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Farmer's perception towards climate change and impact of climatic variables on agrarian economy of Odisha

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Abstract
Climate is one of the major determinants of agricultural production. This study was designed 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 impact on gross cropped area which implies that 1 per cent rise in minimum temperature would lead to reduction of 0.236 per cent in gross cropped area of the state. Relative humidity and rainfall affect the state's agricultural GDP positively. Higher rainfall would result in higher agricultural production thereby increasing the gross domestic product of agriculture. Farming experience, education, and climate information are the factors that positively and significantly influenced the probability of a respondent perceive the threat of climate change. 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, predominantly an agrarian state, is situated in eastern part of India with a long coastline. The extent of India's regional disparities has been a significant issue since independence, and this concern has been 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 has been 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) [3], Seo and Mendelsohn (2008) [9] and Cline (2007) [1]]. Climate change can have serious impact on socio-economic condition of the people especially the farmers. Most farmers of Odisha cultivate paddy. Paddy accounts for 47 per cent of the gross cropped area of the state as in 2015-16 (GoO, Economic survey). 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 complex 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 through a simple model, understand the factors affecting farmers' perception towards climate change 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.

Primary data were collected from 160 sample respondents spread over four districts of Odisha using pre-tested structured interview schedule to elucidate the framers' perception regarding climate change. The following tools were used to analyze the collected data in order to arrive at meaningful results.

Time series OLS (Ordinary Least Square) Method:

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.

$Y_t = a + b_1X_{1t} + b_2X_{2t} + b_3X_{3t} + b_4X_{4t} + e$

Where,

Y = Independent variable

X_1 = Rainfall

X_2 = Maximum temperature

X_3 = Minimum temperature

X_4 = Relative humidity

a = the intercept

b = the slope (regression coefficient)

e = the regression residual

Maximum Likelihood Estimator (MLE): Probit model analysis

The probit model was run and tested for its appropriateness over the estimation of Perception of Climate change for Explanatory variables. The results from the selection model, which analyses the factors affecting the perception of climate change, indicate that age of the head of the household, Farming Experience, Education, Family Size, Extension Contact, Climate information, Irrigation and Constant respectively. Model represents a type of widely used statistical model for studying data with binomial distributions and it can be expressed in probability thus:

$$\text{Prob } (Y=1) = 1\text{-}F\ [-\sum^{K}_{K=1} \beta_K b_K] = F\ [-\sum^{K}_{K=1} \beta_K b_K] = \varphi\ [-\sum^{K}_{K=1} \beta_K b_K]$$

The farmer's decision on use of a particular input depends on the criterion function:

$$Y^* = \gamma - X_i + U_i$$

Where,

Y* = Underlying index reflecting the difference between the use of an input and its non-use.

γ = Vector of parameters to be estimated

Z_i = Vector of exogenous variables which explain use of an input

U_i = Standard normally distributed error term

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 cropped area 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 level of significance. 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 of 0.77 indicates 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.

Maximum Likelihood Estimation of farmers' perception about of climate change

Climate change, as a real threat to agriculture, has not been perceived by majority of farmers due to various socio-cultural impediments in Odisha. A probit model was run and tested for its appropriateness for the estimation of perception of climate change for the selected explanatory variables. The results from the selected model, which analyses the factors affecting the perception about climate change, indicate that age of the head of the household, farming experience, education, family size, extension contact, climate information and irrigation have been presented in Table 3.

The coefficients of farming experience, education, climate information were found to be significant at 5 per cent level. Farming experience, education, and climate information are the factors that positively and significantly influenced the probability of a respondent perceive the threat of climate change. One unit increase in the farming experience would increase the probability of a respondent to perception of climate change by 56.2 per cent, while a unit increase in education would increase the probability of a respondent to perception of climate change 41.0 per cent. Similarly, a unit increase in access climate information would increase the probability of a respondent to perception of climate change by 11.5 per cent.

Nhemachena and Hassan (2007) [7] argued that higher age with highly experienced farmers were likely to have more information and knowledge on changes in climatic conditions of crop and demographic profiles. They also discovered that higher income farmers might, however, less risk-averse and have enough access to information and access to extension services with education was one of the critical elements of farmer's awareness of climate change.

Table 3: Maximum Likelihood Estimates (MLE) of perception about climate change for explanatory variables in the Probit model

Variables	Coefficients	Standard Error	Z value
Age	-0.023	0.041	-0.44
Farming Experience	0.562*	0.13	2.71
Education	0.41*	0.26	2.02
Family Size	0.561	0.29	0.91
Extension Contact	0.26	0.56	0.66
Climate information	0.115*	0.07	2.01
Irrigation	0.071	0.14	0.85
Constant	-5.83	2.11	-1.14

Log Likelihood=67.93, No of observation = 160, * significant at 5% level, Pseudo R^2 = 0.69

Conclusion

As rice is the major crop of Odisha which essentially requires high relative humidity and rainfall and temperature, 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. Farming experience, education, and climate information are the factors that positively and significantly influenced the probability of a respondent perceive the threat of climate change. Thus, government should provide this information through all the machineries at its disposal which include the line departments, media and internet of things (IOTs).

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