



## Research Article

# INSIGHTS, THREATS AND RESPONSES TO CLIMATE CHANGE: SUGARCANE FARMERS' EXPERIENCE IN TAMIL NADU, INDIA

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**Abstract:** Sugarcane area is shrinking in Tamil Nadu due to rainfall variability. Future climate projections indicate more extreme weather events; hence, potential adaptation strategies need to be developed to sustain sugar production. To understand the sugarcane farmer's insight, challenges and response to climate change, a survey was conducted with 410 farmers in Sathyamangalam, Villupuram and Thiruvannamalai regions that supply sugarcane to Bannari Amman Sugar mills. Study revealed that 38% of respondents are well aware of climate change. About 96.1% of the respondents reported continuous increase in temperature and consecutive drought for 2–3 years, that resulted in increased irrigation requirement and decline in sugarcane yield. To manage the climatic variability, creating more water sources, developing drought and disease resilient cultivars with high yield potential, popularizing climate resilient agro-techniques including Sustainable Sugarcane Initiative, increasing area under drip fertigation, making crop insurance as mandatory and increasing the effectiveness of climate services are recommended.

**Keywords:** Climate change, Sugarcane growers, Insights, Threats, Adaptation strategies

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## Introduction

Changes in the statistical distribution of average weather condition in terms of its mean and/or the variability, lasting over an extended period of time is referred as climate change [1]. Change in the climate through variation in temperature, rainfall, atmospheric CO<sub>2</sub> concentration and climatic extremes (such as heat waves and drought) impacts the agricultural sector in many ways, including productivity and quality changes of the agricultural produces and pest and disease occurrence. These impacts demand responses and alterations to the biophysical and social conditions that collectively determine exposure to climate hazards. Adaptation and mitigation are two important terms that are fundamental in the climate change action [2]. Adaptation means, responding to changing climate by taking appropriate action to prevent or minimize the damage that they can cause, or taking advantage of opportunities that may arise. Adaptation is important to assess the impacts and vulnerabilities and to develop and evaluate adaptation options [3]. The International Panel on Climate Change (IPCC) defines mitigation as "an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases." Through adaptation and mitigation activities, sugarcane farmers also respond to climate change. In Southern India, more than 70 percent of the farmers are in small and marginal category having less than one hectare of land, with low adaptive capacity. Lack of access to crop loan and low awareness in crop insurance are also major challenges. The future of sustainable agriculture growth and food security depends on the performance of these small and marginal farmers. Sugarcane crop is highly sensitive climate related stresses such as drought and moisture stress due to low rainfall, water logging due to high intensity excess rainfall and high or low temperatures. Climate related stresses would affect growth, photosynthesis, plant vigour, yield, millable cane quality and sucrose content [4]. Sugarcane crop is also contributing to greenhouse gas emission, as the farmers tend to burn the trashes of the sugarcane crop. The area of sugarcane in Tamil Nadu, one of the important sugarcane growing states in Southern India,

has fallen from 39,12,000 hectares in 2006-2007 to 23,73,000 hectares in 2016-2017 registering a 41% dip. While the shrinkage in cultivation area has been attributed to drought and poor rainfall, unsatisfactory sugarcane price fixed by the government, falling yields and rising labour costs have also contributed to it. To design effective policies for supporting operative adaptation options, it is important to understand farmers' insight about climate variability / climate change, the concerns, knowledge about the type and extent of adaptation methods being taken up by farmers [5]. The study on impacts of climate change on sugarcane production as well as possible adaptation option in Southern India is very limited and hence, in the current study all of the above will be gathered from the sugarcane farmers.

## Study area

The study area is Tamil Nadu State of India. Tamil Nadu is located in the southernmost part of the country. It has a geographical area of 1,30,058 km<sup>2</sup>, which constitutes 3.96 percent area of the country. It lies between the latitude 8°05' and 13°35' N and longitude 76°15' and 80°20' E. The socio-economic data was collected from three sugar mill feeding areas of Bannari Amman Sugars Limited [Fig-1]. Average climate of the study area is presented in [Table-1]. Sathyamangalam lies in the rain shadow region of the Western Ghats. The average annual rainfall is 763 mm with considerable variation from place to place. Major share of the rainfall is from the north east monsoon during October and November. This area receives water from the river Bhavani. Maximum temperature ranges from 30.4 in January 37.1°C in June and minimum temperature from 20.1 in December to 25.7°C in April. Villupuram is landlocked, the weather in Villupuram is generally humid and hot. It relies on the monsoon for rain during October, November and December. Summers are very hot, and temperatures can get up to 40°C. Winters are moderate with temperatures ranging between 30 and 35°C.

Table-1 Climate of the study area

Location (Unit)	Annual Average Rainfall (mm)	Maximum Temperature	Minimum Temperature	Water source	Soil type
Sathyamangalam	763	30.4 – 37.1	20.1 – 25.7	Well /bore well/ canal irrigation	Clay loam
Villupuram	1046	28.2 – 37.1	20.4 – 27.0	Well irrigation	Clay loam
Thiruvannamalai	1033	28.4 – 37.8	19.4 – 26.5	Well irrigation	Clay loam

Table-2 Personal Data of the Respondents

Parameters	Options	No. of respondents			% of respondents		
		Unit 1 N=200	Unit 2 N=90	Unit 3 N=120	Unit 1	Unit 2	Unit 3
Age	Below 40	56	21	37	28	23.3	30.8
	Above 40	144	69	83	72	76.7	69.2
Gender	Male	164	79	109	82	87.8	90.8
	Female	36	11	11	18	12.2	9.2
Level of Education	No formal education	98	40	50	49	44.4	41.7
	Primary School	42	26	37	21	28.9	30.8
	Secondary school	36	11	19	18	12.2	15.8
	Degree	18	11	11	9	12.2	9.2

Unit 1: Sathyamanagalam; Unit 2: Thiruvannamalai; Unit 3: Villupuram

Table-3 Climate change awareness of sugarcane farmers

Parameters	No. of respondents			% of respondents		
	Unit 1 N=200	Unit 2 N=90	Unit 3 N=120	Unit 1	Unit 2	Unit 3
Not aware of climate change	44	25	32	22	27.8	26.7
Just heard about climate change	48	20	28	24	22.2	23.3
Know something about climate change	30	12	14	15	13.3	11.7
Well aware of climate change	78	33	46	39	36.7	38.3

Unit 1: Sathyamanagalam; Unit 2: Thiruvannamalai; Unit 3: Villupuram

Table-4 Sugarcane farmer's perception on climate change and its impacts

Parameter	Sathyamangalam (N=200)			Thiruvannamalai (N=90)			Villupuram (N=120)			Total (%)		
	Yes	No	No idea	Yes	No	No idea	Yes	No	No idea	Yes	No	No idea
Temperature is increasing	194	0	6	85	3	2	115	2	3	96.1	1.2	2.7
Rainfall amount is reducing	200	0	0	82	0	8	103	11	6	93.9	2.7	3.4
Rainfall timing has changed	140	42	18	65	22	3	95	12	13	73.2	18.5	8.3
Frequency of drought is increasing	178	0	22	78	8	4	112	3	5	89.8	2.7	7.6
High intensity rainfall leading to flooding	95	52	53	75	10	5	84	28	8	62	22	16.1
Reduction in number of rainy days	144	23	33	86	2	2	103	12	5	81.2	9	9.8
Delayed onset of monsoon	158	15	27	78	7	5	106	9	5	83.4	7.6	9
Increase infrequency of intermittent dry spell	163	32	5	83	5	2	100	12	8	84.4	12	3.7
Unseasonal rainfall	145	35	20	81	7	2	96	6	18	78.5	11.7	9.8
Lowering of water table	185	12	3	90	0	0	112	0	8	94.4	2.9	2.7
Soil loss	120	52	28	73	11	6	82	23	15	67.1	21	12
Pest and diseases are increasing	176	12	12	80	0	10	104	6	10	87.8	4.4	7.8
Increased number of irrigations	185	8	7	75	12	3	114	3	3	91.2	5.6	3.2
Frequent crop failures	200	0	0	90	0	0	116	0	4	99	0	1

(source Field survey 2017-2018)

Villupuram has a tropical climate. In winter, there is much less rainfall in Villupuram than in summer. The average annual temperature is 28.4°C with average annual rainfall of 1,046 mm. The driest month is March, and most precipitation falls in October. The warmest month of the year is May, with an average temperature of 32.0°C. January has the lowest average temperature of the year at 24.6°C. Thiruvannamalai is located on the foothills of Annamalai hills, has an average elevation of 200 metres (660 ft) and experiences a hot and humid climate. It receives annual average rainfall of 1033 mm in 56 rainy days. Maximum temperature ranges from 28.2 in January 37.1°C in June and minimum temperature from 20.4 in December to 27°C in April.

## Materials and Method

To respondents of the study was determined by purposeful sampling technique. The farmers who were easily reachable and willing to share the information related to the study was included for collection of the data. The questionnaire was administered from 20, 20 and 20 sugarcane growing villages of Sathyamangalam, Villupuram and Thiruvannamalai and collected data from 200, 120 and 90 farmers respectively and was analyzed for drawing results and inferences. To understand the farmer's awareness on climate change, they were given with four options to choose viz., not aware of climate change, just heard about climate change, know

something about climate change and well aware of climate change and the response was converted into percentage to draw the conclusions. Similarly, their perception on climate change, adaptation strategies followed in the extreme weather events and the challenges in following the adaptation strategies were also documented and analyzed. Based on the analysis conclusions were drawn and recommendations made.

## Results and Discussions

### About the respondents

In all the three study locations, maximum respondents fall in the age of above 40 years (69.2 to 76.7%) assuring the quality data on the climate change relevance (Table 2). Majority of the respondents were male, indicating the reluctance of the women farmers to participate in the discussions. With reference to level of education, 41.7 to 49% of the farmers had no formal education and 21 to 30.8 % of the farmers had primary education. 12.2 to 18 % of the farmers had secondary school education and 9 to 12.2 % of the farmers had degree qualification.

### Climate change awareness

From the analysis, it is clear that 38% of the respondents are well aware of climate change and while, 25.5% of the respondents are not at all aware of climate change.

Among the respondents, 23.2% expressed that they just have heard about climate change and 13.3% stated they know something about climate change (Fig. -2a & 2b). Excluding the respondents who were not aware of climate change, the others indicated that the source of information on climate change was mainly from television (47%), radio (24%), newspaper (17%), fellow farmers (7%) and through internet (5%) (Table 3).

### Perception about climate change

As shown in Fig-3, the results of the study showed that 96.1% of the respondents reported that the temperature is increasing. Farmers are more concerned about the rainfall changes. 93.9% reported that the rainfall amount is decreasing; 73.2% has reported change in the rainfall timing; 89.8% stated that the frequency of drought is increasing; 81.2% expressed reduction in number of rainy days; 83.4% uttered that there is delay in onset of monsoon; 84.4% articulated that there is increase in frequency of intermittent dry spell. Problem of unseasonal rainfall was stated by 78.5% of the farmers and high intensity rainfall leading to flooding was reported by 62% of the respondents (Table 4). The findings from the analysis of the survey results are in agreement with scientific findings of [6]. [7] Who has reported increasing temperature, changing pattern of rainfall including timing of rainfall, intermittent dry spell and increase in frequency of rainfall. When the farmers were asked about the impact of these climate related problem in agriculture sector, 94.4% of the respondents indicated lowering of water tables in the open as well as bore wells; 67.1% reported loss of fertile soil; 87.8% said about increase in pest and disease problems; 91.2% stated need for increase in number of irrigation to save the crop and almost 99% of the farmers reported frequent crop failures and yield loss.

### Adaptation strategies suggested by the respondents

Sugarcane farmers adopt several adaptation strategies as a way of coping with the impacts of climate variability on sugarcane production in the study area (Table 5).

Table-5 Adaptation options suggested by the farmers in the study region

S	Adaptation option	Percentage of farmers
1	Drought tolerant sugarcane cultivars	60
2	Strengthening water harvesting structures	85
3	Creating more water sources (Digging bore wells)	82
4	Planting more trees to change the micro climate	90
5	Reducing the chemical fertilizer dose during drought years	73
6	Using more of organic manure to improve the soil fertility	68
7	Trash mulching	55
8	Pest and disease resistant cultivars	42
9	SSI method of planting	19
10	Drip fertigation to economize water	84
11	Timely planting and timely harvest	45

### Impediments to the farmers to cope up / adapting to climate variability/change

Farmers are confronting challenges in adapting to climate change due to the some factors (Table 6)

Table 6- Impediments to adapt to changing climate

S	Adaptation option	Percentage of farmers
1	Consecutive drought for more than 3 years	60
2	Drying up of water from all the irrigation sources	85
3	Uncertainty in release of water from the canal	82
4	Economically poor small farm holders-non availability of funds for timely input	90
5	Non availability of climate information in time	73
6	Low returns and low profit	68
7	Delay in harvesting of the cane	55
8	Lack of knowledge on climate change adaptation technologies	42

### Conclusion

The study has evaluated the sugarcane farmers' perception, challenges and response to climate change in selected areas of Tamil Nadu state in Erode,

Thiruvannamalai and Villupuram Districts. In all the three study locations, maximum respondents fall in the age of above 40 years (69.2 to 76.7%) and majority of the respondents were male, indicating the reluctance of the women farmers to participate in the discussions. With reference to level of education, more than 40% of the farmers had no formal education. The analysis revealed that 38% of the respondents are well aware of climate change and while, 25.5% of the respondents are not at all aware of climate change and the rest of the farmers just have heard and know little about climate change. The source of information on climate change was mainly from television (47%), radio (24%), newspaper (17%), and fellow farmers (7%) and through internet (5%). Regarding the perception on climate change, that 96.1% of the respondents reported continuous increase in temperature, which has resulted in decline in sugarcane yield and increase in irrigation requirement of the crop. Rainfall related issues stated by the respondents such as reduction in rainfall quantity, change in time of rainfall occurrence, increase in drought frequency, reduction in number of rainy days, delay in onset of monsoon and increased frequency of intermittent dry spell has reduced the sugarcane productivity due to water stress, increased the pest and disease problems and resulted in crop failures and low income. To manage the climatic variability, the farmers try to increase the water availability for cultivation of sugarcane by digging bore holes and reconstructing water harvesting structures around their location. They also try to increase the green cover to change the microclimate. However, consecutive drought for more than 2-3 years and drying up of all water resources are the major challenges for the sugarcane growers.

Based on the findings made in the study, the following recommendations are made:

- 1) There is need to raise more awareness on climate change in the area. Government agencies and NGOs can help to educate the farmers and the general public on the reality and impacts of climate change on the environment and agriculture.
- 2) Strengthening of water harvesting structures, clearing the water ways and desilting of ponds and canals need to be taken up priority basis by the Government agencies for effective water utilization and also to prevent the water loss
- 3) Climate proofed watershed approach should be popularized and adopted with Government, NABARD and NGO support.
- 4) There is need for government's intervention in providing subsidy to the farmers to increase the area under drip fertigation to boost their sugarcane production.
- 5) Crop insurance need to be made as mandate to compensate the yield loss due to weather vagaries
- 6) Sustainable Sugarcane Initiative may be popularized among the farming community to maximize the input use efficiency and yield and also the income of the farming community
- 7) Tamil Nadu Agricultural University and the Sugar Mill authorities can jointly take up capacity building programme on the climate resilient technologies
- 8) Weather and climate information and use for farming decision need to be popularized among the farming community
- 9) Government departments should ensure that farmers have access to improved and drought and disease resistant varieties
- 10) Forest Department in collaboration with farmers and NGOs can increase the green cover through suitable tree plantation wherever possible and the farmers may be accomplished with the management and protection of tree seedlings.

**Application of research:** Creation of awareness among the farming community on the changing climate and its impact on sugarcane production. Developed adaptation strategies to minimize the impact of climate change for popularization among the farming community.

**Research Category:** Agriculture Meteorology

**Abbreviations:** IPCC - International Panel on Climate Change

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**Cultivar / Variety / Breed name:** Sugarcane

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