***Original Research Article***

# AN ECONOMIC ANALYSIS OF CLIMATE CHANGE IN DRY LANDS OF MADURI DISTRICT, TAMIL NADU, INDIA


## 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 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 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. The livelihood security analyses that farmers in dry land system were much secure in habitat and social network security. 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.



**KEY WORDS :** 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 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

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.

### 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. Result and Discussion

### 4.1. Vulnerability

The Vulnerability to climate change was analysed with Sudharsan and Iyengar model and the results are presented in Table 1. (Deepa B. Hiremath and R.L. Shiyani. 2013). 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

**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 |

### 4.2. 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. (Nasurudeen and Mahesh , 2006)

#### 4.2.1 Ecological Sustainability

Ecological Sustainability was assessed based on use of chemical fertilizer and management of pests and diseases. 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 was high for sorghum. Thus in ecological sustainability, sorghum was more sustainable.

**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**

**(in %.)**

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

### 4.2.2 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. 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).

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

| Particulars | Cotton | Sorghum |
|---|---|---|
| Stability of yield | 0.07 | 0.03 |

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. 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.

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

**(in ₹/ha)**

| S. No. | Crops | Cotton | Sorghum |
|---|---|---|---|
| **A** | Financial | | |
| i. | Gross return | 113475 | 18674 |
| ii. | Total variable cost | 13391 | 16873 |
| iii. | Output-input ratio | 8.47 | 1.11 |
| **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

### 4.2.3. 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.

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

**(in ₹/ha)**

| 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 |

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 7. Equity in dry land production**

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

### 4.3. Resilience with Sustainable Rural Livelihood analysis of dry land agro ecosystem

Resilience was analysed with Sustainable Rural Livelihood analysis of dry land agro ecosystem ( Reddy and Soussan , 2004) is presented in Table 8. Natural assets was 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.

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

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

### 4.4. 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 famers

**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 |

**4.5. 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.

**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 |

### 4.6. 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 ( CARE, 1996). 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 kutcha 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 11. Livelihood security indices**

| S. No. | Particulars | Dry land |
|---|---|---|
| 1 | **Food security** | |
| | Food expenditure | 1.35 |
| | Diet diversity | 3.89 |
| | Aggregate mean score | 2.62 |
| 2 | **Economic security** | |
| | Income | 2.02 |
| | Value of land | 1.58 |

| | | |
|---|---|---|
| | Aggregate mean score | 1.80 |
| 3 | **Health security** | |
| | Expenditure on health | 2.27 |
| 4 | **Educational security** | |
| | Literacy level | 2.91 |
| 5 | **Habitat security** | |
| | Quality of house | 2.50 |
| | Accessibility to drinking water | 5.00 |
| | Quality of drinking water | 4.32 |
| | Aggregate mean score | 3.94 |
| 6 | **Social network security** | |
| | Level of support (government and other agencies) | 3.18 |
| | Level of active participation in community organization | 3.27 |
| | Aggregate mean score | 3.23 |



### 4.7. 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.

**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 |

### 4.8. 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 adoption of climate resilient technologies with a proportion of 17.33 per cent.

**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 |

## 5. CONCLUSIONS

Thirumangalam block was highly vulnerable to climate change with the index value of 0.689 . FYM application, fertiliser application and labour employment was 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 famers. 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 framers 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.

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