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CLIMATE VARIABILITY AND ADAPTIVE BEHAVIOUR OF PADDY CULTIVATORS IN TAMIL NADU

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ABSTRACT
Agricultural systems are increasingly at risk from climate change, especially paddy farmers whose livelihoods heavily rely on monsoon rainfall and ambient temperature. This study looks at how Tamil Nadu's paddy farmers perceive climate change and the tactics they have used to adapt to changing weather. Paddy farmers' awareness, observed changes, and attitudes regarding climate variability were evaluated using a structured questionnaire based on a Likert scale. The variety of adaption techniques used by farmers is also documented in the study. Analysis of meteorological data from 2009 to 2025 showed consistently high maximum temperatures between 34.3°C and 36.5°C as well as notable variations in rainfall, with a marked deficit phase from 2012 to 2020 and surplus conditions after 2021. These patterns were consistently mirrored in farmers' perceptions. The results show that most paddy farmers have responded with varied degrees of autonomous adaptation to climate change, which they strongly perceive as a current and intensifying reality, mostly experienced through rainfall unpredictability and heat stress throughout crucial crop growth stages. The study emphasises the critical need for climate-resilient agricultural technologies, policy-level support, and focused extension services to increase the adaptability of Tamil Nadu's paddy farming communities.

KEYWORDS: climate change, perception, coefficient of variation, adaptation, Likert scale

1. INTRODUCTION

India is the largest producer of cereals (rice, wheat), pulses, fruits, and spices. 50 per cent of population depends on agriculture as their main source of income. The rural economy, which primarily relies on agriculture, is significant since it gives many people a job and a means of subsistence. However, fair 20 per cent of GDP comes from the agriculture sector (Indian Economic Survey, 2023-24). The sector which affects mostly by climate change is agriculture, because of its dependency on variations in climatic conditions such as rainfall, temperature, precipitation and weather events. India is a developing country with different agro-ecological zones, where the vulnerability of climate change is profound. Paddy is the highest cultivating crop, which needs more water and a stable climate, leading to high climate risks. The occurrence of uneven climatic events such as drought, flood, heat waves, cyclones, and variation in rainfall often leads to an increase in risks in production, resulting as affecting the farm livelihoods and food security.

According to the IPCC 6th Assessment report, gas emissions will peak before 2025 and reduce 43 per cent by 2030 to have a decent chance of keeping global warming by 1.5°C (IPCC, 2023). Climate change despite being a natural process, it has accelerated over past 200 years, since the industrial revolution in western world in the 1970's. Recent research done by IFPRI said that 90 million Indians could become hungry by 2030 because of changing climate (IFPRI, 2022). The effects of climate change on agriculture can result in lower crop yields and nutritional quality due to drought, heat waves, flooding, and an increase in pests and disease incidence. Rising temperatures, erratic monsoons, long dry periods, and unseasonal rains all directly lower agricultural yields by inducing heat stress, obstructing flowering and pollination, and damaging grains at maturity. Crops like wheat, rice, and maize that are vital to India's food supply are especially vulnerable. A nationwide temperature increase of 2.5 to 4.9°C is predicted to reduce rice yield by 32–40 per cent and wheat yield by 41–52 per cent (Datta et al., 2022). These reductions lead to an increase in the chance of food insecurity and affect farming communities.

The main factors influencing farmers' perceptions of climate change are observable changes in the local climate, like rising temperatures and erratic rainfall. Despite being aware of long-term environmental changes, farmers in semi-arid regions tend to choose short-term adaptation strategies. (Mehta, 2024). Farmers observe significant changes in rainfall and rising temperatures, which have an immediate effect on agricultural productivity, according to Anuj and (Swami, 2024). According to (Pandey and Mohanty, 2025), farmers are growing increasingly aware of the detrimental impacts of changing climate trends on agriculture. According to (Pankaj Kumar et al., 2025),

farmers' perspectives are greatly impacted by their real-world experiences with droughts, unforeseen rainfall, and extreme weather occurrences, all of which have an impact on how they react.
Various studies have shown that, farmers employ a range of adaptation strategies in response to climate variability, particularly rainfall unpredictability and temperature swings. Some strategies that help farmers deal with unpredictable weather include the use of drought-resistant cultivars, crop diversification, changing sowing dates, and improved water management practices (Kumar et al., 2023). Empirical research from South India (Paramesh et al., 2022) indicates that farmers are implementing integrated farming systems, water and soil conservation methods, and contingency crop planning as key adaptation tactics. These choices are significantly influenced by variables including farm income, education, and access to climatic information. Like this, research conducted in India's various agroclimatic zones shows that many farmers react to rising temperatures, frequent dry spells, and decreasing rainfall by using resource management and diversification techniques to lower risk (Srinivas Rao, 2024).Thus, the paper aims to observe the farmers' perceptions of climate change and to know their adaptation Strategies coping with climate change.

2. METHODOLOGY

The study was carried out in three districts of Tamil Nadu; each district has different agro-climatic conditions. The study uses both primary and secondary data. Primary data were collected through a well-structured and pre-tested interview schedule. The schedule included questions related to Farmers' perception of climate change, Changes in climatic parameters, Perceived impacts on agriculture, causes of climate change and Adaptation strategies adopted. The data were collected through personal interviews, which helped in obtaining reliable and detailed responses from the farmers. The necessary data on temperature and rainfall particulars were collected from the published documents such as Seasonal Crop report and website of IMD. The total sample size is 360 rice growers from Tiruvarur, Tiruvannamalai and Ramanathpuram districts. To analyse the trends in climate parameters percentage analysis and Coefficient of Variation (CV) was used. Likert scale was used to analyse the perceptions about climate change.

3. RESULTS AND DISCUSSION

3.1 Climate indicators in the study area

The two important climate indicators are rainfall and temperature. An increase in these two parameters causes negative effects in paddy production due to the extreme heat stress. A reduction in rainfall leads to a severe outbreak of pest incidence. If the rainfall is inadequate results in drought, while floods result from excessive rainfall. Thus, climate is the most significant factor in agriculture. So, before examining the sample farmers' perceptions and adaptation tactics, we have tried to comprehend the nature of climate change in the research area.

Table 1 Mean, standard deviation, CV and T-test of rainfall from 2011 to 2025

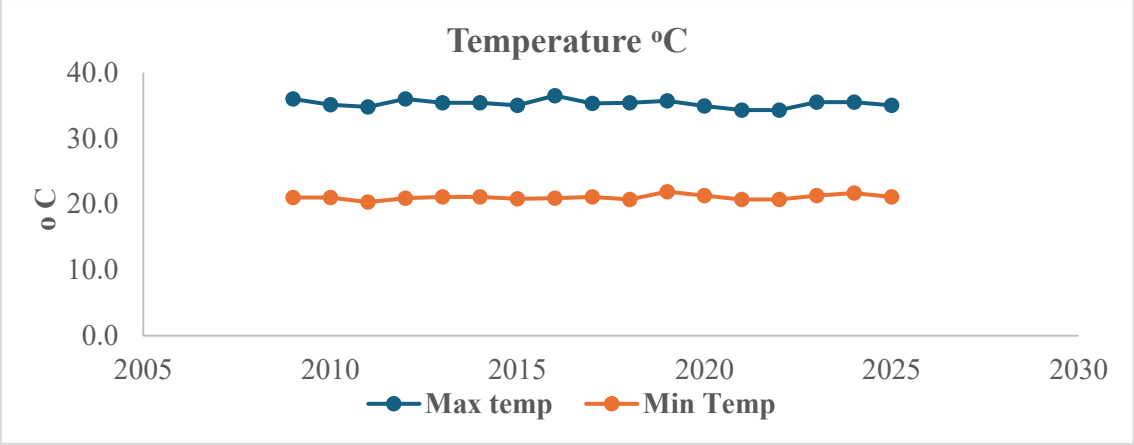
Parameters	Mean	SD	CV	Coefficient	P value
Rainfall	86.08	76.08	88.39	1.94**	0.03
Max. temperature	35.28	3.12	8.84	…	…
Min. temperature	21.04	2.61	12.37	…	…

Source: Author's calculation, 2025. ** - significant at 5% level

Descriptive statistics results in Table demonstrate distinct variations in the climatic variables' variability. Rainfall in the area under study is very variable and unpredictable, with a mean of 86.08 mm with a coefficient of variation of 88.39 per cent. Also, Rainfall has a positive and statistically significant (coefficient = 1.94, p-value = 0.03). This finding is consistent with field-level evidence, most paddy farmers observed erratic rainfall patterns, delayed monsoon commencement, and greater uncertainty in water supply. The significant fluctuation suggests a structural change in rainfall, which would need farmers to adjust their water management strategies and planting schedules.

3.2 Minimum and Maximum Temperature in the study area

The temperature trend (figure 1) from 2009 to 2025 shows both maximum and minimum temperatures, with maximum temperatures (blue line) ranging from 34.3°C to 36.5°C and minimum temperatures (orange line) from 20.3°C to 21.9°C, indicating a comparatively stable yet consistently high thermal regime throughout the period. While minimum temperatures remain remarkably consistent with only slight variations, indicating that nighttime cooling has changed very little over the 16 years. The continuous high-temperature band is important for rice farmers from an agronomic standpoint because it can result in spikelet sterility, decreased grain weight, and ultimately poorer yields when maximum temperatures drift above 35°C during crucial crop growth stages, including blooming and grain filling.

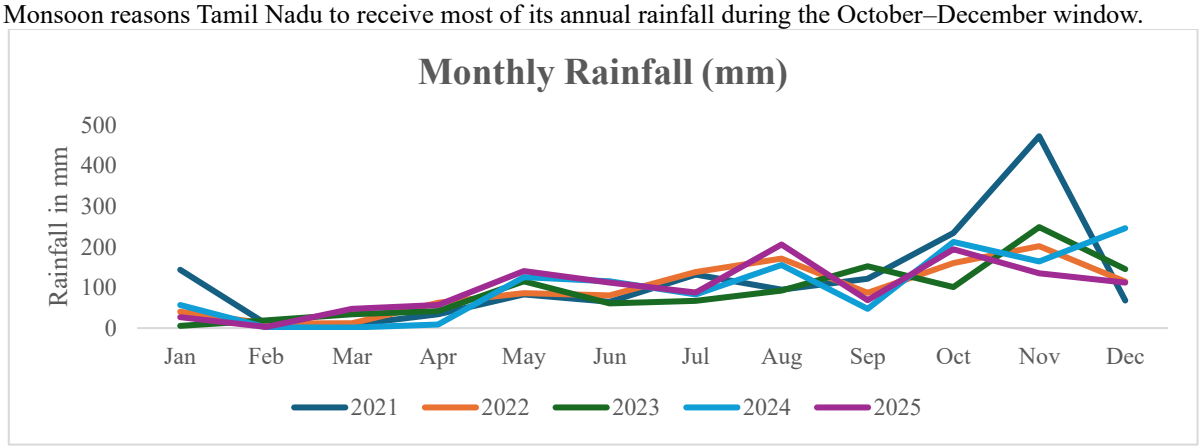


Source: Season and Crop report, 2025, Tamil Nadu

Fig 1 Max vs Min Temperature in º C

3.3 Month-wise rainfall and its deviation

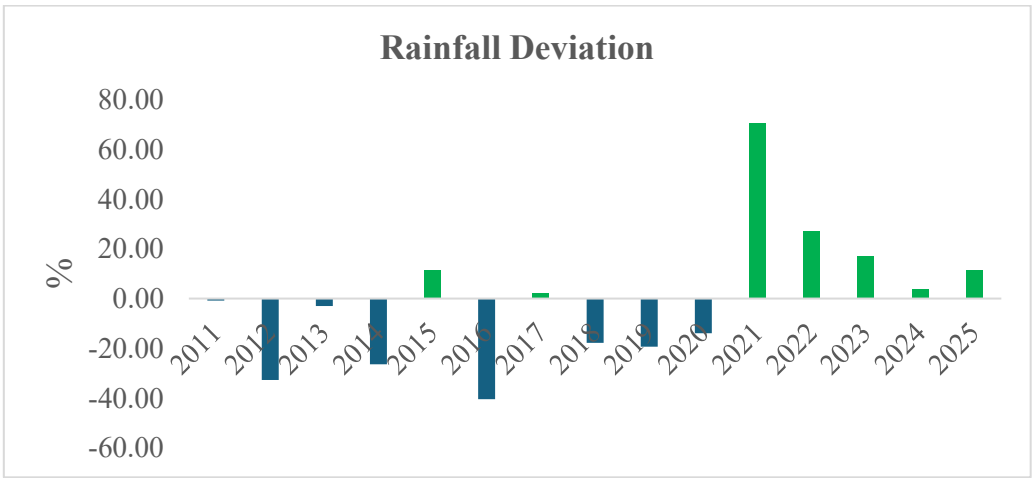
Fig 2 reveals the month wise rainfall in the study area over last 5 years. From the graph, it could be seen that, months of October, November, December received more rainfall compared to other months. The Northeast Monsoon reasons Tamil Nadu to receive most of its annual rainfall during the October–December window.



Source: Season and Crop report, Tamil Nadu

Fig 2 Month-wise rainfall in mm

This climatic pattern is deeply in-built in the agricultural calendar of paddy farmers because the Samba season, which is the most significant and widely grown paddy crop in this state, is specifically timed so that transplanting during August–September ensures the crop's peak water demand during tillering, panicle initiation, and grain filling coincides with this Northeast Monsoon rainfall peak. As a result, its performance is the single most important climate factor influencing paddy productivity, farm income, and food security throughout the state.



Source: Season and Crop report, Tamil Nadu

Fig 3 Deviation of rainfall from Normal rainfall (%)

The rainfall deviation graph (Figure 3) from 2011 to 2025 shows a mostly deficit phase from 2011 to 2020, with the worst shortfall in 2016 distributed with only slight surpluses in 2015 and 2017. After 2021, there was a sharp shift toward excess rainfall, reaching a remarkable +70% in 2021 before progressively stabilising with moderate surpluses through 2025.The lived experiences of paddy farmers during the deficit decade, which included delayed transplanting, crop failures, groundwater depletion, and mounting debt, are directly reflected in this pattern of protracted drought followed by intense surplus. As a result, they perceived seasonal calendars as disrupted and monsoon onset as becoming more unpredictable.

3.2 Perception about changing climate

The results presented in Table 2 reveal a strong and consistent perception among farmers regarding changes in climatic conditions and their impacts on agriculture. A significant percentage of responders agreed or strongly agreed with most comments regarding weather-related criteria. Rising heat conditions are widespread throughout the research area, as evidenced by the vast majority's perceptions of higher temperatures, longer summer seasons, and more frequent dry spells. Over three-fourths of farmers concurred that rainfall has become erratic and unpredictable, with a discernible decrease in both the total amount of rainfall and the number of rainy days. Although slightly more neutral responses indicated some diversity in individual experiences, changes in the monsoon's onset and withdrawal were also commonly acknowledged. Many farmers agreed that there has been less rainfall (48.6 per cent), fewer rainy days (50 per cent), and more erratic and uneven rainfall (51.4 per cent and 47.9 percent) respectively). The statistical conclusion of significant rainfall instability is supported by farmers' perceptions of changes in the onset and withdrawal of the monsoon as well as an increase in dry spells. Many farmers reported extremely high summer temperatures (47.2 percent agree; 38.9 per cent strongly agree) and longer summers, even though temperature variability appears to be lower in the secondary data. This suggests that even relatively stable temperature trends are being experienced as significant stress at the farm level. The results of this study are in line with (Chandran,2025), showing the perception about adapting to climatic variability.

Table 2 Distribution of respondents according to their perception of climate change indicators (n=360)

Statements	SD	D	N	A	SA
A. Change in weather parameters (%)					
Very high summer temperature	2.20	3.30	8.30	47.20	38.90
Rainfall amount less	3.30	13.80	19.90	48.60	26.40
More dry spells	3.30	18.90	13.90	38.00	25.80
Change in onset of monsoon	5.00	10.00	15.00	45.00	25.00
Prolonged summer	9.20	13.30	15.30	37.20	25.00
Heavy showers decreased	5.60	11.10	14.70	44.40	24.20
Winter temperature fluctuation	10.60	9.70	16.70	39.40	23.60
Heavy rain affects grains quality	5.00	19.70	16.70	35.80	22.80
No. of rainy days decreased	3.90	8.90	15.00	50.00	22.20
Rainfall unpredictability	9.80	5.60	12.50	51.40	20.80
Change in monsoon withdrawal	6.90	12.50	19.40	41.70	19.40
Uneven rainfall	2.80	6.90	29.70	47.90	12.70
B. Perceived impact on Agriculture (%)					
Cropping pattern changed	4.2	8.3	16.7	47.2	23.6
Pest attack increased	2.8	5.6	11.1	50.0	30.6
Disease incidence increased	3.3	6.9	22.5	38.6	28.6
Irrigation increased	6.2	9.3	18.9	37.2	28.4
Crop production reduced	3.30	18.90	13.90	38.00	25.80
Traditional varieties extinct	3.90	8.90	15.00	50.00	22.20
Crop quality decreased	9.20	13.30	15.30	37.20	25.00
Crop failure due to climate	3.30	13.80	19.90	48.60	26.40
Groundwater level decreased	2.80	6.90	29.70	47.90	12.70
Post-harvest affected	5.6	9.7	18.7	40.4	25.6
Crop maturity affected	5.60	11.10	14.70	44.40	24.20
Farm operations difficult	2.20	3.30	8.30	45.20	40.90
C. Perceived Causes of Climate Change (%)					
Deforestation is the cause	5.30	7.60	3.9	47.2	36.0
Continuous cropping affects the climate	5.60	9.70	16.7	44.4	23.6
Agrochemicals cause GHG	4.20	8.30	15.1	52.4	20.0
Urbanization causes climate change	13.30	6.90	13.9	38.6	27.2
Climate change is natural	11.10	16.40	25.2	30.6	16.7
No role of human activity	16.70	25.00	22.2	25.0	11.1

Source: Primary survey, 2025

Farmers regard these climate shifts as having a direct influence on agriculture. In line with the substantial impact of rainfall noted in the statistical data, the majority reported increased insect infestations (50 per cent), crop failure owing to climate variability (48.6 per cent) and decreased crop productivity. Additionally, farmers reported poorer crop quality, decreased groundwater levels, altered cropping patterns, and higher irrigation needs, indicating that rainfall variability is directly influencing farm choices and results. Furthermore, while some farmers still believe that climate change is a natural process, most ascribe it to human-caused factors such deforestation and the usage of agrochemicals. Overall, the primary data provides excellent support for the secondary analysis, showing that farmers clearly experience and recognise the statistically recorded climatic variability, particularly in rainfall, which influences both their perception and adaptation behaviour.

3.2 Adaptation strategies of farmers to climate change

The results presented in Table 3 reveal distinct patterns in the adoption of climate change adaptation strategies among farmers in the study area. Changing the time or date of planting was the most popular tactic among the other approaches, as reported by 83.33 per cent of the respondents. This suggests that to respond quickly and affordably to the fluctuations in monsoon commencement and rainfall distribution, farmers mostly rely on modifying crop calendars. In a similar vein, a significant percentage of farmers (70.56 per cent) reported using tolerant or resistant crop types, indicating a growing inclination for crop selections that can endure climatic challenges like drought and pest infestation.

Table 3 Strategies followed in the study area to adapt climate change

S. No.	Adaptation strategies	No.	%
1.	Changes in planting time/ date	300	83.33
2.	Use of tolerant/resistant varieties	254	70.56
3.	Improved crop variety (early/late maturity)	229	63.61
4.	Changes in dose of fertilizer/ time of application	200	55.56
5.	Crop residue management	163	45.28
6.	Changes in sowing method (DSR/ DSR + Transplanted / SRI	150	41.67
7.	Deep ploughing in summer season	149	41.39
8.	Repairing the wells, bunds and drainage system	131	36.39
9.	IPM/ IDM	101	28.06
10.	INM	92	25.56
11.	AWD	71	21.94
12.	Crop insurance	75	20.83
13.	Relay cropping (Rice – fallow- pulses)	68	18.89
14.	Decision of weather advisories/ agro metero services for planting	65	18.06
15.	Site-Specific Nutrient Management	35	9.72

Source: Primary survey, 2025

63.61 percent of respondents said they had adopted improved crop varieties, including early and late maturing kinds. This implies that to deal with shortened or unpredictable growing seasons, growers are actively changing their cultivar selections. To maximise input utilisation in the face of erratic rainfall, more than half of the farmers (55.56 per cent) also reported adjusting the amount and timing of fertiliser application. The usage of short-duration cultivars, which was reported by 51.94 per cent of the respondents, adds credence to farmers' propensity to implement measures that lessen their exposure to climate hazards.

Crop residue management (45.28 per cent), direct-seeded rice and rice intensification systems (41.67 per cent), and deep ploughing in the summer (41.39 per cent) were among the strategies with moderate levels of adoption. Despite their advantages, these methods frequently call for more labour, money, or technical expertise, which may prevent their broader implementation. 36.39 percent of the respondents reported fixing drainage systems, wells, and bunds, suggesting some level of investment in water conservation and field management techniques. On the other hand, more institutional or knowledge-intensive solutions showed comparatively lower uptake. A lower percentage of farmers used integrated pest management (28.06 per cent) and integrated nutrient management (25.56 per cent), perhaps because of insufficient awareness or access to extension services. Crop insurance (20.83 per cent) and alternative wetting and drying (21.94 per cent) were similarly poorly adopted, indicating issues with institutional support, awareness, and technical viability. Relay cropping's limited applicability across various farming systems is evident in the 18.89 per cent of respondents who used it. Farmers have not yet broadly adopted highly specialised and information-intensive approaches, as seen by the lowest adoption rate of 9.72 percent for site-specific nutrient management.

CONCLUSION

The study evaluated the perceptions about climate change and their coping adaptation strategies to the changing climate of paddy farmers in Tamil Nadu, India. Firstly, the trends in temperature and rainfall results revealed that the study area receives the excess rainfall in last few years. Rise in temperature and decline in rainfall was

perceived by most of the sample respondents. Also, farmers felt that weather parameters are changing every year and season without considering the real impacts on other things. Most followed practices to adapt climate change are changing crop varieties, stress/drought tolerant or resistant varieties, adjusting the planting schedule/ cropping calendar and changes in the mode of application and dose of fertilizers.

Authors' contributions

SS was responsible for the conceptualization and formation of the original manuscript. VA contributed through conceptualization and supervision. SKD focused on idea development and reviewing. SS were involved in the collection of the review data. PE and RR provided handled writing and editing tasks.

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