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ORIGINAL ARTICLE

# IMPACT OF CLIMATE CHANGE ON AGRICULTURE – A CASE STUDY IN INDIA

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**Abstract:**

*Agricultural is the major and social activity in the globe. It is understood that agriculture is highly sensitive to climate variability and likely to be affected. It is required to study the impact of climate change. The present study is aims to examine the impact of climate variables such as temperature and rainfall on crop production through temporal analysis with special reference to Tamil Nadu. For the purpose secondary on area, production and productivity of sorghum, bajra, maize groundnut, sugarcane and rice and data on temperature and rainfall in Tamil Nadu were collected from published sources. Rainfall in Tamil Nadu exhibited in cyclical trend. The results of the production function showed that among selected crops production of groundnut and bajra negatively affected by maximum temperature and minimum temperature. The study called for suitable adaptation strategies to tide over climate change.*

**KEY WORDS**

Agriculture, Tamil Nadu,Climate Change and Multiple Regression.

## INTRODUCTION

A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC 2001). Climate change is one of the most important global environmental challenges of the present century. In developed and developing countries reaction to climate change is varies greatly. The noticeableclimate change impacts are the increased global mean surface temperature; increased frequency and severity of drought, variations in precipitation and heat waves. All these signs have a negative impact on agriculture. Among various sectors, agricultural sector is heavily influenced bychanges in weather and climate. Agriculture sector reveals high sensitivity and resilience to climate change changes in global supply and demand for various crops provide new challenges to farmers worldwide.

## IMPACT OF CLIMATE CHANGE ON INDIAN AGRICULTURE

In India agriculture is the major sector and nearly 60 per cent of the labour force depending on agriculture. Of the total land area more than 50 per cent of the land is under rainfed. Rural population depends on agriculture, forest, livestock, fishery and other natural resources for their livelihood. These sectors are sensitive to climate change which also affects the socio-economic system. In India efforts are being made to assess the extent of damage due to climate change in various sectors during 11th plan period. Much importance was given to assess the impact of rise in temperature on various crops. Field level research is also being carried out and it is reported that productivity of few crops could be affected due to rise in temperature or global warming. Since the agriculture is likely to be proactive by taking the suitable

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measures to reduce the damage and also providing food to the people of the country. The target for growth in agriculture sector is 4 per cent but due to changes in climatic condition and vagaries of monsoon it could not be achieved. The growth rate of agricultural sector hovering around 2 per cent. Indian agriculture is dominated by small and marginal farmers and the farm decisions are taken by the millions of farmers scattered over different regions. Hence there is a necessity to protect agriculture thereby millions of resource poor farmers, agricultural laborers and agro based industries.

Though agriculture's share in the total green house gas (GHG) emissions of India is relatively small, it will be a big loser as a consequence of climate change. Agricultural sector contributes 28per cent of the country's GHG emissions as per the sources of Environment and Forest Ministry (Sud, 2008). As per the findings of the study conducted by the Indian Agricultural Research Institute (IARI) New Delhi, with every 10C increase in temperature throughout the growing period of the crop, the overall wheat production may be lost by 4 to 5 million tones. Model output based on future climate change scenario in India (Kalraet al., 2003) indicated that a 0.50C rise in winter temperature will reduce wheat yield by 0.45 tonnes/ha. A 2-5 per cent yield reduction for wheat and maize for a temperature rise of 0.5-1.50C in India was projected (Aggarwal, 2003).A 1.5 degree centigrade rise in temperature and two mm increase in precipitation could result in a decline in rice yields by 3-15 per cent (Senapati, 2009). It is estimated that a 5 per cent increase in climate variation results in 10 per cent drop in the farm income and increase of 200C temperature and 7 per cent rainfall reduces the farm net income to an extend of 8 per cent (Carmer 2008).

Food production in a country directly related to the weather parameters. The changing pattern of weather parameter create the problem of droughts, floods, tropical cyclone, heavy precipitation, heat waves which are negatively affect the crop productivity. Thus results in greater instability in food production and threaten to livelihood security of the poor people. Under this background, an attempt was made to assess the impact of climate change of crop productivity by measuring the relationship between weather parameters and crop productivity in Tamil Nadu state of India.

## METHODOLOGY

The present study was conducted in Tamil Nadu State of India.The study is based mainly on secondary data of weather parameter viz., maximum temperature, minimum temperature, rainfall and area, production, productivity of cropsfor the period of 20 years (from 1990-91 to 2009-10). The secondary data were collected from published sources of the season and crop report of Tamil Nadu during 1990-91 to 2009-10.

## COEFFICIENT OF VARIATION

Coefficient of variation was employed to find out the variation in productivity of selected crops.

C.V = (Standard Deviation/ Mean) X 100
Multiple regression analysis.
Cobb-Douglas function could be chosen as the basis of result presentation because it enjoys a wider in application and also because of the added information implied by its parameter estimates. The function is thus used to examine production performance and resource productivity between insured and non-insured farmers.

The Cobb-Douglas function, generally can be implicitly presented as

$$Q = AXbX(1-b)$$

whereA is a positive constant term and b a positive fraction. Q and X are the variables, the relationship between which are examined by the equation.

**PRODUCTION FUNCTION (1)**

$$Y = a\, X_1^{b1}\ X_2^{b2}\ X_3^{b3}\, U_t$$

$Y$ = Productivity of crops (kg/ha)

$X_2$ = Minimum temperature ($^0$C)

$X_3$ = Maximum temperature ($^0$C)

$X_4$ = Rainfall (in mm)

**PRODUCTION FUNCTION (2)**

$$Y = a\, X_1^{b1}\ X_2^{b2}\ X_3^{b3}\ X_4^{b4}\, U_t$$

$Y$ = Production of crops (tonnes)

$X_1$ = Area of crops (ha)

$X_2$ = Minimum temperature ($^0$C)

$X_3$ = Maximum temperature ($^0$C)

$X_4$ = Rainfall (in mm)

**RESULTS AND DISCUSSION**

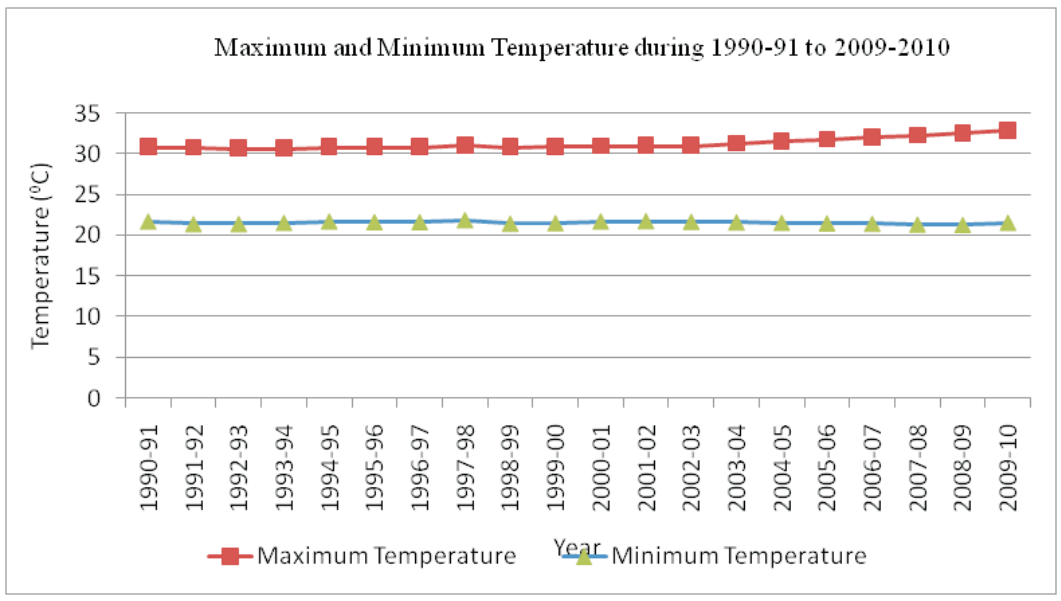
A preliminary analysis for several crops was done to identify crops affected by climate change in Tamil Nadu state and the results are presented in Table 1.From the analysis of coefficient of variation (CV) revealed that the CV of area, production and productivity was more in sorghum, bajra, maize and groundnut may be influence of weather events. Hence, these four crops were selected for the present study.

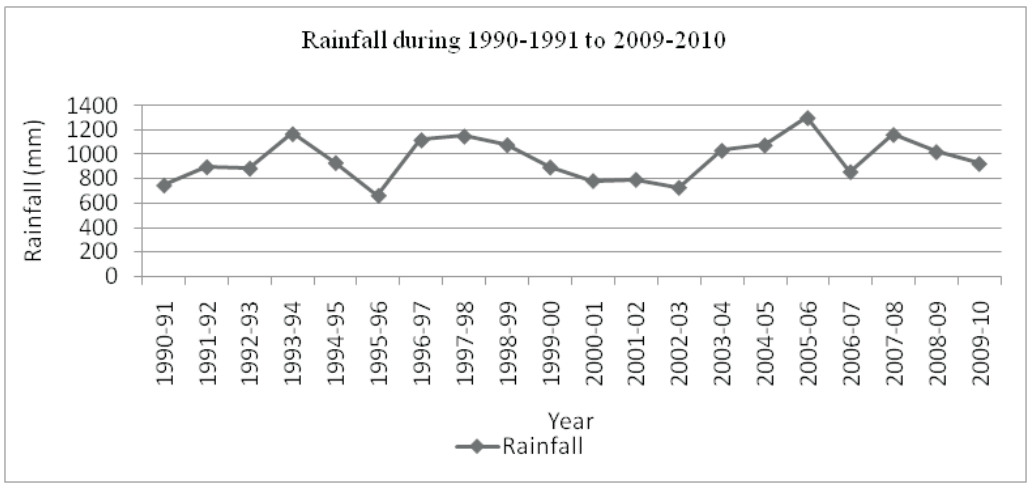
**Table 1. Coefficient of variation of selected crops during 1990-91 to 2009-10**

| Sl.No | Crops | Coefficient of variation | | |
|---|---|---|---|---|
| | | Area | Production | Yield |
| 1 | Sorghum | 24 | 36 | 17 |
| 2 | Bajra | 41 | 38 | 13 |
| 3 | Maize | 68 | 112 | 37 |
| 4 | Groundnut | 28 | 24 | 16 |
| 5 | Sugarcane | 19 | 24 | 7 |
| 6 | Rice | 12 | 21 | 12 |

Trend in minimum and maximum temperature during 1990-91 to 2009-10in Tamil Nadu was presented in Figure 1. It could be inferred from the figure that over the years there was not much fluctuation in minimum temperature. After 2000-01 there was a gradual increase in maximum temperature from 30 0C to 310C. After 2005-06, the maximum is 320C. Compare to minimum and maximum temperature, much fluctuation was observed in rainfall over the period. It ranges from 663.60 mm to 1304.1mm.

**Fig 1. Minimum, maximum temperature and rainfall during 1990-91 to 2009-10**






## IMPACT OF CLIMATE VARIABLES ON PRODUCTION

The effects of temperature and rainfall on production of crops were analyzed and the results are presented in table. It could be observed from the table 2 that R2 value of groundnut and bajra revealed that 38 per cent and 24 per cent variation in productivity of groundnut and bajra was influenced by minimum temperature, maximum temperature and rainfallrespectively. Minimumtemperature would negatively influence the productivity of sorghum, groundnut and bajra.The effect of minimum temperature on productivity of sorghum and bajra was not significant and the sign was expected one, and it also affects the productivity of groundnutnegatively at 5 per cent level of significance which implies that one per cent increase in minimum temperature will reduce the productivity ground by 0.38 per cent. The maximum temperature was negatively affects all the selected four crops and the sign was expected one but it was significantly affects the productivity of groundnut and bajra at 5 per cent level of significance. The variation in rainfall affects only sorghum and maize among selected crops. The finding of the study revealed that the variability in climatic variable would negatively influence the productivity of crops.

**Table 2. Estimated Cobb-Douglas production function (I) of selected crops (1988-99 to 2007-08)**

| Crops | Variables | $R^2$ | Coefficient | Standard error | t value |
|---|---|---|---|---|---|
| Sorghum | Intercept | 0.07 | 10.70 | 4.37 | 2.45*** |
| | Minimum temperature | | -0.06 | 0.24 | -0.25 |
| | Maximum temperature | | -0.55 | 0.91 | -0.60 |
| | Rainfall | | -0.25 | 0.24 | -1.04 |
| Maize | Intercept | 0.15 | 12.73 | 6.32 | 2.01** |
| | Minimum temperature | | 0.20 | 0.35 | 0.57 |
| | Maximum temperature | | -1.51 | 1.32 | -1.14 |
| | Rainfall | | -0.02 | 0.35 | -0.06 |
| Groundnut | Intercept | 0.38 | 11.73 | 3.38 | 3.47*** |
| | Minimum temperature | | -0.38 | 0.18 | -2.11** |
| | Maximum temperature | | -1.41 | 0.70 | -2.01** |
| | Rainfall | | 0.29 | 0.19 | 1.53 |
| Bajra | Intercept | 0.24 | 10.21 | 2.80 | 3.65*** |
| | Minimum temperature | | -0.12 | 0.15 | -0.80 |
| | Maximum temperature | | -1.03 | 0.51 | -2.02** |
| | Rainfall | | 0.16 | 0.15 | 1.07 |

***- 1 per cent level of significance, **- 5 per cent level of significance,

Cobb-Dogulas production function II of the selected crops was analyzed and the results are presented in Table 3. From the table 3 inferred that production of selected crops was positively affected by area under crop grown at one per cent level of significance, which implies increase in area under cultivation will increase the production of crops. Maximum and minimum temperature negatively influenced the production of all selected crops except minimum temperature for maize. The minimum temperature affects the production of groundnut at one per cent level of significance. Maximum temperature had negative effect on production of bajra at significant level. The quantity of rainfall during the crop growing season determines productivity. Rainfall affects the production of sorghum, maize and groundnut negatively.

**Table 3. Estimated Cobb-Douglas production function (II) of selected crops (1990-91 to 2009-10)**

| Crop | Variables | $R^2$ | Coefficient | Standard error | t value |
|---|---|---|---|---|---|
| Sorghum | Intercept | 0.81 | 0.31 | 4.15 | 0.07 |
| | Area | | 1.42 | 0.18 | 7.89*** |
| | Minimum temperature | | -0.18 | 0.22 | -0.82 |
| | Maximum temperature | | -1.18 | 0.84 | -1.40 |
| | Rainfall | | -0.14 | 0.21 | -0.67 |
| Maize | Intercept | 0.91 | 3.06 | 6.35 | 0.48 |
| | Area | | 1.17 | 0.12 | 9.75*** |
| | Minimum temperature | | 0.17 | 0.33 | 0.52 |
| | Maximum temperature | | -0.90 | 1.33 | -0.68 |
| | Rainfall | | -0.22 | 0.36 | -0.61 |
| Groundnut | Intercept | 0.79 | 7.24 | 3.05 | 2.37** |
| | Area | | 0.73 | 0.10 | 7.30*** |
| | Minimum temperature | | -0.37 | 0.16 | -2.31** |
| | Maximum temperature | | -1.06 | 0.62 | -1.17 |
| | Rainfall | | 0.26 | 0.16 | 1.62*** |
| Bajra | Intercept | 0.93 | 3.53 | 2.86 | 1.23 |
| | Area | | 0.95 | 0.07 | 13.57*** |
| | Minimum temperature | | -0.12 | 0.16 | -0.75 |
| | Maximum temperature | | -0.87 | 0.41 | -2.12** |
| | Rainfall | | 0.12 | 0.16 | 0.75 |

***- 1 per cent level of significance, **- 5 per cent level of significance, *- 10 per cent level of significance.

## CONCLUSION

The results from the study suggest thatfield level research should be done to identify the strategies/measures to overcome the problem. The strategies for increasing adaptive capacity of crops may include change in planting dates to bridge the yield gaps, evolving adverse climate tolerant genotypes. Farmers may be assisted through providing weather linked value-added advisory services and weather based crop insurance. Other measures are improved land and water use management, popularization of resource conservation technologies. i.e., zero/reduce tillage to save input and enhance output, increased public investment to tackle issues relating to changes in weather parameter and price polices. The mitigation of climate change can include utilization of opportunities offered by conservation agriculture, use of biofuels, development of watersheds in rainfed areas and nutrient management. Stakeholders of agriculture are to be proactive to avoid the problem of climate change and thereby food security.

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