The Andhra Agric. J 65 (1): 205-208, 2018

Impact of Climate Change on Crop Production in Krishna river basin of Andhra Pradesh.

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ABSTRACT

Climate change is essentially a long term phenomenon and is supposed to be gradual in its impact for most part. Integrated assessment combining insights of many disciplines is used as a primary tool in order to follow the causal chain of events from perturbations in the environment to the final outcomes. This can be done by first assessing the vulnerability of different regions to climatic change and then quantifying its impact on agriculture using the long term data. The present paper presents the impacts of climatic change on productivity and area under three major crops of Andhra Pradesh by employing Ricardian model. Existing base level area and yields are obtained by substituting average values of the explanatory variables for each district in the area and yield regressions

Key words: *Climate Change, Crop production, Krishna river basin, Andhra Pradesh, Ricardian analysis.*

Climate change (CC) or global warming is an important issue on which research is being carried out globally now. CC will have multi-dimensional effect on humanity in terms of several socio-economic parameters. Any scientific study on CC should take into account vulnerabilities of the different regions and then it has to study its impacts on several sectors.

IPCC (2007) defines vulnerability as '*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*'. Among the different sectors, agriculture is the most important sector which will be clearly affected by CC. Hence, the objective is to study the impact of CC on agriculture in Krishna river basin of Andhra Pradesh using an econometric model.

Methodology

There are 10 districts namely, Anatapur, Kurnool, Prakasam, Guntur, Krishna, Khammam, Nalgonda, Warangal, Mahboobnagar and Rangareddy under Krishna river basin of united Andhra Pradesh .To estimate the impact of climate change on crop production in krishna river basin, Ricardian model was adopted. For quantifying the impact of CC, the Ricardian type model was preferred to the traditional estimation methods, given that instead of adhoc adjustments of parameters that are characteristic of the traditional approach, the Ricardian technique automatically incorporates efficient adaptations by farmers to CC. Climate parameters considered in Ricardian models are mainly, rainfall and temperature. The carbon fertilization effects of climate change are not included. Usually climate normals, based on time series averages over a fairly long period of time are considered. The basic approach of Ricardian technique to measure the effects of CC on the value of cropland is as follows. The market value per hectare of cropland is regressed on climate and other exogenous variables to reveal the role of climate in explaining farm value. These climate relationships can then be used to predict the agricultural impact of future climate change. The Ricardian approach examines how climate in different places affects the net rent or value of farmland (Mendelsohn et al., 1994). The most important advantage of the Ricardian approach is its ability to capture the adaptation that farmers make in response to local environmental conditions. It captures the actual response rather than the controlled ones.

The relationship between area/productivity under a crop and various climatic and non-climatic variables is specified by a regression equation. The specifications used for modelling area (A_i) and productivity (Y_i) are as follows.

Ricardian type area regressions

$$A= \beta_0+ \beta_1 TOTCROP+ \beta_2 PROIA+ \beta_3 RLT+ \beta_4 RY+ \beta_5 LLT+ \beta_6 LY+ \beta_7 HLT+ \beta_8 DIUY+ \beta_9 Y$$

Ricardian type productivity regressions

$$Y_i= \beta_0+\beta_1 TOTCROP+\beta_2 PROIA+\beta_3 PROSUR+\beta_4 RLT+\beta_5 RY+\beta_6 LLT +.......$$

$$....+\beta_9 LY+\beta_9 HLT+\beta_9 DIUY+\beta_9 A+\beta_9 C_i IA+\beta_9 PRC_i IA$$

Where, *i* = crop and other variables used above and their units of measurements are explained below.

TOTCROP = Total cropped area in the district (Ha)
PROIA = Proportion of irrigated area to total cropped area
PROSUR = Proportion of surface irrigated area from tanks and canals
RLT = Long-term rainfall average (mm)
RY = Annual rainfall (mm)
LLT = Long-term daily minimum temperature average (°C)
LY =Annual daily minimum temperature average (°C)
HLT = Long-term daily maximum temperature average (°C)
DIUY = Annual daily diurnal temperature variation average (°C)
C_iIA = Irrigated area under i^th crop (Ha)
PRC_iIA = Proportion of irrigated area under i^th crop
A_i = Area of the i^th crop (Ha)
Y_i = Yield of i^th crop (Kg/ha)
Crops = Paddy, Maize and ground nut.

Data on the list of crop and climatic variables give below were collected for the last 30 years and then fine tuned to 29 years by removing the missing years.

a. Crop variables

1. District wise Area under each crop (Ha)
2. District wise Productivity/Production under each crop (kg/ha)
3. District wise Total cropped area (Ha)
4. Total Irrigated area to total cropped area (Ha)
5. Crop wise irrigated area (Ha)

b. Climatic variables

6. District wise 29 year monthly rainfall (mm)
7. District wise 29 year monthly maximum temperature (°C)
8. District wise 29 year monthly minimum temperature (°C)
9. District wise 29 year monthly diurnal temperature variation (°C)

Crop production is affected by many climatic variables and an attempt has been made to analyze the impact of climate change in the Ricardian sense discussed above on major crops.

The weather data was collected from the Indian Meteorological Department (IMD) and local statistical offices.

RESULTS AND DISCUSSION:

Impact of climate change on the area of crop:

The variables Annual rainfall (RY), Long-term rainfall average (RLT), Long term daily minimum temperature average (LLT), Long term daily maximum temperature average (HLT) and yield of paddy were significantly affecting the area of paddy. Further, annual rainfall (RY), long term daily minimum temperature average (LLT) and yield of paddy had positive significant effects on the area of paddy. But, the long term daily maximum temperature average (HLT) and long term rainfall average (RLT) will significantly reduce the paddy area. In case of paddy, the model is adequate as indicated by the F-statistics of the ANOVA. The R - square value is 0.72 implying 72% variation in the area under paddy.

One unit increase in the variable RY, LLT and Yield of paddy will increase the area of the paddy by 56.33, 161230.84 and 12.681 ha respectively keeping the other variables constant. The result implies that the paddy crop is profitable and the paddy area increased under these climate variables. It can be noted that long term daily minimum temperature average (LLT) has maximum effect in increasing the area under paddy. Unit increase of these will likely result in decrease of 95364.89 and 146.86 ha of paddy area respectively. Thus the climate variables such as long term daily minimum temperature average and by 1892.86, 0.100 and 0.718 kg/ha respectively.

Table3. Ricardian Area regression result

Variable	Paddy	Maize	Groundnut
Constant	-7406.542	-429229.092	6996333.300
	(275437.350)	(98619.970)	(368422.640)
TOTCROP	-0.005	0.046***	0.537***
	(0.035)	(0.013)	(0.048)
PROIA	25.665	52.945	553.331***
	(92.050)	(32.980)	(123.460)
RLT	-146.868**	156.011***	65.193
	(79.880)	(28.640)	(107.370)
RY	56.338***	-5.712	-29.949
	(17.040)	(6.150)	(22.940)
LLT	161230.845***	-25935.693***	-112172.100***
	(16619.470)	(5890.810)	(22489.010)
HLT	-95364.895***	28245.113***	-154957.428***
	(14387.530)	(5133.560)	(19240.030)
HY	-12031.940	-2259.933	8226.769
	(7906.760)	(2842.790)	(10653.950)
DUIY	18177.405	-1172.741	9660.648
	(11394.730)	(4113.250)	(15310.030)
Yield	12.681***	3.708***	1.090
	(4.660)	(0.903)	(10.570)
R^2	0.725	0.68	0.860
F-stat	73.650	6.57	171.440

*** indicates significance at 1% and ** indicates significance at 5%

Table 4. Yield Regression Results

Variable	Paddy	Maize	Groundnut
Constant	-2411.473	-2781.106	-924.985
	(5878.460)	(6919.08)	(3536.480)
TOTCROP	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)
PROIA	0.936	0.284	0.588
	(1.258)	(1.955)	(0.739)
PROSUR	-7.761**	-26.773***	-0.892
	(3.964)	(6.810)	(2.250)
RLT	-2.220	-5.923***	-1.954***
	(1.373)	(1.819)	(0.645)
RY	0.178	0.718**	0.214
	(0.231)	(0.362)	(0.131)
LLT	615.371**	1892.86***	572.930***
	(304.000)	(454.24)	(163.26)
HLT	-329.516	-954.148***	-177.202
	(232.540)	(354.26)	(141.44)
HY	-69.089	23.196	-101.691
	(106.160)	(171.46)	(63.11)
DUIY	79.949	14.138	-8.387
	(152.820)	(248.20)	(89.50)
CA	0.036**	-0.014***	0.001
	(0.016)	(0.006)	(0.00)
CiA	-0.035**	0.100***	-0.005**
	(0.016)	(0.015)	(0.003)
PRCIA	57.599**	6.641	10.277***‘
	(26.430)	(4.878)	(2.167)
R^2	0.810	0.602	0.524
F-stat	4.564	13.91	9.903

*** indicates significance at 1% and ** indicates significance at 5%

long term daily maximum temperature average are important determinants of paddy crop.

In case of maize, the model is adequate as indicated by the F-statistics of the ANOVA. The R-square value is 0.19 implying that 19% of the variation in area under maize can be explained by the model. The variables TOTCROP, RLT, LLT, HLT and Yield of maize are significantly affecting the area of maize. The variables TOTCROP, RLT, HLT and yield are positively significant and the long term daily maximum temperature average (RLT) has maximum positive effect on the area under maize i.e., one unit increase in the variable results in increase in the area of maize by 28245.11 ha, whereas long term daily minimum temperature average (LLT) has maximum effect in reducing the area under maize by 25935.69 ha for one unit increase in the variable.

In case of groundnut, the model is adequate as indicated by the F-statistics of the ANOVA. The R - square value is 0.85 implying that 85% of the variation in the area under groundnut. The variables TOTCROP, PROIA, LLT and HLT are significantly affecting the area of groundnut. The variables TOTCROP and PROIA are positively effecting and the variable TOTCROP has maximum positive effect on the area of the groundnut .One unit increase in TOTCROP and PROIA will increase the area of groundnut by 0.537 and 553.33 ha respectively. Similarly, the variables HLT and LLT will significantly reduce the area of the groundnut. One unit increase in HLT and LLT will reduce the groundnut area by 154957.42 and 112172.10 ha respectively. The variables TOTCROP and HLT are the important determinants of groundnut area.

The impact of climate change on the productivity of crop:

The selected variables LLT, Area of paddy and PROCIA were significant and positive affecting the productivity of paddy (tab.3). The variables PROSUR and CiA have negative significant effects on productivity of paddy. One unit increase in the variables LLT, PROCIA and Area of paddy, the productivity of paddy increases by 615.37, 57.59 and 0.036 kg/ha. Similarly, unit increase in the variables PROSUR and CiA reduces the yield of paddy by 7.76 and 0.035 kg/ha respectively. All these variables are significant at 1% level.

In case of maize, the variables LLT, CiA and RY are positively significant affecting the productivity of maize crop. One unit increase in these variables increases the productivity of maize. Similarly the variables PROSUR, RLT, HLT and Area under maize crop are negatively affecting the maize productivity i.e., one unit increase in these variables reduces the yields by 26.77, 5.92, 954.14 and 0.014 kg /ha respectively. All the variables affecting maize productivity are significant at 1% except RY which is significant at 5%. Thus, the irrigation variables CiA and PROSUR are important determinants of maize productivity.

In case of groundnut, the variables LLT and PROIA are positively significant affecting the productivity of groundnut. For one unit increase in these variables, the productivity of groundnut increases by 572.93 and 10.277 kg/ha respectively. Similarly the variables CiA and RLT are negatively significant affecting the groundnut productivity i.e., unit increase in these variables reduces the productivity of groundnut by 0.005 and 1.954 kg/ha respectively. All the variables are significant at 1% except CiA which is significant at 10% level.

CONCLUSION

The results of the area revealed that the climate variables such as long term daily minimum temperature average and long term daily maximum temperature average are important determinants of area of paddy crop. The climate variables long term daily maximum temperature average and long term daily minimum temperature average (LLT) has maximum effect. The variables TOTCROP and HLT are the important determinants of groundnut area.

The results also concluded that LLT and PROSUR in paddy, LLT and HLT in Maize, RLT and LLT in groundnut are the important determinants influencing the paddy , maize and groundnut productivity. This conclusion will very much useful for planning suitable remedial measures to mitigate the effects of climate change

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Received on 15.02.2017 and revised on 21.03.2017