Determinants for the adoption of Climate Resilient Agricultural Technologies in Andhra Pradesh, India.

Abstract

This study investigated the factors influencing the adoption of climate resilient agriculturaltechnologies in Srikakulam and Anantapur districts of Andhra Pradesh by employing 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, farming experience, family size, annual farm income, access to climate information and access to extension contact significantly influenced the adoption of CRA technologies in Srikakulam district. Similarly, in Anantapur district age of the farmer, education, annual farm income, access to climate information, access to extension contact and membership in organisation 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.

Key words: Adopters, Climate change, CRA technologies, Determinants, Logistic regression model, non-adopters.

1. Introduction:

A region's agricultural acreage, crop production and yieldare all influenced by its climate. Throughout the world there is significant concern about the impact of climate change on agriculture as changes in temperature and precipitation are two major climatic events that impact crop productivity (Malhi *et al* 2021 and Saravanakumar*et al* 2022). In general, developing countries like India bears much of the impact because of their heavy dependence on agriculture. Studies revealed that over the years there is significant warming due to increase in temperatures in India (Kothawale*et al* 2010). Further, it is predicted that mean warming in India is expected to be in the range of 1.7–2°C by 2030s and 3.3–4.8°C by 2080s under the CIMP-5, RCP 6 and 8.5 Scenarios.Precipitation is predicted to increase from 4 to 5 per centby 2030s and from 6 to 14 per cent towards the end of the century (2080s) compared to the 1961–1990 baseline(Chaturvedi *et al* 2012).In Andhra Pradesh, maximum and minimum temperatures are predicted to increase by1.3 to 2°C and 1.83 to 2.17°C respectively by 2050 with an average temperature increase of about 1.0°C (Rao *et al* 2017). It is predictedthat an increase in temperature of 2°C and precipitation by 7 per cent are expected to result in a loss of about 8.4 per cent of total net revenue (Kumar and Parikh 2001).Empirical evidences indicate that due to climate change, the productivity of Indian agriculture will be reduced by the end of this century (Mendelsohn *et al* 2001, Aggarwal, P. K. 2009, Birthal*et al* 2014, Rao *et al* 2022).

In Andhra Pradesh 62.17 per cent of total working population is dependent on agriculture and allied activities. The contribution of agriculture under primary sector to the State Gross Value Added for the year 2020-21Advance 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 gross sown area in Andhra Pradesh is under rainfed condition, the climate change will exert adverse influence on 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(Mazhar *et al* 2021).

In this context, National Innovations on Climate Resilient Agriculture(NICRA) project was initiated by the Indian Council of Agricultural Research (ICAR) in 2011 with the aim of equipping farmers with the necessary coping skills to manage the effects of climate change. To combat the negative effects of climate change and ensure sustainable yields, a range of Climate Resilient Agricultural (CRA) technologies are being promoted. They will sustainably boost agricultural productivity and strengthen the agriculturesystems' resistance to climate change on several levels. These technologies include growing drought and floodtolerant varieties, implementing water and soil conservation measures, introducing new crop varieties and changing planting dates, using crop insurance mechanisms, and irrigation practices.

Ithas been suggested that a variety of factors, including how farmers perceive climate change, the size of their farms, the household, socioeconomic, geographic, and institutional factors, influence these adoption decisions made by farmers(Kumar*et al* 2023, Nandini *et al* 2023). Understanding the factors influencing farmers' decisions to adopt CRA technologies is crucial to help private individuals and policymakers plan for the agriculture sector's future adaptation to climate change (Bate *et al* 2019). 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 the CRA technologies was implemented under the NICRA project through Krishi Vigyan Kendras (KVK's). 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, size of land holding, capital resources, yield, annual farm income, access to extension contacts, credit sources to the farmers, and perception on climate change*etc.* were collected.

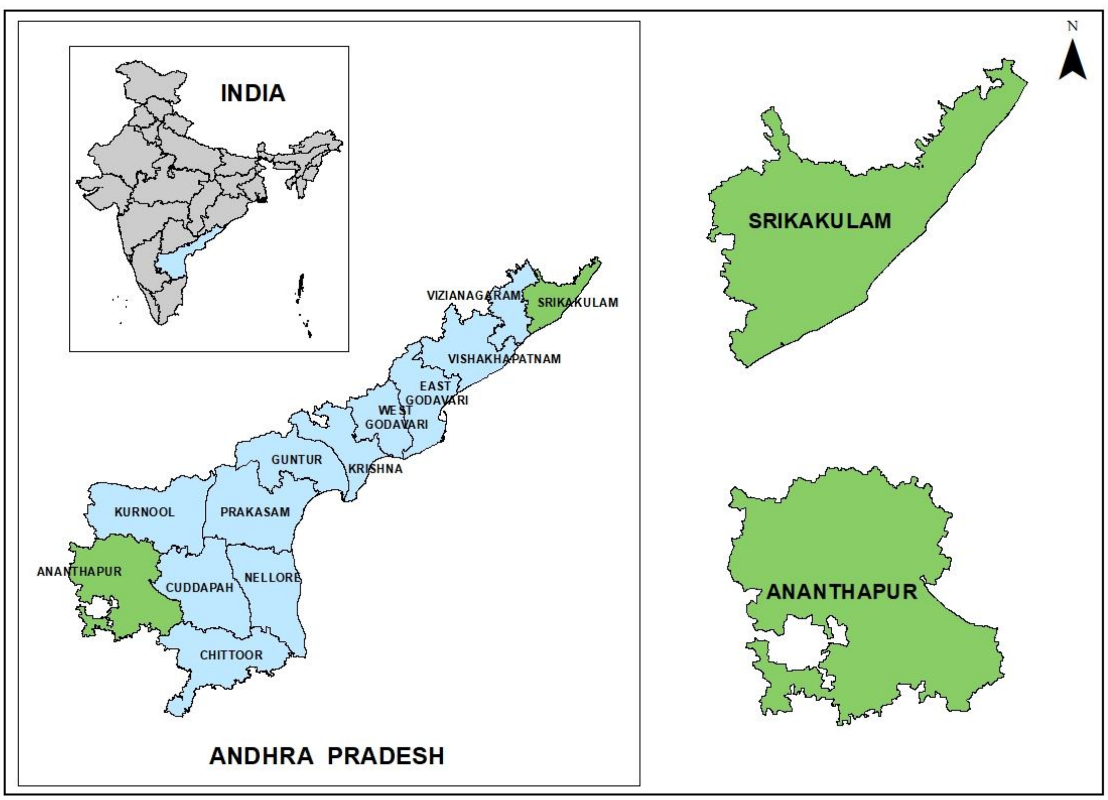

Figure 1. Map indicates study area.

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 (Gujarati, 2004) was given below.

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

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

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

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

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + u_i$$

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: The descriptive statistics of sample respondents in Srikakulam district are presented in Table 1. From the table, the average age of the adopters was 47 years while that of non-adopters is 48 years. The average years of schooling for adopters is 14 years which is greater than that of non-adopters (9.30 years). This indicates that large section of the adopters had high level of education when compared with non-adopters in the study area. Adopters (27 years) have more farming experience than non-adopters (23 years). Average family size of both adopters and non-adopters is similar in the study area. Non-adopters (3.81) had higher average land holding than adopters (3.14 acres). Adopters had higher mean score of 0.73 which indicates more access to climate information compared to non-adopters (0.27). High mean score of 0.79 for adopters represents high level of extension contacts, while non-adopters had relatively low mean score of 0.13. Adopters had relatively high mean score of 0.57 and 0.89 when compared with non-adopters (0.40, 0.37) for access to credit and membership in 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 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 higher level of education than non-adopters (9 years). Both adopters and non-adopters had similar experience in farming of 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 acres. 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 organization and access to credit facilities respectively.

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

3.2 Determinants for the adoption of CRA Technologies

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

3.2.1 Age of the farmer:In Anantapur district, age of the farmer showed negative relationship and was found statistically significant at 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 one year increase in the age of the farmer. When compared to older farmers, younger farmers were more inclined to adopt CRA technologies. As the farmers grow older, there is an increase in risk aversion and a decreased interest in adoption of CRA technologies.It is known that younger farmers were more inventive and resourceful, which enables them to have better access to market knowledge. The results were similar with Uddin *et al.* (2014) and Akrofi-Atitianti*et al.* (2018).

3.2.2 Education of the farmer:Education of the respondents showed positive relationship with the adoption of CRA technologies and was found statistically significant at one per cent LOS. This indicated that positive relation between the education and adoption decision of farmer. The marginal value for this variable 0.062 and 0.066 denotes that the probability of adoption increased by 6.2 and 6.6 percent with one year increase in the farmers' education in Srikakulam and Anantapur districts respectively. The farmers with higher level of education had higher capacity to adopt CRA technologies and the knowledge and skills accumulated over the years of formal education may give them eagle's eye for progressive pathway. This was in consistent with Mazhar *et al.* (2021)and Deshmukh*et al.* (2023).

3.2.3 Experience of the farmer in farming: Experience of the farmer in farming showed positive relationship with adoption of CRA technologies in Srikakulam district and was found to be statistically significant at one per cent LOS. The positive co-efficient indicated that experience of the farmer in farming and 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 one year increase in the experience of the farmer in farming. More experienced farmers were more likely to adopt CRA technologies than less experienced farmers. The results were similar with and Denkyirah*et al.* (2017), Fadina and Barjolle (2018).

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

3.2.5 Average annual farm income of the farmer: The adoption of the CRA technologies was positively correlated with respondents' average annual farm income 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 value of 0.048 and 0.052 revealed a 4.8 and 5.2 per cent increase in the chance of adoption CRA technologies with the increase in the average annual income in Srikakulam and Anantapur districts respectively. Farmers were more likely to adopt CRA technologies because of higher yearly farm incomes due to the higher yield. The results obtained were found to be similar with findings of Kumar *et al.* (2023) and Sisay *et al.* (2023).

Table 3. Determinants for 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 for 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

3.2.6 Access to climate information:Access to climate information was found to have a statistically significant positive relationship with the adoption of CRA technologies at five per cent LOS in both the districts. This suggested a beneficial association between farmers' adoption decisions and the access to climate information. A marginal value of 0.098 and 0.090 showed that a 9.8 and 9.0 per cent increase in the likelihood of adoption of CRA technologies. CRA technologies were more likely to be adopted by farmers who had access to climate information. Similar results were reported by Balew*et al.* (2014) and Sardar *et al.* (2021).

3.2.7 Access to extension contact:Access to contact with extension agent showed positive and statistically significant relationship with the adoption of CRA technologies in both the districts. It was positively significant at one per cent LOS. Thus, farmers who had access to extension services in the cropping season had higher probability of adopting these technologies than those who did not have access extension services. Extension officers are generally responsible for transferring technologies to the farmers. As one per cent increase in access to extension contacts found increase adoption by 16.5 and 17.6 per cent in Srikakulam and Anantapur district respectively. The findings of Bryan *et al.* (2013)and Tambo (2016) were also similar to the results of this study.

3.2.8 Access to membership in farmers' organisation:Farmers membership in farmers' organisation showed positive and statistically significant relationship with the adoption of CRA technologies in 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 percent with increase in the access to membership in farmers' organisation. Belonging to farmers' group/organizations serves as a source of good quality inputs, labour, credit, information and organized marketing of products. Through this, local institution members participate regularly to share experiences about farming, synthesize new information and innovations, discuss problems and explore new opportunities on farming. The results were consistent with Bate *et al.* (2019)and Nandini *et al.* (2023).

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 serious challenge to the smallholder farmers in the area. To identify and implement feasible CRA technologies at the microlevel, it is essential to understand and assess factors that influence their adoption. In this study we have investigated the factors that are influencing the adoption of CRA technologies using the binary logistic regression. The results revealed that education of the farmer, 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 age of the farmer negatively influenced the farmers 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.

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