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QUANTIFYING ECONOMIC IMPACT OF CLIMATE CHANGE ON RICE IN SEMI-ARID TROPICSOF INDIA: USING RICARDIAN APPROACH FOR THE STATE OF ANDHRA PRADESH

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This paper analyzes the economic impact of climate change on agriculture for the state of Andhra Pradesh, India. The objective of this study is to quantify the impact of climate change on net revenue from rice crop in the 20 districts of the state. The Ricardian approach has been used to analyze the effects of climate variables on the net income from Rice. Panel datasets on climatic, agronomic and socio-economic variables were used for this analysis. The results showed that there exists significant nonlinear impact of temperature and rainfall on yield over the years on the net income from rice. On an average in rice; 1^{O}C rise in temperature will reduce the net income by109 INR (2.42US$) per hectare in these districts and the impact of precipitation are not substantial. Among districts taken into account, Anantpur face the maximum brunt of the impact of climate change. As expected, rainfall had positive marginal impacts, however it is very negligible. The socio-economic variable i.e. amount of irrigated area, literacy rate of rural population also shows significant positive effects on the income.

Keywords: Climate change, Ricardian analysis, Semi-arid tropics, Agriculture

INTRODUCTION

The semi-arid tropical (SAT) regions of India provide home for 45 percent of its total population and majority still reside in rural areas and agriculture is the major supporting means of livelihood. Approximately, 380 million people live in the rural areas of Indian Semi Arid Tropic (SAT) and farming is rainfed and therefore highly climate-sensitive. As agriculture presents different dimensions including social, economic and environmental, it is important to optimize these dimensions for the sustainability and futuristic development of the communities of the region. Several studies have emphasized the need for sustainable farming and income that determine the present and future socio-economic conditions of the small farmers of SAT India (Jodha et al., 2012; Bekele et al., 2008). Rainfall variability, droughts (inter and intra seasonal),

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extreme seasonal temperature rise, degrading soil fertility, diminishing owned assets, etc. are the general characteristics of these regions (Bantilan et al. 2007; Shiferaw et al. 2004). However, the frequent occurrence of climate related shock such as droughts, including slow changes in climate, and the simultaneous risks associated with it, have made the farming community in this region vulnerable. Predictions on the future climate are not encouraging for the region and it has been forecasted that the arid and semi-arid tropics could possibly have the maximum negative climatic impacts (IPCC, 2007). Most climate related studies confirm an increasing trend in the surface temperature (Kothawale and Kumar, 2005) and an increasing variability in the seasonal precipitation (Sivakumar et al. 2005) in the Indian semi-arid tracts. Availability of water for supplementary irrigation is crucial in these regions as it determines the socio-economic dynamics of the region (Cooper et al 2009). However, increased frequency of drought, decreasing number of rainy days monsoon (June - September), delay of the onset of monsoon, decreasing quantum of rainfall, rising average atmospheric temperature and increasing demand of water, etc. result in negative imbalance of available of water. Globally, several studies have been conducted to quantify climatic impacts in terms of monetary loss using the Ricardian approach (Praneetvatakul et al., 2011; Mendelsohn et al., 1994; Kumar and Parikh, 1998). There exist several approaches that seek to understand and quantify the impacts with respect to climatic variables; however, three approaches have widely been used in relevant literatures to measure the sensitivity of agricultural production to climate change; agro-economic models, cross-sectional models and agro-ecological zone models such as:

a) the agronomic-economic method that begins with a crop model that has been calibrated from carefully controlled agronomic experiments (FAO, 2000; Kumar and Parikh, 1998). Crops are grown in fields or laboratory settings under different possible future climatic conditions and carbon dioxide levels keeping all farming methods across experimental conditions fixed so that all differences in the outcomes can be attributed to climate variables, viz., temperature, precipitation, or carbon dioxide.

b) next is to measure the impact of climate change utilizes agro-ecological zones (AEZ) (FAO, 1996).

c) also the cross-sectional approach, known as the Ricardian method, farm performances are examined across different climate zones (Mendelsohn et al., 1994; Mendelsohn and Nordhaus, 1996; Kumar and Parikh, 1998). In this approach, land value is regressed on a set of environmental inputs to measure the marginal contribution of each input to farm income. The approach has widely been applied (Mendelsohn et al., 1994; Mendelsohn and Nordhaus, 1996) and is being considered satisfactory. The climate parameters considered are precipitation, minimum, maximum and diurnal

temperature. The objective of the present study is to use the Ricardian modeling approach to study the impacts of climate change on rice crop of different districts of Andhra Pradesh of India.

METHODOLOGY AND DATA

The Ricardian approach is a cross-sectional model and usually applied to agricultural production. This approach describes by specifying a net productivity function (Mendelsohn et al., 1994) as follows:

$$RV = \sum p_i q_i (x, f, z, g) - \sum p_x x \qquad \text{...(1)}$$

Where, RV is the net revenue per hectare in the constant price (in Indian rupees), p_i is the market price of crop *i*, q_i is output of the crop *i*, x is a vector of purchased inputs (other than land), f is a vector of climate variables, z is a set of soil variables, g is a set of economic variables such as market access, literacy, population density etc., and p_x represents a vector of input prices. It accounts how variations in the climate change affect the farmers' net revenue. Farmers are assumed to choose inputs, x to maximize net revenue at the given farm and market prices. Assuming a quadratic function for crop output, the model is specified as follows:

$$R = \beta_0 + \beta_1 f + \beta_2 f^2 + \beta_3 z + \beta_4 g + \mu \qquad \text{.................................(2)}$$

Where, μ represents an error term and f and f^2 are levels and quadratic terms for temperature and precipitation, respectively. β_0, β_1, β_2 and β_3 are coefficients and would vary over time. This quadratic function with temperature and precipitation has non-linear shapes of the response function between the net revenue and present climate. The inclusion of quadratic terms for temperature and precipitation ensures non-linearity. The usual expression is that the farm revenues will have a concave relationship with temperature. When the quadratic term has a positive sign, the net revenue function is U-shaped; but when the quadratic term is negative, the function is inverted U-shaped.

Physiologically, every crop has an optimal temperature for its maximum growth, so the function is expected to have a hill/inverted U-shape. Hence, after fitting the equation, the marginal impacts of climate are estimated. Thus, from the equation (2), we have:

$$\frac{\partial R}{\partial f} = \beta_1 + 2\beta_2 \bar{f} \qquad \text{...(3)}$$

Where, $\bar{f}$ is the mean of the selected climatic variables. This shows that the marginal effect of a particular climatic variable is equal to the sum of: i) the coefficient of the linear term; and ii) twice the product of the coefficient of the quadratic term multiplied by the mean level of that climatic variable.

The climatic variables included in the model are the season temperatures and their squares, seasonal precipitation rates and their squares. MATLAB, a statistical software package, has been used to fit the model. Though the Ricardian model is considered as a cross-sectional model, it has proven advantages in estimating panel data. Panel data gives opportunity to distinguish extreme years and its impacts instead of a single year. It is also argued that with panel data one can capture better performance of the panel method (Massetti and Mendelsohn, 2011). The region considered for the current analysis fall in the semi-arid region (SAT) of India, highly prone to droughts that take place, at least, once in every three years.

However, there are identified limitations in the Ricardian approach as assumptions such as technology, policy or any other time varying factors are not changed as it is considered to affect farmers' decisions (Antle, 1995) and so have not been considered in the analysis. Andhra Pradesh is an agriculturally important state of India and is the second largest state in the rice production of the country. Hence, its contribution to the national food basket is also very important. In Andhra Pradesh, paddy (rice) is the most important crop and occupies 31.7% of the cropped area of the state (DES, 2010; Season and Crop Report of Andhra Pradesh, 2008-09) (*Figure- 1*) and is expected to be affected from climate change. With this realization, the study focuses on the changes in the net revenue from paddy (prime crop of the state).

The dataset for the present study included panel data on three types of data: i) climatic ii) crops area and production and iii) socio-economic. The climatic variables included are temperature and precipitation during the four seasons (south west, north east, winter and summer). The crop variables included are area and production under each crop. The socio-economic variables are fertilizer consumption (N, P, K), tractors, pump sets, etc. The detailed list of the variable considered for this analysis is given below (*Table-1*). These data were collected from the various government and other publications. The out variable, i.e. Net revenue per ha was computed as follows:

$$Net\,Revenue\ per\ ha = \frac{Gross\,Revenue\ from\ Crops - Fertilizer\ Cost - Estimated\ Labour\ Cost}{Total\ Area\ under\ Crops}$$

As this study use meso-level information, hence costs attributed to other inputs such as tractors, bullocks, irrigation, etc. have not been included as it

is difficult to estimate them. However, these variables have been used as control variables in the model given in equation (2). The net incomes have been converted to 1981-82 constant prices (in Indian Rupees). As suggested by equation (2), the net revenue per acre was regressed on climate and socio-economic variables. The squares of the climate variables are also included in the model. The list of these variables is given in Table-2. Similar methodology was adopted by Praneetvatakul et al. (2011) in estimating the regression equations.

Map-1: The State of Andhra Pradesh of India

Figure-1: Crop-wise distribution of agricultural area in Andhra Pradesh

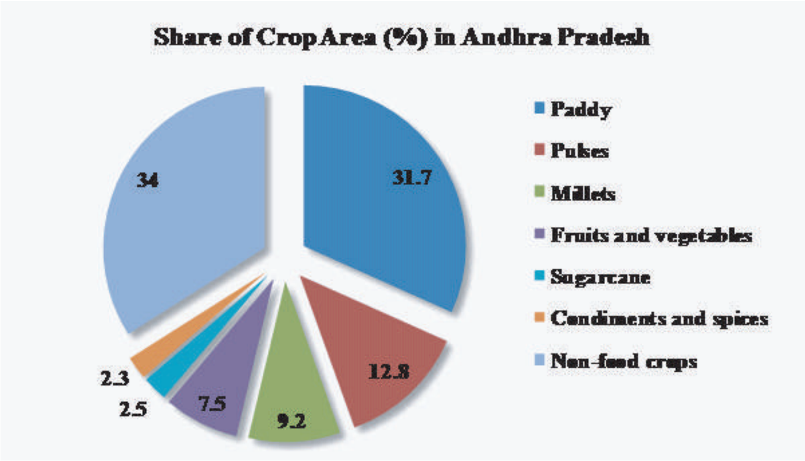

Table-1: List of variables considered in the study

Sl. No.	Classification of Variables	Variables	Short Notation
1	Climatic	South West Monsoon Temperature (^{o}C)	TSWM
2		North East MonsoonTemperature (^{o}C)	TNEM
3		Jan-Feb. Temperature(^{o}C)	TWP
4		Mar-May Temperature (^{o}C)	THWP
5		South West Monsoon Precipitation (mm)	RSWM
6		North East Monsoon Precipitation (mm)	RNEM
7		Jan-Feb. Precipitation (mm)	RWP
8		Mar-May Precipitation (mm)	RHWP
9	Socio-Economic	Tractors (‘000)	TRACTOR
10		Pump sets (‘000)	PUMPSET
11		NPK consumption (‘000) tons	NPK
12		Rural literacy (%)	LITPOPRU
13		Population Density (%)	POPDEN
14		Percentage of area under high yielding varieties (%)	HYV
15		Percentage of irrigated area to gross crop area (%)	IRR

South-West monsoon: June - August; North-west monsoon season: Sept-Oct to Nov- December

RESULTS & DISCUSSION

Table-2 provides the mean values of area and net revenue per ha for rice for all the selected 20 districts. West Godavari, East Godavari and Krishna districts of Andhra Pradesh are predominantly rice producing districts. In these districts, the area under rice occupies 80 percent, 66.6 percent and 58 percent of the total area under all major crops, respectively.

Table-2: Mean values of area and net revenue of rice in the study districts of Andhra Pradesh

Sl. No.	District	Rice Area (000'ha)	Rice net Revenue (Indian Rs. per ha)
1	Adilabad	65.7	2288
2	Anantapur	58.8	3560
3	Chittoor	103.3	3252
4	Cuddapah	62.4	3245
5	East Godavari	378.5	3130
6	Guntur	354.7	3542
7	Ranga Reddy	43.6	1334
8	Karimnagar	186.8	2950
9	Khammam	133.1	2397
10	Krishna	366.4	2867
11	Kurnool	102.9	3631
12	Mahabubnagar	117.3	2800
13	Medak	100.3	2433
14	Nalgonda	234.4	3233
15	Nellore	252.1	3125
16	Nizamabad	135.3	2667
17	Srikakulam	257.8	1888
18	Visakhapatnam	156.7	1908
19	Warangal	147.3	2797
20	West Godavari	426.9	2905
	Average	**184.215**	**2797.6**

US$=50 INR (Indian Rupees)

The net revenue per ha for rice ranges between Rs.1334 (US$29.6) to Rs. 3631 (US$80.7) across the districts, while Kurnool, Anantapur and Guntur are found to be the first three districts with a maximum net revenue per ha for rice production. Their net revenues are estimated to be Rs.3631 (US$80.7), Rs.3560 (US$79.1) and Rs.3542 (US$78.7), respectively. All these net revenues are weighted by 1981-82 constant prices[1].

Table-3 gives the mean values of all input variables used in the analysis. The average temperature during the four seasons ranges between 24.5^{o}C to 30.8^{o}C. Average temperature during the summer months (March to May) is 30.8^{o}C. Across the districts, during south-west monsoon period, the temperature has a range of 3.6^{o}C with Nellore having the highest temperature (29.9^{o}C) and Anantapur having the lowest (26.3^{o}C). During the summer months, the average temperature ranges between 27.4^{o}C to 32.1^{o}C. Rainfall has a wide range in the four seasons with south-west monsoon (634.3mm) and north-east monsoon (213mm) having major contributions. One important feature of the distribution of rainfall is the variability across the districts in the two seasons mentioned. During the south-west monsoon, it ranges between 331mm to 926mm. The north-east monsoon has a range of 564mm across the districts. The contribution of other two seasons is negligible. All the other input variables also have similar variability. For example, the percentage of irrigated area has a range of 72.6 percent with West Godavari having 84.1 percent and Adilabad having 11.5 percent. Again, West Godavari district has the highest percentage of area (67.4 percent) under high yielding varieties while Anantapur has 6.2 percent.

1. The 1981- 82 base year was chosen as the appropriate base as it was perceived to be so on three major count s vi z., (a) it was a normal year in terms of price and production data; (b) it was closer to the actual data period of the 1990s; and, (c) it was close to the base year of other revised index series commonly in use for economic decision making. Hence, the new series represented the underlying economic activity more accurately and adequately, presumably in a more representative manner.

Table-3: Mean values of the input variables used in the analysis*

District	TSWM	TNEM	TWP	THWP	RSWM	RNEM	RWP	RHWP	TRACTOR	PUMP SET	NPK	LITPOPRU	POPDEN	HYV	IRR
Adilabad	28.6	24.1	24.1	32.1	925.8	98.6	18.1	40.8	0.001	0.032	4.2	19	122.9	18.7	11.5
Anantapur	26.3	23.9	24.4	29.7	331.3	157	4.7	76.3	0.002	0.056	1.1	25	157.7	6.2	16.2
Chittoor	27.5	24	23.7	29.2	428.7	382.3	15.8	93.3	0.007	0.209	8.8	31.4	187.1	17.4	40.2
Cuddapah	27.6	24.3	24.6	30.5	402.5	251.5	6.8	63.2	0.005	0.071	9.1	30.2	163	16.1	34.3
East Godavari	29.4	25.6	24.5	30.2	730.6	309	19.4	101.2	0.008	0.054	84.2	31.5	388.7	57	63
Guntur	29.7	25.6	25.2	31.4	562.4	234.8	17.1	69.8	0.004	0.021	55.7	28.4	262.9	33.4	41
Ranga Reddy	28	24.7	24.9	31.6	619.2	138.1	18.5	68.1	0.008	0.183	26.3	8	684.9	24.6	22.3
Karimnagar	28.1	23.9	24	31.5	773.4	101.5	18.2	47	0.009	0.286	50.8	23.8	241.7	49.8	54.4
Khammam	29.3	25.5	24.9	31.5	880.2	144.2	15.2	75.9	0.004	0.059	37.1	24.9	132	31.4	32.9
Krishna	29.5	25.6	24.9	30.7	662.6	240.6	15.5	65.5	0.007	0.034	94.7	29.7	399.5	48.6	58.8
Kurnool	28.3	25.2	25.6	31.8	478	146	4.6	71.9	0.002	0.025	7.4	24.9	161.7	14.4	18.7
Mahabubnagar	28	25.1	25.4	31.9	501.2	118.4	5.3	61.1	0.005	0.151	6.1	21.7	156.4	18.3	19.2
Medak	27.3	24	24.3	31.4	696.2	108.2	12.8	59.3	0.004	0.154	12.8	24.1	227.3	29.7	29.2
Nalgonda	28	24.3	24.4	31.1	518.9	144.4	10	50.6	0.007	0.16	35.7	27.2	188.3	36.5	40
Nellore	29.9	25.6	25.2	31.2	338.1	662.1	35.7	63.7	0.008	0.098	38.2	30	166	41.9	56.8
Nizamabad	27.4	24.3	24.4	31.7	888.7	111.5	15	43.8	0.005	0.182	32.6	22.7	241.2	39.4	57.9
Srikakulam	26.9	23.6	22.3	27.4	722.9	260.8	23.8	114.7	0.001	0.024	47.7	26.4	352.7	36.9	43.7
Visakhapatnam	28.6	24.8	23.8	29.7	682.2	279.8	25.8	146.8	0.001	0.027	14.0	18.6	283.9	24.5	34.4
Warangal	28.8	24.9	24.7	31.7	793.5	120.5	19.5	58.9	0.004	0.221	33.0	24.5	209.1	33.3	44.9
West Godavari	29.7	25.8	24.8	30.3	749.5	250.3	17	85.7	0.01	0.059	161.4	37.7	419	67.4	84.1
Average	28.3	24.7	24.5	30.8	634.3	213	15.9	72.9	0.005	0.105	38.0	25.5	257.3	32.3	40.2

*The unit and the full form are in *Table-1*

THE RICARDIAN MODEL FOR NET REVENUE PER HA FOR RICE

a) Model Fit

Considering the importance of rice, Ricardian model was fitted for net revenue per ha for rice. *Table-4* summarizes the model fit outcomes. The results of the Ricardian analysis show that temperature and its square terms during all the monsoons, except for Jan-Feb, have significant impact on the net revenue of rice crop, including the major rice growing seasons (June - September).

Table-4: Ricardian Model for net revenue per ha for rice

Variable	**Coefficient**	**Standard Error**	**t-stat**	**P-value**
Intercept	-33381.153	13717.99	-2.433	0.02
TSWM	-1482.804*	849.94	-1.745	0.08
TNEM	1657.433*	860.98	1.925	0.05
TWP	265.853	1033.82	0.257	0.80
THWP	2066.000**	856.24	2.413	0.02
RSWM	-0.746*	0.40	-1.874	0.06
RNEM	-0.058	0.45	-0.129	0.90
RWP	-0.846	1.96	-0.432	0.67
RHWP	0.432	0.76	0.571	0.57
TSWM-squared	24.236**	11.933	2.031	0.04
TNEM-squared	-35.223**	17.33	-2.032	0.04
TWP-squared	-2.512	21.14	-0.119	0.91
THWP-squared	-31.976**	14.04	-2.278	0.02
RSWM-squared	0.0003	0.00	1.055	0.29
RNEM-squared	-0.0003	0.00	-0.551	0.58
RWP-squared	0.005	0.01	0.361	0.72
RHWP-squared	0.000	0.00	-0.175	0.86
TRACTOR	-22811.084	8751.17	-2.607	0.01
PUMPSET	-905.235	378.31	-2.393	0.02
NPK	-1.189	1.20	-0.992	0.32
LITPOPRU	67.723	3.23	20.990	0.00
POPDEN	-1.058	0.24	-4.419	0.00
HYV	-4.246	1.93	-2.206	0.03
IRR	8.687	2.49	3.488	0.00

*Significant at 10% level; **Significant at 5% level;***Significant at 1% level

The non-linear effect of the temperature in these three seasons is implied by the significance of the coefficients of the square terms. It shows that during the south-west monsoon season, net revenue decreases initially with an increase in temperature and then again increases. It attains a minimum value of 30.6^{o}C. On the other hand, in the north-east monsoon season, net revenue reaches a maximum level at about 23.5^{o}C. Similarly, between March & May, which is a summer period, temperature reaches a maximum at about 32.3^{o}C. Thus the relationship is non-linear and is U or inverted U-shaped. This finding is consistent with some of the existing literatures (Praneetvatakul, 2011; Mendelsohn et al., 1994 and 2003; Kurukulasuriyaet al., 2006). Similarly, rainfalls during the south-west monsoon and its square terms have a significant effect on net revenue. It shows the relationship U-shaped and confirms to the results of some of the earlier studies (e.g. Praneetvatakul and Khamwong, 2011). Thus climatic variables have significant non-linear effect on the net revenue per ha for rice crop.

In the case of socio-economic variables, the percentage of irrigated area and literacy of the rural population have positive significant effects. For other variables, the coefficients are estimated to be negative which is difficult to explain but some of the coefficients are also found to be significant. Finally, the R-square value for the model fit is found to be 0.563, which shows the adequacy of the model fit for the present analysis.

b) District wise marginal Impact of Climate Change on rice crop

The impact of climatic variables on the net revenue was computed on the basis of the equation (3) mentioned above and the findings are presented in the *Table-5*.

In general, across the districts, the south-west and north-east monsoon temperatures have a decreasing effect on the net revenue (*Table-5*). The negative effect during the south-west monsoon season is at its peak level for Anantapur district with a value of Rs. 209.9 per hectare. This means that when the temperature increases by one degree during the south-west monsoon season, the expected net revenue (in 1981-82 constant prices) is found to be Rs.209.9. Similarly, the temperature rise during the north-east monsoon found to have a maximum adverse effect at West Godavari region with a marginal impact of Rs.157.7. However, temperature has a positive effect on the rice crop net revenue during the remaining two seasons. In case of rainfall, south-west and north-east monsoons have negative impacts, even though they are not substantial.

c) Combined effect of climate variables

The Ricardian model assumes that climatic variables have an impact on net revenue from agricultural activities. However, to draw meaningful conclusion,

this hypothesis must be tested statistically. With this view in mind, separate regression equations were fitted with and without climatic variables and the residual sum of squares were found to be statistically significant. The results (*Table- 6*) show that climatic variables do have significant contribution in this case.

Table-5: District wise impact of climate variables on the net revenue per ha for rice

Region	TSWM	TNEM	TWP	THWP	RSWM	RNEM	RWP	RHWP
Adilabad	-96.9	-38.4	144.8	10.1	-0.3	-0.1	-0.7	0.4
Anantapur	-209.9	-25.1	143.3	168.6	-0.6	-0.1	-0.8	0.4
Chittoor	-151.5	-32.5	147.0	201.7	-0.5	-0.3	-0.7	0.4
Cuddapah	-144.0	-51.8	142.4	114.6	-0.5	-0.2	-0.8	0.4
East Godavari	-57.9	-147.9	142.8	132.0	-0.4	-0.2	-0.7	0.4
Guntur	-41.7	-146.1	139.2	56.0	-0.5	-0.2	-0.7	0.4
Hyderabad	-127.8	-82.6	141.0	45.9	-0.4	-0.1	-0.7	0.4
Karimnagar	-122.2	-29.7	145.2	52.5	-0.4	-0.1	-0.7	0.4
Khammam	-62.8	-138.4	140.7	54.1	-0.3	-0.1	-0.7	0.4
Krishna	-50.7	-143.5	140.6	105.5	-0.4	-0.2	-0.7	0.4
Kurnool	-111.2	-116.2	137.2	31.0	-0.5	-0.1	-0.8	0.4
Mahabubnagar	-123.4	-109.6	138.1	27.5	-0.5	-0.1	-0.8	0.4
Medak	-160.9	-34.9	143.7	60.0	-0.4	-0.1	-0.7	0.4
Nalgonda	-126.0	-56.5	143.4	77.0	-0.5	-0.1	-0.7	0.4
Nellore	-33.7	-143.9	139.1	73.9	-0.6	-0.4	-0.5	0.4
Nizamabad	-153.0	-53.4	143.2	40.4	-0.3	-0.1	-0.7	0.4
Srikakulam	-179.4	-3.2	153.8	313.5	-0.4	-0.2	-0.6	0.4
Visakhapatnam	-97.7	-92.2	146.2	165.7	-0.4	-0.2	-0.6	0.4
Warangal	-86.6	-99.1	141.6	36.2	-0.3	-0.1	-0.7	0.4
West Godavari	-43.4	-157.7	141.1	126.4	-0.4	-0.2	-0.7	0.4
Average	-109.0	-85.1	142.7	94.6	-0.4	-0.2	-0.7	0.4

Table-6: Testing the combined effect of climate variables on net revenue

Sum of Squares with climate variables	476861679
Sum of Squares without climate variables	418460711
Increase in Sum of Squares	58400968
Number of climate variables	16
Increase in Mean Sum of Square	3650061
Residual Sum of Squares with Climate Variables	369927938
Error-- Degrees of Freedom with Climate Variables	756
Residual Mean Sum of Squares with Climate Variables	489323
F-Ratio: Numerator	3650061
F-Ratio: Denominator	489323
Calculated-F-Ratio	7.5
F-Ratio-Table value at 5%	1.7
F-Ratio-Table value at 1%	2.0

CONCLUSION

The study clearly establishes that climatic variables do have a significant negative effect on rice (crop) revenue for Andhra Pradesh districts of India. Among the climatic variables, south-west monsoon temperature and rainfall seem to have a significant effect on paddy crop as it is the major cropping season of this region. However, the impacts are not uniform across the districts and Anantapur district has the highest impact. Variability in rainfall and temperature with seasonal effects can also be found in case of the other districts. It is hoped that these findings will help policy makers, planners and extension workers to formulate suitable adaptation strategies to nullify the negative effects of climatic variables on agricultural production. The study suggests that semi-arid tropical region, especially Andhra Pradesh, should begin to plan for long-term climate contingencies. The government should anticipate the slow changes in climate, as well as the extremes and should provide and ensure enabling environment for the poor farmers in the region to adapt effectively. Contingency plans or schemes such as crop insurance, conservation of natural resources, ensuring effective market response, encouraging adaptable crops/seeds, information on climate, thereby increasing assets viz., natural, social, physical, economic and social should be taken. Hence, putting all these important factors together, wide range of potential outcome and can encourage communities to adapt to new circumstances.

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