# Climate Change Impact on Farmers' Perception and Adaptation Response under Rainfed Agriculture in Southern India


## ABSTRACT

Rainfed agriculture covers 80 percent of the World's cropland and produces about 60 percent of the World's food grains. In India, 55 percent of gross sown area accounts 40 percent of food production. In Tamil Nadu, nearly 48 per cent of gross sown area is under rainfed cultivation which is highly vulnerable to climate change and therefore it requires appropriate climate adaptation strategies. The present study covering 180 sample households to examine the farmers perception on climate change and various adaptation responses practiced in rainfed agriculture in Tamil Nadu, Southern India. The farmers were requested to choose one or more response among the three options namely, change in rainfall pattern, change in temperature and decrease in ground water availability. The results of the analysis indicated that rainfall and ground water availability are major concerns due to climate change were perceive by 84 and 58 percent of farmers. The adaptation responses to climate change are examined and the farmers were requested to indicate the various adaptation strategies viz., changing the cropping pattern, drilling new bore wells, deepening existing wells, introducing water saving irrigation methods and reducing the number of irrigations etc. The change in rainfall and temperature perceived by farmers were followed the reduction in number of irrigations, change in cropping pattern, advancement or delaying of cropping seasons and growing rain-fed crops are the major adaptation strategies to reduce the impact of climate change.



Key words: Climate change, farmers' perception, rainfed agriculture, adaptation response, Tamil Nadu




## 1. Introduction

There is ample evidence that the climate on Earth is changing, and further changes cannot be avoided [1]. Forced with increases in green house gases emissions, one robust result from present-day climate models' projections is an increase in monsoon rainfall over parts of South

Asia [2, 3] and weakening of the monsoon circulation [4]. Global climate change has attracted much scientific and public attention in recent years, as a result of fears that human's economic activities are leading to an uncontrolled increase in Greenhouse Gas (GHG) emission and concentration in the earth's atmosphere leading to a global rise in the earth's temperature due to the radioactive properties of these gases. Global warming is expected to continue, with projected increase to be in the range of 1.4 to 5.8º C by 2100 in comparison to 1990 [5]. There is increasing observational evidence that regional changes in climate have contributed to various changes in physical and biological systems in many parts of the world [5]. These include the shrinkage of glaciers, changes in rainfall frequency and intensity, shifts in the growing season, early flowering of trees and emergence of insects and shifts in the distribution ranges of plants and animals in response to changes in climatic conditions [6].

Agricultural productivity can be affected by climate change in two ways: first, directly, due to changes in temperature, precipitation and $CO_2$ levels and second, indirectly, through changes in soil, distribution and frequency of infestation by pests, insects, diseases and weeds [7]. Rainfed agriculture dominates world food production, but water investments in rainfed agriculture have been neglected over the past 50 years [8, 9]. Upgrading rainfed agriculture promises large social, economic and environmental paybacks, particularly in poverty reduction and economic development. Rainfed farming covers about 80 per cent of the World's cropland and produces about 60 per cent of the World's food grains. Rainfed farming systems also generates income for livelihoods in rural areas and producing food for urban areas [10]. Rain-fed agriculture will also have to shoulder the largest burden of providing food in the developing countries [11].

As climate changes due to rising concentrations of greenhouse gases in the atmosphere, agriculture will be one of the key human activities affected. Projections show that while overall global food production in the coming decades may keep pace with the food requirements of a growing world population, climate change might worsen existing regional disparities because it will reduce crop yields mostly in lands located at lower latitudes where many developing countries are situated conditions. Strategies to enhance local adaptation capacity are therefore needed to minimize climatic impacts and to maintain regional stability of food production [12, 13]. At the same time, agriculture as a sector offers several opportunities to mitigate the portion of global greenhouse gas emissions that are directly dependent upon land use, land-use change and land-management techniques. This paper gives issues in rain fed agriculture and climate change, with special attention to perception and adaptation strategies followed in rainfed farming systems in Tamil Nadu.

## 2. Data and study area

The study area for the present study includes four rainfed districts by covering the four agro-climatic zones of Tamil Nadu. A detailed field survey is being carried out in Vellore, Dharmapuri, Perambalur, and Ramnad districts representing north eastern, north western, western and southern zones of Tamil Nadu respectively. To study the adaptation strategies followed by farmers to climate change, a field survey in four rainfed districts each representing one agro-climatic zone was conducted using a pre-tested questionnaire. In each district totally 45 farmers, 15 each from marginal, small and large categories were selected and information on adaptation strategies followed by them to overcome the effects of climatic change was collected.

## 3. Methodology

### 3.1. Percentage Analysis

Percentage analysis was employed to analyze the general characteristics, cropping pattern and adaption response of the sample respondents.

### 3.2. Chi-square test

The Chi-Square test is widely used statistical procedure for determining the difference between observed and expected data. It is used to determine whether it correlates to the categorical variables in the data. It helps to find out whether a difference between two categorical variables is due to chance or a relationship between them.

$$x_c^2 = \frac{\Sigma\,(O_i - E_i)^2}{E_i}$$

Where

O = Observed Value

E = Expected Value

c = Degrees of freedom

The degrees of freedom in a statistical calculation represent the number of variables that can vary in a calculation. The degrees of freedom can be calculated to ensure that chi-square tests are statistically valid. These tests are frequently used to compare observed data with data that would be expected to be obtained if a particular hypothesis were true.

## 4. Results and Discussion

### 4.1 Shift in cropping pattern

The districts selected for this survey mainly cultivating by the rainfed crops compared to all other districts in Tamil Nadu. The adaptation framework by farmers to climate change has several actions. The first one is shift in cropping pattern.

Cropping pattern adopted by the sample farmers were presented in Table 1. It gives information on the cropping pattern followed by the farmers 5 years ago and during current year and the transitions. It could be observed that the cultivation of our major stable crop paddy is increased compared to commercial crop such as cotton and turmeric. This increase is due to cultivating of rainfed paddy crop in Ramnad district which requires less number of irrigation.

**Table 1. Cropping pattern of the sample respondents**

| | Current Year | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Five years ago | Crop | Paddy | Cotton | Sugarcane | Turmeric | Groundnut | Sorghum | Maize | Tomato | Samai | Coconut | |
| | Paddy | 86 | - | - | 1 | 9 | - | - | - | - | - | 96 |
| | Cotton | - | - | 24 | - | - | - | - | - | - | - | 24 |
| | Sugarcane | 14 | - | 1 | - | - | - | - | - | - | - | 15 |
| | Turmeric | 1 | 20 | - | - | - | - | - | - | - | - | 21 |
| | Groundnut | 10 | - | - | - | - | - | - | - | - | - | 10 |
| | Sorghum | - | - | - | - | 3 | - | - | - | - | - | 3 |
| | Maize | - | - | - | 4 | - | - | - | - | - | - | 4 |
| | Tomato | - | - | - | - | 1 | - | - | - | - | - | 1 |
| | Samai | 3 | - | - | - | - | - | - | - | 1 | - | 4 |
| | Coconut | - | - | - | - | - | - | - | - | - | 2 | 2 |
| | Total | 114 | 20 | 25 | 5 | 13 | 0 | 0 | 0 | 1 | 2 | 180 |



From the Table 1, it could be observed that about 24 and 83 per cent of the farmers who raised turmeric and cotton five years ago continue to raise the same crop. Remaining 76 and 17 per cent of the turmeric and cotton farmers were shifted to other commercial crops such as sugarcane and groundnut respectively. It must be concluded that due to scarcity of water which in turn implies a decline in rainfall, farmers are shifting to these crops. This conclusion is supported by the gradual increase in the depth of wells used by farmers of different category during the five years as shown in the Table 2. The sample farmers has indicated that the depth of wells have increased by about 8, 6 and 10 feet for marginal, small and large farmers compared to five years ago.

**Table 2. Increase in depth of water table (ft)**

| Farmers category | Current year | 5 years ago |
|---|---|---|
| Marginal | 36.11 | 27.83 |
| Small | 38.16 | 31.51 |
| Large | 47.95 | 37.51 |

## 4.2 Supplementing water demand

Farmers have adopted several techniques to augment additional water requirements. These are drilling new bore wells, deepening existing wells, adaptations of water saving technologies such as drip irrigation, change in cropping pattern, conventional water saving technologies, growing rain fed crops, livestock as an additional component, cultivating annual to perennial crops, etc. Table 3 gives a summary of these adaptation behaviours of the farmer under different categories. It provides frequency of the farmers who adopted several water saving strategies due to changes in i) rainfall ii) temperature and iii) decline in ground water table. It shows that irrespective of the factors of climate change, farmers of all categories are adopting several water saving strategies.

**Table 3. Adaptation response for climate change impact in rainfed farming systems of Tamil Nadu**

(Numbers)

| Particulars | Change in RF pattern/frequency | | | Change in Temperature | | | Change in ground water | | |
|---|---|---|---|---|---|---|---|---|---|
| | Marginal | Small | Large | Marginal | Small | Large | Marginal | Small | Large |
| **Impact Response** | **51** | **50** | **51** | **11** | **10** | **7** | **33** | **33** | **38** |
| Drilling new bore wells | 7 | 4 | 12 | 2 | - | - | 6 | 4 | 14 |
| Deepening of the existing wells | 14 | 17 | 19 | 3 | - | - | 15 | 15 | 20 |
| Adoption of Drip/Sprinkler irrigation methods | 4 | 5 | 7 | 2 | - | 1 | 2 | 5 | 6 |
| Change in Cropping pattern | 27 | 26 | 30 | 9 | 6 | 1 | 27 | 22 | 28 |
| Conventional water saving Irrigation methods | 3 | 3 | 3 | 2 | - | - | 3 | 2 | 2 |
| Growing rain fed Crops | 19 | 19 | 19 | 6 | 4 | 3 | 18 | 17 | 23 |
| Change to livestock rearing | 23 | 16 | 18 | 3 | 3 | - | 23 | 12 | 15 |
| Cultivating annual crop to perennial crops | 3 | 2 | 2 | 2 | - | - | 1 | 3 | 3 |
| Advanced /delaying of cropping season | 23 | 27 | 25 | 5 | 7 | 5 | 10 | 12 | 15 |
| Reducing the no of irrigations | 24 | 25 | 37 | 5 | 5 | 3 | 21 | 24 | 30 |

The study found that reduction in number of irrigations, change in cropping pattern and advancement or delaying of cropping seasons are the strategies followed by majority of farmers who perceive that climate change is caused by change in rainfall pattern. From those farmers who perceive climate change as change in temperature, a majority of them follow advancement or delaying of cropping seasons, change in cropping pattern and growing rain-fed crops. Also a majority of those who perceive climate change as decrease in ground water availability, follow change in cropping pattern, reduce the number of irrigations and growing rain-fed crops.

### 4.3 Are the perceptions of climate change among farmers depend on the location of agro climatic zones?

To find out whether farmers in north eastern zone (Vellore district), north western zone (Dharmapuri district), western zone (Perambalur district) and southern zone (Ramnad district) follow uniform perceptions about climate change, they were grouped based on the location of the agro climatic zones and perceptions of climate change. The zone wise climate change response of the farmers for climate change impact among the three options, namely, i) change in rainfall pattern or frequency ii) change in temperature and iii) decrease in ground water availability were given in Table 4.

**Table 4. Agro climatic zone-wise adaptation response for climate change impact in rainfed farming systems of Tamil Nadu**

| Agro climatic regions | Number of farmers | | |
|---|---|---|---|
| | Change in rainfall pattern/frequency | Change in temperature | Change in ground water |
| North eastern zone | 45 | 5 | 45 |
| North western zone | 45 | 1 | 45 |
| Western zone | 17 | 17 | 14 |
| Southern zone | 45 | 5 | 0 |
| Total | 152 | 28 | 104 |

A chi-square test was performed to test the null hypothesis that farmers' perceptions on climate change are independent of the location of agro climatic zones. The test (with observed chi-square value=83.37 at 6 degrees of freedom) rejected the null hypothesis implying that farmers' perception on climate change depends on the agro climatic zones.

### 4.4 Are the perceptions of climate change among farmers depend on their farm holdings?

To find out whether farmers in different farm holding categories (marginal, small and large) follow uniform perceptions of climate change, they were grouped based on their land holdings and impact response of climate change. The resulting farmers category wise climate change response of the farmers for impact among the three options, namely, i) change in rainfall pattern or frequency ii) change in temperature and iii) decrease in ground water availability were given in Table 5.

**Table 5. Farmers category-wise adaptation response for climate change impact in rainfed farming systems of Tamil Nadu**

| Farmers category | Number of farmers | | |
|---|---|---|---|
| | **Change in rainfall pattern/frequency** | **Change in Temperature** | **Change in ground water** |
| Small | 51 | 11 | 33 |
| Medium | 50 | 10 | 33 |
| Large | 51 | 7 | 38 |
| Total | 152 | 28 | 104 |

A chi-square test was performed to test the null hypothesis that farmers' perceptions on climate change are independent of their farm holdings. The test (with observed chi-square value=1.36 with 4 degrees of freedom) does not reject the null hypothesis implying that category of farmers and their perception about climate change are independent which implies that farmers in all the categories have similar perception on the climate change.

To sum up, the above discussion shows that perception on climate change do depend on the location of the agro climatic zones in Tamil Nadu while they are independent of farm holdings.

## 5.0 Conclusion

The study found that reduction in number of irrigations, change in cropping pattern and advancement or delaying of cropping seasons are the strategies followed by majority of farmers who perceive that climate change is caused by change in rainfall pattern. Also a majority of those who perceive climate change as decrease in ground water availability, follow change in cropping pattern, reduce the number of irrigations and grow rain-fed crops. A chi-square test was used to test the null hypothesis that farmers' perceptions on climate change are independent of their farm holdings and their location of agro climatic zones. The study revealed that farmers' perception on climate change depends on the agro climatic zones to which they belong while it is independent of their farm holdings. The present study indicated that about 76 and 17 per cent of the turmeric and cotton growers were shifted to other commercial crops such as sugarcane and groundnut respectively. The sample farmers has indicated that the depth of wells have increased by about 8, 6 and 10 feet for marginal, small and large farmers compared to five years ago.

Automatic Weather Stations may be utilized for better agro advisory services [14, 15], government interventions viz., precision farming, subsidies for drip irrigation systems [16], implementation of weather-based crop insurance schemes [17] increasing irrigation water productivity [18] and crop diversification [19] are the viable options to practice climate change adaptation strategies for sustainable agriculture.

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