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An economic analysis of climate change in Salem district of Tamil Nadu, India

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Abstract
Climate change being one of the most dependent and devastating factors especially for agriculture and monsoon now a days became one unpredictable and more instances of crop loss due to heat wave occur. For the present study, a total of 5 blocks were purposely selected from a Salem district. A total of 200 samples were collected randomly from 20 villages. Pearson correlation coefficient was used to analyze the degree of association between production and climatic variables and Ricardian model was used to quantify economic impact of climatic variables on net income. The results of compound annual growth rate revealed that the positive compound growth rate of both maximum temperature and minimum temperature and negative growth rate of rainfall in the study area. The correlation analysis revealed the positive and negative association between climatic variables and production of different crops in Salem district. The regression analysis revealed that rainfall and gross cropped area had a positive impact on production of crops while the mean temperature had negative impact on production of crops in Salem district. Ricardian model revealed that both kharif season and rabi season rainfall had positive impact on net income of farmers while the maximum temperature had a detrimental effect on net income of farmers. It was observed that climatic variables had significant impact on production and net income of farmers in Salem district and hence crop planning of the district have to be programmed with due weightage to the climatic variables.

Keywords: maximum temperature, minimum temperature, rainfall, pearson correlation coefficient and Ricardian model

Introduction
Climate change means a change in the average weather conditions over longer average conditions. Climate change is likely to directly impact food production across the globe. The relative change in temperature over a period of time may affect the crop climate cycle and thus subsequently affecting the average productivity of crops. In areas where the climate change has reached the crop maximum temperature, will adversely affect the crop yield and occurrence of physiological disorders.

Climate change around the world now poses a severe threat to food security. It results in pushing many third world countries into extreme poverty as they have restricted financial and technical resources. Even in developing countries like India where more than half of population depending on agriculture as mainstay of income and contributing around 16.70 per cent, climate change has become an alarming factor of influence. However almost two-thirds of country’s cropped area is still depending on rainfall, which fundamentally depends on weather.

A growing global population and changing diets are driving up the demand for food. The challenge is intensified by agriculture’s extreme vulnerability to climate change. Climate change’s negative impacts are already being felt, in the form of increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops and pests, and more frequent extreme weather events. On farms, climate change is reducing crop yields, the nutritional quality of major cereals, and lowering livestock productivity. Substantial investments in adaptation will be required to maintain current yields and to achieve production and food quality increases to meet demand. Climate change is perceptible through a rise in all India mean temperature and increased frequency of extreme rainfall events in the last three decades. This causes fluctuation in production of major crops in different years.

Tamilnadu is one of the severely affected states by natural calamities as it depends on both monsoons for the water requirement. Thus Tamilnadu becomes a unique whose agriculture is highly depend on climate.

Tamilnadu receives rain mostly from northeast monsoon which supplies nearly 46 per cent of the state's agricultural production. Due to those uncertain weather and extreme droughts and insufficient water form perennial rivers, the gross cropped area had drastically reduced from 33 per cent in 2000-01 to 31 per cent in 2010-11.

Objectives

The specific objectives of the study are:

- To study the weather trend in Salem District.
- To find strength of association between production of crops and different climatic variables.
- To study the impact of climate change on production and income of principal crops in Salem district.

Review of literature

Akinsanola and Ogunjobi (2014) [2] in analysing rainfall and temperature variabilities in Nigeria showed that the temperature data showed negative coefficient of kurtosis and positive coefficient of skewness in peaked distribution. First two decades showed negative influence but the third decade showed positive influence in most parts of the country showing increasing trends in temperature of about 0.05 to 0.08°C/decade. Similarly assessment by Abdul-Rahaman, Campion *et al*., (2016) [1] showed skewness of rainfall (1.25) as not normally distributed. Gornott and Wechsung (2016)[5] studied three regression models estimating relative climate impacts on relative crop yield changes where the Correlation was stronger for maize (0.86***) than for wheat (0.66**). Deressa, Hassan *et al*., (2005) [3] employed a Ricardian model for analysing the impact of temperature on land values in sugarcane ecosystem in which the results showed that climate change has significant nonlinear impacts on net revenue per hectare of sugarcane in South Africa with higher sensitivity to future increases in temperature than precipitation. Seo, Mendelsohn *et al*., (2005) [6] measures climate change impacts on Sri Lankan agriculture using the Ricardian method in which the results claimed that net revenue will decrease by SLR 4105 per degree of warming.

Design of the study

Selection of the study area

Salem district in Tamil Nadu was selected for the study. Five crops based on the area of cropping were selected and based on the crops, five blocks were purposely selected. In each block four villages were randomly selected, summing up to a total number of twenty villages. Ten farmers were selected randomly from each village and thus the total number of farmers considered for the present study was two hundred.

Tools of analysis

Pearson correlation coefficient

Pearson correlation technique was used to analyze the degree of association between climatic variables and area of different crops in Salem district. Time series data on area of various crops in Salem district, maximum temperature, minimum temperature and rainfall received during kharif and rabi seasons were collected for 51 years from 1970 to 2020 and were used for correlation analysis.

Pearson coefficient is specified as,

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where,
r =Pearson correlation coefficient
x=climate variables representing mean maximum temperature, mean minimum temperature and average rainfall received for 51 years from 1970 to 2020.
y = area of different crops grown over years in the district.

Multiple regression

In the present study, a quadratic production function model was specified to study the quantitative relationship between the average production of crops grown in the district and the climatic variables such as annual rainfall, annual mean maximum temperature and annual mean minimum temperature and also other variables such as total cropped area. To find the average production in the district in a particular year, the production of all major crops during the crop production period in that year were summed up.

The quadratic production function specified for the study is given as

$$Y_i = b_o + b_1RAIN + b_2RAIN^2 + b_3TEMP + b_4TEMP^2 + b_5AREA + \mu$$

Where,
Y_i = average production of all major crops grown during the i^{th} year (tonnes/Ha)
RAIN = annual rainfall during i^{th} year (mm)
$RAIN^2$ = squared annual rainfall during i^{th} year (mm)
TEMP = annual mean temperature during i^{th} year (degree Celsius)
$TEMP^2$ = squared annual mean temperature during i^{th} year (degree Celsius)
AREA = gross cropped area of that crop in i^{th} year (Ha)
b_0 = intercept
μ = error term
b_1, b_2, b_3, b_4 and b_5 are coefficients of respective variables.

Ricardian model

The Ricardian technique is a well-known cross-sectional technique used to measure the effects of climate change on the value of crop land. In a well-functioning market system, the value of particular piece of land should reflect its profitability, showing the impact of climate variations over the land values. In Ricardian model the market value per hectare or the net income per hectare is regressed on climate and other exogenous variables to show the role of climate in expressing the farm values. Thus, the Ricardian approach examines, how climate in different places affect their net rent or value of farmland.

In the present study, Ricardian model as specified by Deressa (2007) [4] was employed to measure the economic impact of climatic variables on crop production in Salem district. In modelling, the climatic variables over the kharif and rabi season were taken analysis for the Ricardian model.

Ricardian model is given by

$$V = \beta0 + \beta_1\ KMAXTEM + \beta2\ KMAXTEM^2 + \beta3\ KMINTEM + \beta4\ KMINTEM^2 + \beta5\ KRAIN + \beta6\ KRAIN^2 + \beta7\ KRAINDAY + \beta8\ RMAXTEM + \beta9\ RMAXTEM^2 + \beta10\ RMINTEM + \beta11\ RMINTEM^2 + \beta12\ RRAIN + \beta_{13}\ RRAIN^2 + \beta_{14}\ RRAINDAY + \beta_{15}\ EDU + \beta_{16}\ FARMEXP + \beta_{17}\ FAMSIZE + \beta_{18}\ EXTN + \mu$$

Where,
KMAXTEM = Kharif season maximum temperature in degree Celsius
$KMAXTEM^2$ = Squared kharif season maximum temperature in degree Celsius
KMINTEM = Kharif season minimum temperature in degree Celsius
$KMINTEM^2$ = Squared kharif season minimum temperature in degree Celsius
KRAIN = Kharif season rainfall in mm
$KRAIN^2$ = Squared kharif season rainfall in mm
KRAINDAY = Total rainy days during kharif season
RMAXTEM = Rabi season maximum temperature in degree Celsius
$RMAXTEM^2$ = Squared rabi season maximum temperature in degree Celsius
RMINTEM = Rabi season minimum temperature in degree Celsius
$RMINTEM^2$ = Squared rabi season minimum temperature in degree Celsius
RRAIN = Rabi season rainfall in mm
$RRAIN^2$ = Squared rabi season rainfall in mm
RRAINDAY = Number of rainy days in rabi season
EDU = Education in years
FARMEXP = Farm experience in years
FAMSIZE = Family size in numbers
EXTN = Extension contact in number of times
b_0 = intercept
μ = error term
b_1, b_2, b_3, b_4…. B_{18} are coefficients of respective variables.

Results and Discussion

Climate trend

Descriptive statistics for climatic data

The trend in the climatic variables of maximum temperature, minimum temperature and rainfall were studied using compound annual growth rate and with analysing skewness and kurtosis using descriptive statistics and the results are furnished in tables 1 and 2.

The skewness is a measure of the symmetry in a distribution. For a perfectly symmetrical data the skewness is 0. From the table 1 the skewness was found to be between 0.5 and -0.5 which is fairly symmetrical in distribution. Kurtosis is measured against the normal distribution. If the kurtosis is close to 0, then a normal distribution is often assumed. From the table 1, it could be observed that the kurtosis values were less than 0 with means the distribution follows light tails at end and are called as platykurtic distribution.

Table 1: Descriptive statistics for climatic data from 1950-2020

Descriptive Statistics					
Max temp		**Min temp**		**Rainfall**	
Mean	32.29	Mean	19.79	Mean	936.94
Median	32.30	Median	19.70	Median	941.70
Mode	32.20	Mode	20.20	Mode	1054.10
Kurtosis	0.635465	Kurtosis	0.87273	Kurtosis	0.486861
Skewness	0.046366	Skewness	0.491961	Skewness	-0.10867

Test for normality of data

From the analysis, it was found that Kolmogorov-Smirnov test was significant at 0.200. The probabilities are greater than 0.05 (the typical alpha level), so these data are not different from normal. So, with normal distribution we can use compound growth rate to identify the trends of climate variables.

Compound growth rate of climate variables

From the table 2. it could be inferred that the compound annual growth rate for maximum and minimum temperature was positive and significant showing that there was an increasing trend in those climatic parameters over years (1950-2020). On the other hand, the compound annual growth rate for rainfall was negative indicating that there was a decreasing trend over years of rainfall in Salem district between 1950 and 2020.

Table 2: Compound growth rate of climate variables over a period of 71 years (1950-2020)

Parameters	CAGR
Maximum temperature	0.0070721
Minimum temperature	0.0118343
Rainfall	-0.0609100

Association between climatic variables and production under different crops in Salem district

Correlation analysis was employed to analysis the data so as to establish degree of association and direction of association between production of crops and different climate variables in the study area and results are presented in table 3.

Table 3: Degree of association between climatic variables and production under different crops in Salem district

S. No	Crops	Max temp	Min temp	Rainfall
1	Thenai	-.361**	-.310*	.057
2	Samai	-.208*	-.222	-.022
3	Maize	.529**	.566**	-.109*
4	Bengal gram	-.003	-.017	-.069
5	Green gram	.445**	.476**	-.133
6	Red gram	.021*	-.201	-.056*
7	Black gram	.031	.031	-.032

8	Horse gram	-.127	-.136	.014
9	Chilli	-.423**	-.284*	.013*
10	Garlic	-.143	-.108	.003*
11	Turmeric	.079*	.009*	.218*
12	Coriander	-.234	-.274*	-.024
13	Potato	-.076	-.175	-.271*
14	Onion	-.159	-.240*	-.027*
15	Gingely	-.194*	-.068	.118*
16	Paddy	-.337*	-.219*	.385**
17	Cholam	-.068*	-.078*	-.095*
18	Cumbu	-.403**	-.325*	.046
19	ragi	-.308*	-.215*	.147
20	Sugarcane	-.227	-.324*	.031*
21	Banana	-.344	-.228*	.071
22	Mango	.218*	.253*	-.028*
23	Cotton	.104	.101	.058**
24	Groundnut	-.280*	-.270*	.136**

** significant at 1 per cent level, * significant at 5 per cent level

Table 3 revealed that correlation coefficient between mean maximum temperature and production of crops in Salem district of maize, green gram, red gram, turmeric and mango were found to be positive indicating that the maximum temperature in Salem district was conducive for these crops. On the other hand, correlation between mean maximum temperature and production of crops in Salem district of thenai, samai, horse gram, chilli, gingelly, paddy, cholam, cumbu, ragi and groundnut were found to be negative indicating that the maximum temperature was not conducive.
The correlation coefficient between mean minimum temperature and production of crops in Salem district of maize, green gram, turmeric and mango were found to be positive indicating that the minimum temperature in Salem district was conducive for these crops. On the other hand, correlation between mean minimum temperature and production of thenai, chilli, coriander, onion, paddy, cholam, cumbu, ragi, sugarcane, banana and groundnut were found to be negative indicating that the minimum temperature was not conducive.
The correlation coefficient between rainfall and production of garlic, chilli, turmeric, gingelly, paddy, sorghum, sugarcane, cotton and groundnut were found to be positive indicating that the rainfall in Salem district was conducive for area under these crops. On the other hand, correlation between rainfall and production of crops in Salem district of maize, red gram, potato, onion and mango were found to be negative indicating that rainfall in Salem district was conducive for these crops. The correlation analyses revealed that climatic variables of maximum temperature, minimum temperature and rainfall had significant association with production of crops in the study area.

Quantitative relationship between average production of crops and climate variables and total area of crops in Salem district.

The quantitative relationship between the average production of all major crops in the district and the different climate variables and total gross cropped area over years were analysed by fitting quadratic function and the results of estimated regression function was presented in Table 4
It could be observed from table 4 that the adjusted coefficient of multiple determinations ($\bar{R}^2$) was 0.65, indicating that 65 per cent of variation in mean production of crops in Salem district was explained by independent variables in the quadratic form. The coefficient of annual rainfall was positive and significant at one per cent level with value of 13828.50, showing that an increase in rainfall by one millimeter would cause to increase the overall production of Salem district by 13828.50 tonnes. The coefficient of annual mean temperature was negative and significant at five per cent level indicating that an increase in mean temperature by one degree Celsius would decrease the production by 5864.43 tonnes in Salem district. The coefficient of gross cropped area was positive and significant at five per cent level, indicating that the increase in gross cropped area would increase the overall production of crops in Salem district. The results of the analysis revealed that the annual rainfall and gross cropped area had a positive relationship with production of crops in Salem district whereas the mean temperature had a negative impact on production of crops in Salem district.

Table 4: Quantitative relationship between average production of crops and climate variables and total area of crops in Salem district

Variables	co efficient	t stat
Intercept	113422.38**	2.8450
Average rain (mm)	13828.50**	2.1546
Average rain sq (mm)	-1549.61	-1.8463
Average mean temp (°C)	-5864.43*	-3.7841
Average mean temp square (°C)	-0.03	-1.5788
Area (ha)	4.25*	7.6563

** significant at 1 per cent level, * significant at 5 per cent level

R^2 = 0.73** $\bar{R}^2$ = 0.65

Impact of climatic variables on net income of sample farmers

To measure the impact of climatic variables on net income of farmers, Ricardian cross sectional model was used and the estimated results for the paddy crop was given in the Table 5.

It could be observed from the table 5 that the adjusted coefficient of multiple determinations ($\overline{R^2}$) was 0.72, indicating that 72 per cent of variation in net income was explained by the variables included in model. The intercept was positive but non-significant.

The coefficient of kharif season maximum temperature was negative and significant at one per cent level, which indicate that increase in kharif season maximum temperature would decrease the net income. The squared kharif season maximum temperature and squared kharif season minimum temperature were positive and significant and they show that the quadratic curve forms a hill shape, which indicates that a prolonged further increase in temperature would cause a detrimental effect on net income. The coefficient of kharif season rainfall was positive and significant at one per cent level indicating that with increase in kharif season rainfall, the net income of the farm would increase.

The coefficient of rabi season maximum temperature was negative and significant, indicating that increase in rabi season maximum temperature would decrease net income of the farm. The squared rabi season minimum temperature was negative and significant at five per cent significance level, indicating that increase rabi season rainfall would give a promising increase in net income with diminishing marginal benefit up to maximum turning point after which it would have decreasing impact on the net income. The rabi season rainfall showed a positive coefficient and significant at one per cent level indicating that increase in rabi season rainfall would increase the net income benefit of the farmer in paddy ecosystem.

The coefficient of education, farm experience and extension contact were positive and significant at five per cent levels with values of 92.03, 881.37, 68.75 respectively, implying that increase in one year of education and farm experience would increase the net income by Rs.92.03 and Rs.881.37 respectively and increase in one extension contact would increase the net income by Rs.68.75.

From the above findings it was evident that an additional rainfall during the kharif season had increased the net income of farmers. On the other hand, the increase in kharif season maximum temperature had a detrimental effect on net income of farmers when prolonged for longer time. The rabi season rainfall has showed a positive impact on net income but with prolonged effect there may be marginal impact of decrease in net income of farmers. Increase in education, farm experience and extension contact has showed an increase in net income with positive effect.

Table 5: Estimated Ricardian income function for Paddy in Salem district

Particulars	Paddy
Net income / Ha.	47186.07
Kharif season maximum temperature	-313.77**
Kharif season minimum temperature	-3965.62
Kharif season rainfall	1581.68**
Total rainy days during kharif season	-120.33
Squared kharif season maximum temperature	2024.11*
Squared kharif season minimum temperature	152.58
Squared kharif season rainfall	0.00
Rabi season maximum temperature	-1840.05*
Rabi season minimum temperature	74.69*
Rabi season rainfall	1354.89**
Squared rabi season maximum temperature	7.03
Squared rabi season minimum temperature	286.43
Squared rabi season rainfall	-3.49*
Squared rabi season rainfall	0.05
Education	92.03*
Farm experience	881.37*
Family size	71.20
Extension contact	68.75*

** significant at 1 per cent level, * significant at 5 per cent level

R^2 = 0.79 $\overline{R^2}$ = 0.72 N = 40

Summary and Conclusion

The study revealed that the positive compound growth rate of both maximum temperature and minimum temperature and negative growth rate of rainfall in the study area. The correlation analysis revealed the positive and negative association between climatic variables and production of different crops in Salem district. The regression analysis revealed that rainfall and gross cropped area had a positive impact on production of crops while the mean temperature had negative impact on production of crops in Salem district. Ricardian model revealed that both kharif season and rabi season rainfall had positive impact on net income of farmers while the maximum temperature had a detrimental effect on net income of farmers. Also, socio economic characters of education, farm experience and extension contact were positive impact on the net income of farmers. Thus, it could be concluded that climatic variables had significant impact on production and net income of farmers in Salem district. Hence suitable policy advocacy with due importance to climatic parameters has to be undertaken while adopting crop planning in Salem district of Tamil Nadu, India.

References

1. Abdul-Rahaman I, Campion B, Edziyie R. "Rainfall And Temperature Changes and Variability in the Upper East Region of Ghana." 2016.

2. Akinsanola AA, Ogunjobi KO. "Analysis of Rainfall And Temperature Variability Over Nigeria." Global Journal of Human-Social Science: B Geography, Geo-Sciences, Environmental Disaster Management 2014;14(3):1-19.
3. Deressa T, Hassan R, Poonyth D. "Measuring The Impact Of Climate Change On South African Agriculture: The Case Of Sugarcane Growing Regions." Agrekon 2005;44(4):524-542.
4. Deressa TT. "Measuring The Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach." World Bank Policy Research Working Paper 2007,4342.
5. Gornott C, Wechsung F. "Statistical Regression Models For Assessing Climate Impacts On Crop Yields: A Validation Study For Winter Wheat And Silage Maize In Germany." Agricultural and Forest Meteorology 2016;217:89-100.
6. Seo, S.-N. N., R. Mendelsohn And M. Munasinghe. "Climate Change And Agriculture In Sri Lanka: A Ricardian Valuation." Environment And Development Economics 2005;10(5):581-596.