Climate resilient technologies, adaptation, mitigation and their influence on farm income in Telangana State of India

ABSTRACT

Climate change is a challenge for developing countries like India due to climate variability. The study area of Telangana is also prone to frequent droughts, resulting in distress among farming communities, and witnessed crop failures leading to farmer's suicides. The State Action Plan on Climate Change (APCC) reported these issues of drought and heat waves in agriculture. Therefore, the present study was undertaken in 2017-18 by using an ex-post facto research design to assess the climate resilient technologies, mitigation strategies adopted here, and their influence on farm income among the already ascertained most vulnerable Mahabubnagar district and least vulnerable Khammam district farmers of Telanagana State. A total of 480 respondents, 240 from each district, were selected randomly. The technology adoption index was constructed to ascertain the extent of adoption of climate-resilient technology, and further study analyzed the factors influencing the adaptation of climate-resilient, technologies such as the technology adoption index on household farm income, along with other factors. The results of the study indicated that different strategies adopted by farmers in mitigating climate change, such as use of drought-tolerant varieties and life saving irrigations had a positive influence on adaptation to climate change. Further, the study reported that the technology adoption index (TAI) showed a positive, non-significant impact on farm income in both scenarios considered i.e. Mahabubnagar and Khammam which implies that there needs, adopting more technologies intensively and timely, have to significant influence on farm income.

Keywords: Climate resilience, Agriculture, Technology Adoption Index, Climate-resilient technologies, Telangana.

INTRODUCTION

Climate change can be understood as a long-term phenomenon indicating the statistical distribution of weather patterns over a period of time ranging from decades to millions of years (IPCC, 2011). Climate change is an important issue for the 21st century, requiring renewed attention by all stakeholders to address its adverse impact on agricultural productivity, the environment, and its effect on food security (Fischer, 2001). Livelihoods can be defined as an adequate stock and flow of food and cash for an individual or a family to meet its basic needs (Acharya, 2006). Agriculture provides such a livelihood to more than half of the Telangana state's workforce, which is crucial for restoring sustainable growth in the rural economy. According to (Rehana, 2018) the frequency of severe and widespread multi-year droughts is due to erratic summer monsoon, and an increase in air temperature, creating huge damage to crops and society. Crop failure due to drought has resulted in 342 farmers committing suicide, in 2015 as reported by the Ministry of Agriculture, Government of India. In 2016, about 14 lakh people from Mahabubnagar, Ranga Reddy, Medak, and Nizamabad migrated to Hyderabad and other cities like Pune, Mumbai, and Ahmedabad, as mentioned in the report of farmers organizations (Hindustan Times, 2016). Hence, climate extremes pose a serious threat to crop yields, food security and farm income [Kalli and Jena, (2022, 2023)]. Effectively addressing climate change in agriculture requires a comprehensive strategy, with the focal point being a transition toward agricultural practices resilient to climate variations. Theoretically, farmers can adopt climate-resilient practices through a combination of external and internal factors. External factors play a role in rebuilding farmers' capacity to enhance their adaptive skills. Access to extension services, such as training [Tanti et al. (2023), Zakaria et al., (2020)], farm field schools (Osumba *et al.*, 2021), and demonstrations, makes farmers aware and knowledgeable about the Climate-Smart Agricultural (CSA) practices [Mgendi et al., (2021), Makate et al., (2019)]. Farmers who receive credit from public banks, private banks, and cooperative societies are better equipped to adopt climate-resilient practices (Kongogo et al.,2021).

Based on the above background, it can be concluded that there is a low level of awareness about climate change and knowledge of the factors influencing the decision with the suitable adaptation strategies and the extent of adoption of those strategies by the farmers. Coping and mitigating adverse effects of climate change depends on the behavior of climatic variables, accordingly, the present study has been taken up at the district level in Telangana.

METHODOLOGY

The present study was undertaken in 10 erstwhile districts of Telangana state. Paddy, maize and cotton are the three major crops widely grown in Telangana, which constitute a major part of the total cropped area. The climate-resilient technologies for all the above mentioned crops were identified, and further primary data pertaining to the information on qualitative factors vis-a-vis climate change, adaptation strategies, and coping mechanisms adopted by the farmers was collected purposively from the already, selected villages of the most vulnerable (Mahabubnagar) and least vulnerable (Khammam) districts of Telangana state after ranking all the districts based on the estimated vulnerability indices.

1. Technology Adoption Index (TAI): An adoption index was constructed to quantify the adoption of such technologies:

TAI = A/P*100

where,

A = Number of practices adopted by respondents, and

P = Total number of practices recommended.

2. Multiple linear regression

$$\mathbf{Y_i = B_O + B_1X_1 + B_2X_2 + \text{----------} + B_n X_n + e}$$

Where, for i=1 to n observations

Y_i = dependent variable

X_i = explanatory variables

B_o = Intercept

B_i = slope coefficient

e = error term

3. Tobit model

Adoption of agricultural technology generally involves a two-part decision-making process: whether to adopt and then how much to adopt. The Tobit model can be used in analyzing adaptation when the two decisions are made jointly.

Results and discussion

1.1 Adaptation to climate change by sample farmers

The data on various adaptation strategies being used by the farmers against the changing climate was collected and presented in Table 1. A dialogue with the respondents on adaptation of technologies against climate aberrations is followed by the respondents in both scenarios considered, i.e., the most and least vulnerable districts. The results revealed that Mahabubnagar and Khammam districts were practicing improved irrigation related to micro irrigation technologies as adaptation measures to combat the continuous occurrence of drought. In addition, to cope with climate variability, the study found that farmers adopted a wide range of management practices, such as adapting drought tolerant / resistant varieties, changing the variety in use and selecting a resistant variety (96.25%), change in cropping pattern, and delayed sowing (99.58%). The most vulnerable conditions prevailing in Mahabubnagar district due to frequent droughts might have been the reason for adapting drought tolerant varieties. As the farmers are comparatively well-to-do and are earning better in Khammam, they have the ability to change cropping patterns which might attract new investment or bear the risk of delay in sowing. Apart from these, use of trap crops, use of bio pesticides, staggered planting, delay in sowing, moisture retention by making deep furrows, mulching, adoption of contingent crops, leaving one season and going for the next season and providing one life saving irrigation *etc* were considered and ranked in the order of their usage by a large number of farmers. Most of the farmers in both the districts were leaving the existing crop and going for next season for cultivation in cases of climatic conditions. Due to recurring under rainfed conditions farmers in the study area preferred drought tolerant crop varieties. Information on adaptation to climate change utilizing these technologies was used to develop a technology adoption index, and the results are furnished in Table 1. Developing the adoption of technology indicators is difficult and complicated to calculate, as majority of the farmers cannot distinguish which measures they practice can be called technology and which they practice based from indigenous knowledge or experience. But the practices followed by respondents which clearly have a bearing on climate resilience, were considered carefully. A technology adoption index has been worked out for each sample farmer and found that technology adoption index ranged from 51 to 70 percent in both districts.

Table 1 Adoptions of technology to climate variability by respondents in Khammam and Mahabubnagar districts (n1= 240 and n2= 240)

Adaptation	Khammam		Mahabubnagar	
	Number	Rank as per priority	Number	Rank as per priority
Change in variety such as Drought tolerance / resistant varieties	235 (97.91)	2	231 (96.25)	1
Change in cropping pattern and delayed sowing	239 (99.58)	1	227 (94.58)	2
Staggered planting	114 (47.50)	5	122 (50.83)	5
Leaving existing an crop and growing another crop	108 (45.00)	9	112 (46.67)	8
Leaving the existing crop and growing next season	125 (52.08)	3	130 (54.17)	3
Moisture retention by making deep furrows etc	109 (45.42)	8	125 (52.08)	4
Mulching	106 (44.17)	10	113 (47.08)	7
One life saving irrigation	115 (47.92)	4	111 (46.25)	9
Use of trap crops such as marigold, cowpea and bhendi	110 (45.83)	7	122 (50.83)	5
Use of pesticides	111 (46.25)	6	116 (48.33)	6

Based on the calculation of technology adoption index (TAI) for all the respondents were classified as low adopters (0-25), medium adopters (26-50), semi medium adopters (51-75) and high adopters (75 -100) and presented in Table 2. The technology adoption index ranged from 0-100. Evidently, it was found that only 7.5 % and 2.92 % of the erstwhile Khammam and Mahabubnagar districts were low adopters, so it can be understood that the lowest level of technology adoption was observed in Mahabubnagar farmers compared to Khammam. This might be due to the least loss incurred, so they might not have adopted many measures to combat the drought in Mahabubnagar district. Mean Technology adoption index for Khammam sample farmers is 48.2, while that of Mahabubnagar is 57.54.

Technology adoption index in case of medium adopters among Khammam sample farmers about 57.5% were there when compared to 39.18% of farmers in Mahabubnagar. But when the semi medium level of adaptation among these districts was compared to 42.08% of Mahabubnagar farmers they were found to have adopted more technologies than 31.67% of farmers in Khammam. It can be concluded that the vulnerability scenarios both do not show a differentiated effect on the technology adoption index it is the income, resource endowment, awareness, affordability and knowledge gained from the media and their fellow farmers that might have helped them decide which set of adaptation measures to follow.

Table 2 Technology adoption index among the sample farmers

Distribution of TAI (%)	Number of Farmers	
	Khammam	Mahabubnagar
Low Adopter TAI (0-25)	18 (7.50)	7 (2.92)
Medium Adopters TAI (26-50)	138 (57.50)	94 (39.18)
Semi Medium Adopters TAI (51-75)	76 (31.67)	101 (42.08)
High adopters TAI (>75)	8 (3.33)	38 (15.82)
Mean Technology Adaptation Index	48.2	57.54

1.2 Determinants of the level of adaptation to climate change in agriculture

From the results, it is inferred that the coefficient of farm income has a positive influence on adaptation to climate change in Khammam but negative in Mahabubnagar district, implying that the higher the farm income, higher the willingness and level of climate adaptation technologies and vice versa in Mahabubnagar as it is the most vulnerable district. Unlike other limited dependent models, the coefficients in the Tobit model can be interpreted directly with the magnitudes of influencing the level of adaptation to climate change. It could be interpreted as one unit increases in the farm income, will be produce a chance of a 3.05 percent increase in adaptation to climate change. Farm size was negatively associated with the level of adaptation to climate change in both the districts, and the coefficient -1.806* was statistically significant in Khammam, implying that smaller the farm size, higher the intensity of adaptation to climate change, which may be the cost to be incurred for following adaptation technologies might increase as farm size increases. If one unit increases in the farm size, there will be a chance of a decrease of 1.8 percent in adaptation to climate change among the Khammam district respondents. Similarly, the coefficient of access to credit was negative but highly significant, implying that the higher the access to credit, the lower will be the level of adaptation. If one unit increases in the credit access will give chance of decreasing 4.95 percent in adaptation to climate change in agriculture because farmers might not come forward for utilize their credit money towards climate adaptation technologies due their risk averse attitude.

Table 3 Determinants of climate change adaptation

Variables	**Khammam**			**Mahabubnagar**		
	Coefficient	**Standard error**	**Pr(>|z|)**	**Coefficient**	**Standard error**	**Pr(>|z|)**
Intercept	2.719	4.568	2.00E-16	2.714	4.568	2.00E-16
Age	5.927	1.669	0.7225	1.779	1.338	0.1838
Farming experience	1.41	1.679	0.401	**5.361*** **	2.102	0.0108
Education	2.884	1.962	0.1415	2.007	2.116	0.343
Farm income	**3.053***	1.761	0.83	-1.457	1.696	0.948
Farm size	**-1.806***	9.804	0.0655	-3.425	1.019	0.8863
Extension contact	2.21	2.077	0.9153	**3.425***	2.007	0.0879
Access to credit	**-4.95*****	2.016	0.0141	2.02	1.995	0.3113
Membership in farmer associations	2.7	2.027	0.1829	2.215	2.038	0.2771
Climate change awareness	2.641	2.687	0.9217	3.533	2.024	0.8614
Depth of ground water levels	-1.27	1.635	0.4374	-2.514	1.719	0.1437
Log-likelihood	-993.193			-986.17		

Note:* and *** indicate .1 and .001 level of significance

1.3. Performance of various factors influencing farm household income in different scenario

In order to study if there is any significant influence of level of technology adaptation on farm income along with other factors such as age, education, farm size, seed, cropping intensity, fertilizer use, plant protection chemicals, experience, number of members available for farm work, human labor, credit availability, and cropping intensity were considered and multiple linear regression analysis and Tobit analysis were carried out, and the results were presented in Table 4

Table 4 Factors influencing farm household income in most and least vulnerable scenarios

Variables	Khammam			Mahabubnagar		
	Coefficients	Standard Error	P-value	Coefficients	Standard Error	P-value
Intercept	4857.623	10274.161	0.637	7822.869**	5197.420	0.001
Age	393.100**	141.514	0.006	39.884	67.332	0.554
Education	26.102	188.828	0.890	171.269	115.932	0.141
Size of land holding	88.644	787.708	0.910	3703.311***	989.606	0.000
Experience	117.451	131.977	0.374	100.284	135.368	0.460
Technology adoption index (TAI)	8.318	61.382	0.892	15.451	36.540	0.673
No. of members available for farm work	458.833	430.202	0.309	2.000	669.998	0.555
Credit availability	0.372**	0.125	0.003	-0.023	0.024	0.334
Human labour	-0.081	0.290	0.781	-0.107	0.198	0.589
Machine labour	-0.999	0.787	0.206	-0.256	0.566	0.652
Cropping intensity	0.127	0.079	0.110	0.010	0.018	0.998
Irrigation	2.900	2.454	0.239	-2.345	1.262	0.064
Seeds	- 0.985**	0.289	0.001	- 0.724***	0.163	0.000
Fertilizer and manures	1.888***	0.424	0.000	0.384	0.285	0.179
Plant protection	-3.213**	1.003	0.002	-0.274	0.439	0.533
R square	31.330			36.510		

Note: ** and * indicate .01 and .001 level of significance**

The results presented in Table 4, indicated that the technology adoption index (TAI) showed a positive, non significant impact on farm household income in both scenarios considered i.e. Mahabubnagar and Khammam, which implied that they could adopt more technologies intensively and timely; to have a significant influence on farm income. This calls for intensification of research in the direction of developing more crop specific strategies, technologies, including drought tolerant and disease-resistant ones, and popularizing the same information using all the digital tools to ensure faster implementation of those technologies at the field level. Among the other variables considered, seeds and plant protection chemicals showed a negative correlation with farm income, indicating excessive use in both districts. However, fertilizers (1.888) and credit availability (0.372) have significantly influenced farm income in Khammam district. In Mahbubnagar, the size of the holding has significantly influenced the farm income implying that there is a need to consolidate the holdings to realize economies of scale.

The results are in line with the study conducted by Jena et al. (2023), where findings show that both paddy crop yield and net agricultural income have been higher for the adopters of crop rotation and integrated soil management, while, adoption of technologies resulted in an increase of 42–45% in farm income. Further, adoption of these practices led to a yield improvement of about 2.5 quintals per acre of paddy crop for the adopters. The major drivers that jointly influenced farmers to adopt these practices were found to be access to extension services, access to credit, subsidies for seed, and electricity use in agriculture.

Conclusion

It can be concluded that among all districts of Telangana, there was a general trend of narrowing crop diversification which has to be widened. The decline in crop diversification resulted in crop failures followed by market failures, and subsequently reduced farm income. The climate resilient technologies that are proved successful must be promoted. Providing subsidies for the cultivation of millets and creating market linkages might help in bringing crop diversity to the districts with high vulnerability. There is a need to reorient the extension approach to promote climate adaptation technologies, and necessary measure, have to be taken to increase the purchasing power of the farmer as the climate adaptation technology index produced a non significant positive impact on farm income.

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