extension contact

Access to contact with extension agents showed a positive and statistically significant relationship with the adoption of CRA technologies in both districts. It was positively significant at one per cent LOS. Thus, farmers with access to extension services in the cropping season had a higher probability of adopting these technologies than those who did not have access to extension services. Extension officers are generally responsible for transferring technologies to the farmers. One per cent increase in access to extension contacts increased adoption by 16.5 and 17.6 per cent in the Srikakulam and Anantapur districts, respectively. The findings of Bryan *et al*., [23] and Tambo [24] were also similar to the results of this study [25,26].

3.2.8 Access to membership in farmers' organisations

Farmer's membership showed a positive and statistically significant relationship with adopting CRA technologies in the Anantapur district. It was positively significant at five per cent LOS. This suggested a beneficial association between membership and the farmer's adoption decision. A marginal effect value of 0.071 for this variable indicated that the probability of adoption increased by 7.1 per cent with increased access to membership in farmers' organisations. Belonging to farmers' groups/organisations is a source of good quality inputs, labour, credit, information and organised marketing of products. Through this, local institution members regularly share experiences about farming, synthesise new information and innovations, discuss problems, and explore new opportunities in farming. The results were consistent with Bate *et al.,* [13] and Nandini *et al.,* [12].

4. SUMMARY AND CONCLUSION

The study areas, Srikakulam and Anantapur districts, are fragile ecologically, with a high risk of flooding and drought due to climate change and extreme weather events. Climate variability and further current and future change could pose a severe challenge to the smallholder farmers in the area. To identify and implement feasible CRA technologies at the micro level, it is essential to understand and assess factors that influence their adoption. In this study, we investigated the factors that influence the adoption of CRA technologies using binary logistic regression. The results revealed that the farmer's education, farming experience, family size, annual average farm income, access to climate information, access to extension contact and membership in an organization positively and significantly influenced farmers' decision to adopt CRA technologies. While the age of the farmer negatively influenced the farmer's decision. Therefore, it is necessary to set up an appropriate institutional structure to provide climate information, extension services and non-formal education to farmers on the benefits of CRA technologies for the wide spread adoption of CRA technologies.

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 manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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