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Assessment of Farmers' Adoption Level of Climate Change Adaptation Practices in the Southern Parts of Tamil Nadu

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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

Climate change is a global hazard to the world's food and nutritional security. As greenhouse-gas emissions in the atmosphere rise, so does the temperature due to the greenhouse effect. The average world temperature is steadily rising and is expected to climb by 2 degrees Celsius by 2100, resulting in significant global economic losses. Climate variability in the form of temperature and precipitation may impact on agricultural production and productivity. The study was conducted in the wetland, dryland, and garden land farming systems of the Tamil Nadu districts of Madurai and Sivagangai with a sample size of 120 farmers. Descriptive statistics were used in this study. For compare all three systems; a simple percentage analysis was performed. The majority of respondents in the wetland (65.00%), dryland (70.00%), and garden land (75.00%) farming reported a medium level of climate change adaptations. Cropping system diversification includes

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mixed cropping (65.00%), intercropping (36.66%), perennial and tree crop agriculture (30.00%), and fallow cropping (25.8%). Summer ploughing (36.67%) and micro-irrigation systems (34.17%) were among the water conservation strategies used by nearly one-third of those polled. The majority of respondents (85.00%) were rearing cattle followed by working as a r worker (off-farm activities) (56.67%) in the local industry is the second most common income diversification activity done by farmers.Government and agencies must play an important role in improving farmers' adaptive capacity by disseminating agrometeorological data and tools, conducting vulnerability assessments, and providing policy advice to strengthen institutional approaches to disaster risk reduction so that farmers can respond to the immediate risks of climate change and make the best use of climate variability.

Keywords: Adoption level; adaptation practices; climate change; crop diversification.

1. INTRODUCTION

Adapting to climate change necessitates that farmers first recognize that the climate has changed and then find and apply valuable modifications. The process of adaptation is divided into two parts. The first step is for the farmer to understand what climate change is. And what are the hazards associated with it? In the second step, the farmer reacts to the perceived changes to mitigate their adverse effects. Farmers were reported to be taking passive measures to adapt to climate change [1]. Farmers' perceptions of climate change's threat and severity have the most important motivational factor in voluntary mitigation [2]. India is suffering terrible climatic conditions, which significantly influence people's livelihoods. Because of its enormous agricultural sector, large population, rich biodiversity, long coastline, and high poverty levels, it is one of the most susceptible countries [3]. Climate change's potential implications must be examined to ensure the long-term viability of any future agricultural development [4]. According to Bahinipati and Patnaik [5], Indian farmers are implementing various farm-level adaptation strategies to mitigate the potential impacts of climate change and extreme events. The observed climate-driven agricultural production variability must be better described to determine which specific factor(s) (temperature, precipitation, or both) influence crop yield variability [6]. Farmers preferred to adopt improved varieties and short duration crops, substitute cash crops for cereals, drought-tolerant crops, dug tube wells to supplement water supply, improve short variety duration crops, reduce high water requiring rice cultivation, adopt mixed cropping, shift to mono-cropping of soybeans, increase sugar cane or other high-value cultivation (canal irrigation), delayed cultivation to conserve rainwater, and income diversification [7]. Even though various policy initiatives are in place to promote farm-level adaptation strategies, states have a low implementation rate [8]. The majority of them adapt by growing heat-tolerant crops for short periods of time, advocated building small check dams, increasing unpredictability for monsoon rains, preserving existing farm ponds, and modifying farm operations and crop calendar. Farmers were unanimous in their desire to promote diverse livelihood options to safeguard their livelihoods in climate change-related hazards such as crop damage, pests, and insect assault. It was advised that other adaptation options, such as agricultural weather insurance and early warning systems, and drought/salt-tolerant seeds, be more widely used to meet their adaptation needs [9]. The supports the use of climate change adaptation measures may take into account location-specific factors that influence farmers' perceptions of climate change and adaptive responses to it [10]. Hence, finding factors that influence farmers' adaptive behaviour is the primary study question for various studies. Accordingly, this study was conducted in southern part of Tamil Nadu to identify farmers' adoption level of climate change adaptation practices.

2. MATERIALS AND METHODS

2.1 Study Area and Sampling

This research was conducted in the wetland, dryland, and garden land farming systems of Tamil Nadu's Madurai and Sivagangai districts. The sample size for the study is 120, with 40 each from wet, dry, and garden land situations.

2.1.1 Location and geographical feature

Madurai district is considered Tamil Nadu's southern capital. It is bordered on the north by

Dindigul and Thiruchirappalli districts, on the east by Sivagangai, on the west by Theni, and on the south by Virudhunagar. It covers 3741.73 square kilometres. It is located between 9°30' and 10°30' north latitude and 77°00' and 78°30' east longitude. In Madurai district, the total cultivable area is around 1, 17,678.33 acres.

Sivagangai district is flanked on the north and northeast by Pudukkottai District, on the southeast and south by Ramanathapuram District, on the southwest by Virudhunagar District, on the west by Madurai District, and on the northwest by Tiruchirappalli District. Sivagangai district is located between 9° 43' and 10° 2' north latitude and 77° 47' and 78° 49' east longitude. The entire cultivable land in the Sivagangai district is 1,83,338 acres.

2.1.2 Climate

The climate in Madurai district is moderate, with no extremes. Summer temperatures are 40°C, while winter temperatures are 27°C. The district has a subtropical climate with temperatures ranging from 15°C to 41°C. Summer is really hot. Summer day temperatures range from 31°C to 41°C. January average temperatures are 26°C, February average temperatures are 26°C, March average temperatures are 29°C, April average temperatures are 32°C, and May average temperatures are 33°C. During the North East monsoon, it receives a lot of rain. Rainfall totals 335.9 mm during the South West monsoon and 419.1 mm during the North East.

The climate of the Sivagangai district is tropical wet and dry. The maximum temperature in the summer is 39 °C, and the minimum temperature in the winter is 28 °C. The minimum temperature ranges from 24.5 to 26.0 degrees Celsius. The seasonal climate conditions are mild, and the weather is consistently pleasant. During the North East monsoon, the town receives a lot of rain. The average annual rainfall is 336.2 mm. The town receives 931 mm of rainfall on average each year.

2.2 Data Collection and Analysis

A semi-structured interview schedule was developed based on the objectives and variables under consideration. The interview schedule was pre-tested in a non-sampling area before it was finalized. Following pre-testing, any inconsistencies discovered were corrected, and the data gathering schedule was completed. This research employed descriptive statistics. F test and Simple percentage analysis of acquired data from survey respondents were used to compare all three systems via wetland, dryland, and garden land.

3. RESULTS AND DISCUSSION

3.1 Adoption of Climate Change Adaptation Practices

Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or benefit from climate change opportunities [11]. So the different adaptation measures followed by the respondents were studied and discussed in the following subheads [12].

3.2 Crop Selection and Sowing

The selection of a particular crop or variety is an essential aspect of the farming operation. It was followed by the farmers based on their climatic factors, soil type, market demand, and cost of production. So the adaptation measures followed during crop selection and sowing to overcome the problems due to climatic changes in crop production are studied and given in Table 1.

It could be observed from Table 1 that if we consider all the categories combined together, the majority of the respondents had selected the crop according to the climate variability (70.83%) and selection of suitable variety for their conditions (66.67%). In sowing operations, nearly half of the respondents only followed the direct sowing or sowing after precipitation (41.67%) and changed or delaying the planting dates to adjust the climatic changes (47.50%).

A comparison of the three land systems in the adaptation of cropping selection and sowing due to the climate changes revealed the following observations. Almost in all the land systems, half of the respondents had selected the crops according to the climate variability. For the selection of variety with drought-tolerant, short duration, pest and disease resistance is concerned, three fourth of respondents in the wetland (75.00%) had adopted it whereas in the garden (65.00%) and dryland (60.00%) conditions nearly three – fourth of respondents had adopted. Direct sowing or sowing after precipitation adopted by more than 80% of the respondents in the dryland (82.50%) followed by garden (40.00%) and wetland (27.50%) respondents due to the effect of climate change. Changing or delaying the sowing, planting, and transplanting was adopted more in the wetland (72.50%), followed by garden land (45.00%) and dryland (25.00%) respondents for adjusting the crop to the climatic conditions. Among the four adaptation measures, changing the date of sowing /planting was found be differ in adoption pattern among dry, wet, and garden land conditions, which was substantiated by a significant 'F' value (4.528) at a five percent level of probability.

3.3 Water Conservation Measures

Water is an essential component of agriculture. The climatic changes cause monsoon failures and lead to the scarcity of water. So the conservation and storage of water is also an adaptation measure to mitigate the climate change effects on agriculture. The adoption details of water conservation practices for mitigating the climatic changes in the study area are provided in Table 2.

Table 2 shows that when we put three categories of respondents together, 20% of the respondents only formed the water storage structures. Nearly 30% of them used moisture conservation techniques (28.33%) during the cropping season to avoid the effects of climate change. About one-third of the respondents followed summer ploughing (36.67%) and micro-irrigation systems (34.17 %) to conserve water.

If we compare the water conservation measures adopted due to climate change, the formation of water storage structures like farm ponds and moisture conservation techniques was very low among the respondents of the three categories. It was found that the negligible number of dryland farmers adopted the practice of erecting farm ponds/water conservation structures, despite many government programs being in garden land and wetland micro-irrigation was adopted by the farmers due to the government support and their learning from other farmers who have adopted micro-irrigation and harvested the benefits. The 'F' value of the water conservation measures was not significant, which indicates that there existed no significant difference in the adoption of moisture and water conservation measures among the farmers of wet, dry, and garden land systems.

3.4 Diversification of Cropping System

Climatic change causes severe loss in yield and income in farming, particularly the cultivation of a single crop is becoming riskier because of its failure. Diversification in the cropping pattern may ensure the farmers get additional income and adjust themselves to agriculture. The adoption pattern of crop diversification in the study area is presented in Table 3.

Table 1. Distribution of respondents based on their adoption of crop selection and sowing due to climate change (n=120)

S.No.	Adaptation measures	Wetland		Dryland		Garden land		Total		F value
		No.	%	No.	%	No.	%	No.	%	
1	Selection of crop according to the climatic variability	27	67.50	32	80.00	26	65.00	85	70.83	2.419^{NS}
2	Selection of short duration/ climate specific variety / Pest and disease resistant /drought tolerant variety	30	75.00	24	60.00	26	65.00	80	66.67	0.596 ^{NS}
3	Direct sowing or sowing after precipitation	11	27.50	33	82.50	16	40	50	41.67	1.560 ^{NS}
4	Changing the date of planting/ transplanting	29	72.50	10	25.00	18	45	57	47.50	4.528*

*(Multiple response *)*

Table 2. Distribution of respondents based on their adoption of water conservation measures to mitigate the effects of climate change (n=120)

S.No.	Adaptation measures	Wetland		Dryland		Garden land		Total		F value
		No.	%	No.	%	No.	%	No.	%	
1	Formation of farm ponds / Water harvesting structures	11	27.50	2	5	11	27.50	24	20.00	2.419^NS
2	Summer plough	25	62.50	4	10	15	37.50	44	36.67	0.596^NS
3	Micro irrigation system	19	47.50	1	2.5	21	52.50	41	34.17	1.560 ^NS
4	Formation of moisture conservation structures	12	30	7	17.50	15	37.50	34	28.33	1.652^NS

*(Multiple response *)*

Table 3. Distribution of respondents based on their adoption of crop diversification due to climate change (n=120)

S.No.	Adaptation measures	Wetland		Dryland		Garden land		Total		F value
		No.	%	No.	%	No.	%	No.	%	
1.	Intercropping	4	10	15	37.50	29	72.50	44	36.66	23.96**
2.	Mixed cropping	25	62.50	26	45.00	27	67.50	78	65.00	2.388^NS
3.	Fallow cropping	22	55.00	6	15.00	3	7.50	31	25.83	2.965*
4.	Tree and perennial crops/ Agro-forestry	10	25.00	0	0	26	65.00	36	30.00	26.528*

*(Multiple response *)*

It could be understood from Table 3 that out of 120 respondents, 78 farmers followed mixed cropping (65.00%). At the same time, 44 of them adopted intercropping (36.66%) followed by the cultivation of perennial and tree crops (30.00%) and fallow cropping (25.83%).

In wetlands, more than half of the respondents had adopted a mixed cropping system (62.50%) and fallow cropping (55.00%), and one-fourth of them were cultivating tree crops (25.00%). Paddy and banana were cultivated in the major area as mono-crops in the wetland system. Only a few respondents were growing vegetables as intercrop in the coconut fields. During the fallow season, sesame is cultivated in the wetlands. In drylands, nearly half of the respondents had adopted the mixed copping system (45.00%). More than one-third of them adopted intercropping (37.50%), and only 15.00 percent of the respondents followed fallow cropping. Black and green grams were grown in mixed cropping while red grams were grown as an intercrop in cotton cultivation. In garden land conditions, most farmers practiced intercropping (72.50%) and mixed cropping (67.50%) systems. Groundnut was grown as intercrop in mango orchards. Vegetables like chili, tomato, and onion are grown in the mixed cropping system in the garden land. More than half of the farmers grew mango and coconut trees as perennial crops to overcome the climatic problems.

The 'F' value was significant for intercropping (23.96), tree or perennial crop cultivation (26.528), and fallow cropping (2.965), which indicated the existence of substantial differences among the three systems for these practices. It could be concluded that farmers in garden land and dryland had diversification in the cropping system. In contrast, wetland farmers were following the only mono-cropping pattern, and it may be due to the crops in the wetlands are not suitable for intercropping and mixed cropping.

3.5 Income Diversification

The economic condition of the farmers used to be affected or slowed down due to the repeated crop failure due to the weather fluctuations. In this situation, the diversification of farm enterprises could act as a source of income to retain their economic status. So the details about income diversification were studied among the respondents of three types of farming systems, and the data is presented in Table 4.

Table 4. Distribution of respondents based on their income diversification due to climate change (n=120)

S.No.	Adaptation measures	Wetland		Dryland		Garden land		Total		F value
		No.	%	No.	%	No.	%	No.	%	
1.	Cattle rearing	30	75.00	26	65.00	28	70.00	102	85.00	0.876^{NS}
2.	Poultry rearing	7	17.50	3	7.50	5	12.50	15	12.50	0.596^{NS}
3.	Farm labours	15	37.50	10	25.00	20	50.00	45	37.50	1.560^{NS}
4.	Off-farm activities	25	52.50	35	62.50	30	55.00	68	56.67	1.765^{NS}

*(Multiple response *)*

It could be understood from Table 4 that when we took all the respondents as a whole, the majority of the respondents were rearing the cattle (85.00%) like cows, sheep, and goats, followed by working as a labour or workers (off-farm activities) (56.67%) in nearby industries as income diversification activities. More than one-third of the respondents worked as farm labour (37.50%), and only 12.50 percent of the respondents were involved in poultry rearing activities. In wetlands, the majority of the respondents were rearing cattle (75.00%), followed by those involved in off-farm (52.50%) and working as farm labourers (37.50%). Meager percent of the respondents were involved in poultry rearing (17.50%) in their households. The similar pattern of income diversification which was observed in the wetland, was observed in dry and garden lands. Cattle rearing was a primary source of income in both the farming systems, with 65.00 percent and 70.00 percent of the respondents in dry and garden land, respectively, taking the cattle rearing. Off-farm activities followed this, with 62.50 percent of respondents in dryland and 55.00 percent of the respondents in the wetlands choosing this as the income diversification option.

The 'F' value of income diversification activities was non-significant, which is clear that there is no significant difference observed among the respondents of wetland, garden, and dryland with respect to income diversification activities. From the above results, it is inferred that cattle rearing was one of the vital income diversification activities, and it was followed by the majority of the farmers irrespective of the farming system. Some of the farmers had moved from farming to other industry works due to the difficulties faced in farming, which is reported to be yet another essential income-earning activity. Apart from these two, some of the farmers were working as a labour in other agricultural fields.

3.6 Overall Adoption of Adaptation Measures to the Climate Change

The adoption of different adaptation measures followed by the respondents was summarized, and the data was classified and given in Table 5. From Table 5 that if all the respondents were pooled, nearly one-third of them had a medium (70.00%) level of adoption followed by high (17.50%) and low (12.50%) level of adoption. The majority of the respondents in the wetland system had followed adaptation measures in medium level (65.00%). It was followed by the respondents' low (22.50%) and high (12.50%) level categories in adopting climate change adaptation measures under wetland conditions. In dryland and garden land farming, most of the respondents (70.00% and 75.00%) had adopted the climate change adaptations at the medium level, and the high-level adoption category was found to be equal to 20% of the respondents. A comparison of the adoption level of all the three land systems revealed that a high level of adoption was equally more in dry and garden

Table 5. Distribution of respondents based on their overall adoption of adaptation measures to climate change (n=120)

S.No.	Category	Wetland		Dryland		Garden land		Total	
		No.	%	No.	%	No.	%	No.	%
1.	Low	9	22.50	4	10.00	2	5.00	15	12.50
2.	Medium	26	65.00	28	70.00	30	75.00	84	70.00
3.	High	5	12.50	8	20.00	8	20.00	21	17.50
	Total	**40**	**100.00**	**40**	**100.00**	**40**	**100.00**	**120**	**100.00**
F value : 3.945*									

land (20 %) than wetland (12.50%) respondents. In the low-level category, wetland respondents (22.50%) were higher in number, whereas in the medium level of adoption, it was almost equal in all the three farming systems. The 'F' value (3.945) of the adoption of climate change adaptation measures was significant at five percent level, which indicates that there is existed a significant difference in the respondents of the three types of land systems. This difference in the adoption is due to the profile of farmers in the particular farming system and its ecological conditions.

4. CONCLUSION

Adaptation techniques have become essential for mitigating the effects of climate change and preparing the nation for climate change. According to the conclusions of this research, farmers have been actively or passively responding to the effects of climate change. The majority of farmers were found to have cattle in order to diversify their income and adapt to climate change. The responsibility of the government is to improve and promote livestock and poultry among farmers to offset the loss of income caused by climate change. To promote knowledge and use of meteorological and agricultural advisory services, training and demonstrations should be provided. As a result, policy measures for the promotion of farmer groups at the grass-roots level should be developed to enhance the adoption of climate-specific adaptation technology. Farmers in all three farming areas used adaptation strategies such as crop or variety selection based on climate variability; planting according to the prevailing monsoon; intercropping; mixed cropping; and cow rearing. To increase the adoption rate, this must be increased up.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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