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Impact of climatic variables on agricultural economy of Odisha

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Abstract
Climate is one of the main determinants of agricultural production. This study was to analyze agriculture-climate nexus, quantify the impact of selected climatic variables on agricultural economy of Odisha and suggest a perspective for its development. The secondary data were collected from Directorate of Economics and Statistics, Directorate of Agriculture and Food Production, Odisha, Government of Odisha and the rainfall, temperature and relative humidity data were compiled from "Climatological data of Orissa" published by the Directorate of Economics and Statistics, Government of Odisha for a period of eighteen years from 2000-01 to 2017-18. Multiple linear regression analysis was carried out to find out the extent of relationship between dependent (agricultural economy of Odisha) and selected independent variables (climatic variables). The important climatic variables affecting gross cropped area and agricultural GDP of Odisha are rainfall, maximum temperature, minimum temperature and relative humidity. Rainfall contributes positively to gross cropped area of Odisha at one per cent significance level. Minimum temperature has been found to have a negative coefficient on gross cropped area which implies that 1 unit rise in minimum temperature would lead to reduction of 0.236 units in gross cropped area of the state. Relative humidity and rainfall affect the state's GDP of agriculture positively. Higher rainfall would result in higher agricultural production thereby increasing the gross domestic product of agriculture. Watershed development for raising yields of largely rainfed crops to cover oilseeds pulses fruits and vegetables would yield promising results.

Keywords: Climate, agriculture, Odisha, economy

Introduction
Odisha is predominantly an agrarian state situated in eastern India. The extent of India's regional disparities has been an issue since at least independence, and this concern has been partly motivated by a desire to alleviate poverty (Datt and Ravallion, 1996) [2]. Climate is one of the main determinants of agricultural production. Throughout the world there is significant concern about the effects of climate change and its variability on agricultural production. Since climatic factors serve as direct inputs to agriculture, any change in climatic factors is bound to have a significant impact on crop yields and production. Studies have shown a significant effect of change in climatic factors on the average crop yield [(Dinar *et al.* (1998), Seo and Mendelsohn (2008) and Cline (2007)] [3, 8, 1]. Climate change can have serious impact on socio-economic condition of the people especially the farmers. Assessing the impact of climate change faces a fundamental challenge of complexity. The set of mechanisms through which climate may influence economic outcomes, whether positive or negative, are extremely large and difficult to investigate.
Given this backdrop, the broad objective of this study was to analyze agriculture-climate nexus, quantify the impact of selected climatic variables on agricultural economy of Odisha and suggest a perspective for its development

Materials and methods:
The study was conducted for the entire state of Odisha. The secondary data were collected from Directorate of Economics and Statistics, Directorate of Agriculture and Food Production, Odisha, Government of Odisha and other reliable secondary sources. The rainfall, temperature and relative humidity data were compiled from "Climatological data of Orissa" published by the Directorate of Economics and Statistics, Government of Orissa for a period of eighteen years from 2000-01 to 2017-18.

Multiple regression analysis
Multiple linear regression analysis was carried out to find out the extent of relationship between dependent (agricultural economy of Odisha) and selected independent variables (climatic variables). Further, the computed 'b' values (regression coefficients) were tested with 't' test for its significance.

$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots + b_tX_t + e$

Where,
Y = the variable that we are trying to predict
Xi = the variable that we are using to predict Y (climatic variables)
a = the intercept
b = the slope (regression coefficient)
e = the regression residual

The coefficient of determination (R^2)
This represents the proportion of the total sample variability in Y that is explained by a linear relationship between X and Y. R^2 is always less than unit and expressed in percentage. It means the extent of variation in dependent variable (Y) which can be explained by the independent variables (Xi) together. R-squared measures how well the model fits the data. Values of R^2 to 1 fit well. Values of R^2 close to 0 fit badly. Coefficient of Multiple Determination (R^2) was calculated by

$$R^2 = \frac{SS(Y) - SSE}{SS(Y)}$$

Where,
R^2 = Coefficient of Multiple Determination
SS(Y) = Sum of squares of dependent variable (Y)
SSE = Sum of squares due to deviation from regression

Results and discussion

Impact of climatic variables on Gross Cropped Area

A multiple linear regression (MLR) was run to study the impact of climatic variables of gross cropped area of Odisha. The data pertains to time series years 2000-01 to 2017-18. The results of the MLR are presented in Table 1.
The important climatic variables affecting gross cropped area are rainfall, maximum temperature, minimum temperature and relative humidity. The table reveals that rainfall contributes positively to gross cropped area of Odisha at one per cent significance level. The model results in positive but non-significant coefficient of relative humidity on gross cropped area.
Minimum temperature has been found to have a negative coefficient (-0.236) at 5 per cent level of significance on gross cropped area which implies that 1 unit rise in minimum temperature would lead to reduction of 0.236 units in gross cropped area of the state. The coefficient of maximum temperature has been found to be non-significantly negative.
The R^2 of model is found to be 0.74 which indicates that 74 per cent of the variation in gross domestic product of agriculture was explained by independent variables included in the present study. F value indicates that the model is efficient.
Rainfall contributes positively to gross cropped area of Odisha at one per cent significance level. Maximum temperature and relative humidity have inverse relationship with agricultural production. Higher the maximum temperature and relative humidity, lower is the state's gross domestic product of agriculture. Any increment in maximum temperature had a negative and statistically significant impact on crop productivity. Rising in temperature leads to a prolonged period of droughts endangering the cropping pattern.

Table 1: Impact of climatic variables on Gross Cropped Area in Odisha

Sl No	Particulars	Parameters	Coefficients
1	Intercept	A	7.11* (0.846)
2	Rainfall (X_1)	b_1	0.239* (0.043)
3	Maximum Temperature (X_2)	b_2	-0.113 (0.218)
4	Minimum Temperature (X_3)	b_3	-0.236** (0.117)
5	Relative Humidity (X_4)	b_4	0.297 (0.21)
	R^2 (Coefficient of Determination)	0.74	
	F value	183.32	

Note: *,** and *** are significant at 1 per cent, 5 per cent and 10 per cent level of significance, respectively. Figures in parentheses indicate standard error.

Impact of climatic variables on Gross Domestic Product of agriculture

The use of a multiple linear regression was done to identify and characterize the most important drivers of climate variables with gross domestic product of agriculture in the state of Odisha. In this method we have used Gross Domestic Product of agriculture as dependent variable and the independent variables under consideration are rainfall, maximum temperature, minimum temperature and relative humidity. The results have been depicted that in Table 2. Among the selected independent variables, rainfall, maximum temperature and relative humidity are found to significantly influence the Gross Domestic Product of agriculture in Odisha.
Relative humidity and rainfall affect the state's GDP of agriculture positively at 1 per cent and 5 per cent levels, respectively. One mm rise in rainfall would most likely increase the GDP of agriculture of the state by 0.11 units. One per cent rise in relative humidity would improve the agricultural GDP of Odisha by 0.61 units. One degree increase in maximum temperature would result in decrease in agricultural GDP by 0.966 units. The coefficient of minimum temperature is positive (0.60) but, non-significant.
The R^2 value was 0.77, indicating that 77 per cent of the variation in gross domestic product of agriculture was explained by independent climatic variables included in the present study.
Rainfall, maximum temperature and relative humidity are found to significantly influence the gross domestic product of agriculture in Odisha. Higher rainfall would result in higher agricultural production thereby increasing the gross domestic product of agriculture. The significant and positive effect of rainfall on gross domestic product of agriculture is a well-known phenomenon in a state like Odisha where more than two-third per cent of gross cropped area is rainfed. It is interesting to note that the elasticity coefficient for rainfall was high for the state.

Table 2: Impact of climatic variables on Gross Domestic Product of agriculture of Odisha

Sl. No	Variable	Parameters	Regression Coefficients (b Values)
1	Intercept	A	2862.58
2	Rainfall (X_1)	b_1	0.11* (0.025)
3	Maximum Temperature (X_2)	b_2	-0.966* (0.453)
4	Minimum Temperature (X_3)	b_3	0.60 (0.49)
5	Relative Humidity (X_4)	b_4	0.61* (0.278)

	R^2 (Coefficient of Determination)	0.77
	F value	270.11

Note: *,** and *** are significant at 1 per cent, 5 per cent and 10 per cent level of significance, respectively. Figures in parentheses indicate standard error.

Conclusion

Rainfall and minimum temperature significantly affect GCA of the state; while rainfall and relative humidity significantly affect the agricultural GDP of Odisha. Nearly 60 per cent of the cultivated area in Odisha is rainfed. For promoting dry land technologies, emphasis on technology based agricultural growth is needed. Watershed development for raising yields of largely rainfed crops to cover oilseeds pulses fruits and vegetables would yield promising results.

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