



# An Economic Analysis of Climate Change in Dry Lands of Maduri District, Tamil Nadu, India

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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

The study was conducted in dry lands of Madurai district with a sample size of 150 to study the vulnerability, resilience and adaptation strategies to climate change and also to assess the sustainability of dry land farming and livelihood security of dry land farmers. The results revealed that Thirumangalam block was highly vulnerable to climate change with the index value of 0.689. In ecological sustainability, sorghum was more sustainable. Economic viability analyses showed that cotton was more sustainable. The dependency on local inputs was higher for both cotton and sorghum with comparative higher usage of local inputs, such as labour, seed and Farm Yard Manure. Migration percentage was relatively high in dry land agro ecosystem due to low employment generation in this system. Thus, the resilience analysis showed that the migration has to be checked, savings has to be enhanced. Farm Yard Manure was the most important green technology adopted by the farmers with a proportion of 50.00 per cent. The livelihood security analyses that farmers in dry land system were much secure in habitat and social network security.

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Farmers' perceived decline in yield was the most important impact of climate change and labour shortage was the most important constraint in adoption of climate resilient technologies. Policy implication suggested include suitable technological interventions should be given to sorghum farmers to make the crop more economically viable. Government should initiate agricultural development and welfare programmes for dryland farmers in the region.

*Keywords: Vulnerability; resilience; adaptation strategies; sustainability and livelihood security.*

## 1. INTRODUCTION

Climate change in India has been a disastrous change over a period of time. Between 1951 and 2018, the average temperature in India increased by about 0.7°C. From 1951 to 2018, the summer monsoon precipitation (June to September) across India decreased by about 6 per cent. Over the same period, the area affected by drought has also grown by 1.3 per cent each decade. India is one of the world's major agrarian economies. The negative impacts of climate change are already being felt in India with increased temperatures of 0.62°C over the past century, weather variability, shifting agro-ecosystem boundaries, invasive crops and pests and more frequent extreme weather events.

According to the Tamil Nadu State Action Plan on Climate Change (TNSAPCC), 2015, "Tamil Nadu's average maximum and lowest temperatures would rise by 33°C and 4.5°C, respectively, during this century. On the other side, Tamil Nadu's average rainfall would decrease by 12 per cent within this century. Due to those uncertain weather and extreme droughts and insufficient water from perennial rivers, the gross cropped area had reduced from 60.47 lakh hectares in 2015-16 to 59.42 lakh hectares in 2019-20 (Season and crop report 2019-20, Government of Tamil Nadu). Hence the present study was proposed in Madurai district with general objective of to study the impact of climate change in Madurai district with emphasis on vulnerability, resilience and adaptation strategies to climate change and to assess the sustainability of dry land farming and livelihood security of dry land farmers"

## 2. OBJECTIVES

- a. To measure the vulnerability, resilience and adaptation strategies to climate change
- b. To assess the sustainability of dry land farming and livelihood security of dry land farmers

- c. To suggest suitable policy measures for improvement of dry land farms.

## 3. METHODOLOGY

### 3.1 Location of the Experiment and Data Collection

The study was conducted with a sample of 30 farmers each from Thirumangalam, Kalligudi, Kallupatti, Usilampatti and Sedapatti blocks of Madurai district. The sample size was 150. The sample size was fixed based on multi stage random sampling method. Ex post-facto research design was used. The climate data for maximum temperature, minimum temperature and rainfall data were collected from Tamil Nadu climate change portal. The average and percentage analysis were used to collect the data on demographic characteristics, adaptation strategies to climate change, sustainability and livelihood security. Then the following models were employed.

### 3.2 Sudarshun and Iyenger Model of Climate Change

In this model, demographic, agricultural, climatic and occupational indicators were used. The normalisation was then done for the indicators

### 3.3 Household Resilience Model

Household Resilience model consists of evaluating five capital assets. The selected assets were natural capital, financial capital, physical capital, human capital and social capital and this was assessed in high, medium and low dry land system.

### 3.4 Criteria and Indicators of Sustainability

Agricultural sustainability was assessed from the perspective of ecological soundness, social acceptability and economic viability. Ecological Soundness was assessed based on two

indicators of input use and pest and disease management. Economic viability refers to profitability of crops and livestock. Social acceptability was assessed in terms of input self-sufficiency, equity and food security.

### 3.5 Livelihood Security

Livelihood security indices were developed using indicators given in the livelihood security model of CARE. The selected indicators for Livelihood security are food security, economic security, health security, educational security, habitat security and social network security. One-to-five-point scale was developed for the following selected indicators

## 4. RESULTS AND DISCUSSION

### 4.1 Demographic Characteristics of Sample Households

Among the sample farmers, nuclear family type was only present. Proportion of males was slightly higher in the family with a proportion of 45.61 per cent and the average size of the family was 3.86. Sample farmers belonged to middle age and old age groups. Sample farmers were of more literates and especially education up to secondary level was prevalent among sample farmers. Sample farmers had up to 20 years of experience.

### 4.2 Vulnerability

The Vulnerability to climate change was analysed with Sudharsan and Iyengar model and the results are presented in Table 1 [1]. It could be revealed from the table that Thirumangalam block was highly vulnerable to climate change with the index value of 0.689. Kallupatti, Sedapatty and Usilampatty blocks were moderately vulnerable to climate change with index values of less than 0.4.

### 4.3 Analysis of Sustainability Using Farm Level Indicators

Agricultural sustainability was assessed by combining the three sustainability criteria of ecological soundness, economic viability and social acceptability for cotton and sorghum crops [2].

#### 4.3.1 Ecological sustainability

“Ecological Sustainability was assessed based on use of chemical fertilizer and management of

pests and diseases” [3]. The declining soil fertility has been a major concern for agricultural sustainability in the region. It is believed that declining land productivity, to a considerable extent, was due to lack of adequate amounts of organic matter in the soil. The farmers applied only 1.57 t/ha of FYM in cotton and 2.01 t/ha in sorghum (Table 2). The same trend was observed for fertilisers and plant protection chemicals. There was no plant protection chemical application in Sorghum. Labour employment was higher for sorghum than cotton with 37.41 man-days per hectare for cotton and 51.54 man days per hectare for sorghum. The pest and disease management in dry land production was presented in Table 3. It could be observed from the table that the proportion of plant protection chemical application was 75.33 per cent in cotton. There was no bio- pesticide application in both the crops. FYM application, fertiliser application and labour employment were high for sorghum. Thus in ecological sustainability, sorghum was more sustainable.

**Table 1. Vulnerability index**

S. No.	Blocks	Vulnerability index
1.	Kallupatti	0.379
2.	Sedapatti	0.293
3.	Usilampatti	0.306
4.	Thirumangalam	0.689

#### 4.3.2 Economic viability

It was assessed based on two indicators of yield stability and profitability of crops. “The stability of yield crop yield was examined by constructing an index based on farmer’s subjective response to a question related to yield trend” [3]. The index was lower for both cotton and sorghum with 0.07 for cotton and 0.03 for sorghum which showed their relatively instability (Table 4).

“The profitability of cropping system was analyzed based on financial returns and value-addition per unit of land to understand the performance of an agricultural system. Profitability of dry land crops was worked out and the results have been presented in Table 5. The output- input ratio was higher for cotton with 8.47 as compared to sorghum with 1.11” [3]. To determine the net contribution of agriculture to the economy, the value of chemical fertilizer and pesticides from outside the agricultural sector have to be deducted from the value of the agricultural output. The results indicated that the

value-addition was higher for cotton with ₹ 1105267/ha followed by sorghum with ₹18263 /ha. Thus the economic viability analyses showed that cotton was more sustainable by having higher output-input ratio and value addition as compared to sorghum.

#### 4.3.3 Social acceptability

It was assessed in terms of input self-sufficiency and equity. The high dependency on external inputs, such as chemical fertilizers and pesticides increases farmer's vulnerability and reduces profit. The sustainability should seek to minimize dependency on external inputs. Hence, input self-sufficiency in the study area was analysed

and presented in Table 6. It could be seen from the table that the dependency on local inputs was higher for both cotton and sorghum with comparative higher usage of local inputs, such as labour, seed and FYM. These were reflected in the input self-sufficiency ratios with 65.98 per cent for cotton and 71.93 per cent in Sorghum.

Any activity that creates employment opportunities will have a higher equity effect through the process of chain reaction across the rural economy. The details of equity are given in Table 7. It could be observed from the table that labour requirement to produce one Kg. was higher for sorghum with ₹ 11.07 per Kg. as against ₹ 2.19 for cotton.

**Table 2. Average input use in dry land production**

S. No	Input	Cotton	Sorghum
1.	FYM (t/ha)	1.57	2.01
2.	Fertilizer (Kg/ha)	72.13	96.13
3.	Plant protection chemical (lit/ha)	1.50	-
4.	Labour (in man days/ha.)	37.41	51.54

**Table 3. Pest and disease management in dryland production**

S. No.	Particulars	Cotton	Sorghum
1.	Chemical alone	75.33	-

(in %.)

**Table 4. Stability of yield of dry land crops**

Particulars	Cotton	Sorghum
Stability of yield	0.07	0.03

**Table 5. Profitability of major dry land crops**

S. No.	Crops	Cotton	Sorghum
<b>A</b>	Financial		
i.	Gross return	113475	18674
ii.	Total variable cost	13391	16873
iii.	Output-input ratio	8.47	1.11
<b>B.</b>	Value addition		
i.	Cost of chemical fertilizers	1450	411
ii.	Cost of pesticides	1499	-
iv.	Cost of intermediate goods (i+ii)	2949	411
v.	Value-addition*	110526	18263

\*Value-addition =Gross return-Cost of intermediate goods

**Table 6. Input self-sufficiency in dry land production**

S. No.	Particulars	Cotton	Sorghum
1.	Cost of all variable inputs	13391	16873
2.	Cost of local inputs	8835	12137
3.	Input self-sufficiency ratio (%)	65.98	71.93

(in ₹/ha)

#### 4.4 Resilience with Sustainable Rural Livelihood Analysis of Dry Land Agro Ecosystem

Resilience was analysed with Sustainable Rural Livelihood analysis of dry land agro ecosystem [4] is presented in Table 8. Natural assets were measured in terms of land value. It could be observed from the table that land value of dry land system was ₹ 377933. The Table 11 clearly depicts the financial assets such as income and saving which were ₹ 105409 and ₹ 2183. The value of durable assets reflects the physical assets of dry land ecosystem. It was higher with ₹ 15556. Human assets such as health and education were measured on the basis of expenditure. Expenditure on education and health was ₹33403 and ₹2153 respectively in dry land ecosystem. Education expenditure was higher over health expenditure by 1551.46 per cent. It could be observed from the table that the migration of dry land agro ecosystem was 32.00 per cent. Migration percentage was relatively high in dry land agro ecosystem due to low employment generation in this system. Thus, this analysis showed that the natural assets, human assets and physical assets was higher in this system, the migration has to be checked, savings has to be enhanced.

#### 4.5 Adoption of Green Technologies

The adoption of green technologies are presented in the Table 9. It could be seen from the table that organic manure application especially the FYM was the most important green technology adopted by the farmers with a proportion of 50.00 per cent. This was followed by crop varietal diversification and drought tolerant crops adoption with a proportion of 33.33 per cent and 30.00 per cent. The third important technology adoption was integrated farming system with a proportion of 22.00 per cent followed by increased use of fertilisers with a proportion of 12.00 per cent. Mixed cropping and pest and disease management was followed by low proportion of farmers.

#### 4.6 Socio-economic Factors to Overcome Climate Change

The socio-economic factors to overcome climate change are discussed in Table 10. Borrowing and decrease of consumption expenditure were the most important strategies to overcome climate change with a proportion of 26.00 per cent and 25.33 per cent respectively. Migration

was also a significant factor with a proportion of 16.67 per cent. Shifting to other profession (15.33 per cent) and selling of land and livestock (12.00 per cent) were the comparative less important strategies to overcome climate change.

#### 4.7 Livelihood Security Analyses with CARE Model

“The Table 11 presents the comparative livelihood index scores for food security, economic security, education security, habitat security and social network security for the dry land systems with CARE model” [5]. Food security was studied in terms of two indicators, namely, expenditure spend on food items and diet diversity. The aggregate mean score of 2.62 was above the mid score and so they are food secured. It could be observed from the Table that aggregate mean score of economic security was 1.80 which was less than the mid score and so the dry land farmers are economically insecure. The health security was measured by the expenditure of health services which was 2.27 which was less than the mid score and so the dry land farmers are health wise insecure.

The educational security has been captured by indicator of literacy level. It could be observed from the Table that the literacy score was higher dry land system with 2.91 and so they are educationally secure. Habitat security was measured by quality of house, accessibility to drinking water and quality of drinking water. The Table revealed that the score of quality of house was just the mid level since all the farmers have kutchra house. The score of accessibility to drinking water was high dry land system with 5.00 since all the farmers are having panchayat taps near to the house. The quality of drinking water was also high in dry land system with 4.32. Hence The aggregate mean score of habitat security was high in dry land system with 3.94. . Thus the dry land system had higher habitat security.

The Table revealed that the support from the government was high with 3.18 in dry land system. The active participation in community organization was high with 3.27 in dry land system. The aggregate mean score of social network security was high with 3.23. Thus it could be concluded from the livelihood security analyses that farmers in dry land system were much secure in habitat and social network security. In food and educational security, they were just above the mid-point. In economic and health security, they were poor.

**Table 7. Equity in dry land production**

S. No.	Particulars	Cotton	Sorghum
1.	Labour cost per Kg. of output (₹)	2.19	11.07

**Table 8. Sustainable Rural Livelihood analysis of dry land agro ecosystem**

S. No.	Assets	Dry land agro eco system
<b>I</b>	<b>Natural assets</b>	
	Land value (in ₹)	3,77,933
<b>II</b>	<b>Financial assets</b>	
	Income (in ₹)	105409
	Saving (in ₹)	2183
<b>III</b>	<b>Physical assets</b>	
	Durable assets (in ₹)	15556
<b>IV</b>	<b>Human assets</b>	
	Expenditure on education (in ₹)	33403
	Expenditure on health (in ₹)	2153
<b>V</b>	<b>Social assets</b>	
	Migration (per cent)	32.00

**Table 9. Adoption of green technologies**

S. No.	Particulars	No.	%
	Technological mitigation		
1.	Mixed / Inter cropping	2	1.33
2.	Organic manure application	75	50.00
3.	Crop varietal diversification	50	33.33
4.	Drought tolerant crops	45	30.00
5.	Integrated farming system	33	22.00
6.	Increased use of fertilizers	18	12.00
7.	Pest and disease Management	3	2.00

**Table 10. Socio-economic factors to overcome climate change**

S. No.	Socio-economic factors	No.	%
1.	Decrease of consumption expenditure	38	25.33
2.	Shifting to other profession	23	15.33
3.	Borrowing	39	26.00
4.	Selling of land and livestock	18	12.00
5.	Migration	25	16.67

#### 4.8 Farmer's Perception on Impact of Climate Change

The farmer's perception on impact of climate change is presented in Table 12. It could be seen from the table that farmers perceived decline in yield was the most important impact of climate change with a proportion of 48.67 per cent. Pest and disease outbreak and erratic rainfall with proportions of 36.00 per cent and 35.33 per cent respectively followed this. The third important impacts were decrease in net income and crop failure with proportions of 30.67 per cent and 28.67 per cent respectively.

#### 4.9 Constraints in Adoption of Climate Resilient Technologies

The constraints in adoption of climate resilient technologies are presented in Table 13. It could be seen from the table that labour shortage was the most important constraint in adoption of climate resilient technologies with a proportion of 24.67 per cent. This was followed by less fertility of lands with a proportion of 22.67 per cent. Lack of information and lack of own funds were the third important constraint with proportions of 20.67 per cent and 19.33 per cent. Lack of insurance coverage was last constraint in

**Table 11. Livelihood security indices**

S. No.	Particulars	Dry land
1	<b>Food security</b>	
	Food expenditure	1.35
	Diet diversity	3.89
	Aggregate mean score	2.62
2	<b>Economic security</b>	
	Income	2.02
	Value of land	1.58
	Aggregate mean score	1.80
3	<b>Health security</b>	
	Expenditure on health	2.27
4	<b>Educational security</b>	
	Literacy level	2.91
5	<b>Habitat security</b>	
	Quality of house	2.50
	Accessibility to drinking water	5.00
	Quality of drinking water	4.32
	Aggregate mean score	3.94
6	<b>Social network security</b>	
	Level of support (government and other agencies)	3.18
	Level of active participation in community organization	3.27
	Aggregate mean score	3.23

**Table 12. Farmer's perception on impact of climate change**

S. No.	Particulars	No.	%
1.	Decline in yield	73	48.67
2.	Decrease in net income	46	30.67
3.	Pest and disease outbreak	54	36.00
4.	Erratic rainfall	53	35.33
5.	Crop failure	43	28.67

**Table 13. Constraints in adoption of climate resilient technologies**

S. No.	Particulars	No.	%
1.	Lack of information	31	20.67
2.	Lack of insurance coverage	26	17.33
3.	Lack of own funds	29	19.33
4.	Labour shortage	37	24.67
5.	Less fertility	34	22.67

adoption of climate resilient technologies with a proportion of 17.33 per cent [6-11].

## 5. CONCLUSIONS

Thirumangalam block was highly vulnerable to climate change with the index value of 0.689. FYM application, fertiliser application and labour employment were high for sorghum. Thus in ecological sustainability, sorghum was more

sustainable. Economic viability analyses showed that cotton was more sustainable by having higher output-input ratio and value addition as compared to sorghum. It could be seen that the dependency on local inputs was higher for both cotton and sorghum with comparative higher usage of local inputs, such as labour, seed and FYM. Migration percentage was relatively high in dry land agro ecosystem due to low employment generation in this system. Thus, the resilience

analysis showed that the natural assets, human assets and physical assets was higher in this system, the migration has to be checked, savings has to be enhanced. FYM was the most important green technology adopted by the farmers with a proportion of 50.00 per cent. Mixed cropping and pest and disease management was followed by low proportion of farmers. It could be concluded from the livelihood security analyses that farmers in dry land system were much secure in habitat and social network security. In food and educational security, they were just above the mid-point. In economic and health security, they were poor. Farmers perceived decline in yield was the most important impact of climate change with a proportion of 48.67 per cent. Labour shortage was the most important constraint in adoption of climate resilient technologies with a proportion of 24.67 per cent.

## 6. POLICY IMPLICATIONS

- The sustainability analysis showed that sorghum is relatively ecologically acceptable however, not economically viable. Hence, suitable technological interventions should be given to sorghum farmers to make the crop more economically viable.
- Livelihood security analyses revealed that dryland farmers are in low livelihood security trap especially in economic indices. Therefore, Government should initiate agricultural development and welfare programmes for dryland farmers in the region.
- Most of the farmers reported that lack of information was the major constraint in adopting technologies to mitigate climate change. Hence, frequent result demonstration and method demonstration should be conducted by Agriculture Department to encourage the farmers to adopt suitable climate mitigation technologies.
- Poor insurance cover was one of the major constraints felt by farmers in adoption of climate resilient technologies. So more insurance cover for cotton and sorghum crops should be extended by the Agriculture Department.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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