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Research Article

IMPACT OF CLIMATE CHANGE ON FOOD GRAIN PRODUCTIVITY IN MIRZAPUR DISTRICT OF UTTAR PRADESH

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Abstract- The Agriculture productivity is being affected by number of factors of climate change like rainfall pattern, temperature, changes in sowing time, water availability, evapotranspiration and land suitability. Temperature and rainfall are the key factors affecting agricultural productivity. During the study period 1950-2013 the *Kharif* and *Rabi* seasons maximum temperature indicated the negative trend while minimum temperature has shown positive trend. However, rainfall indicated the negative trend in monsoon season. The results of regression analysis have shown that increase in mean maximum temperature may decrease the rice yield. However, increase in mean minimum temperature may decrease the wheat yield.

Keywords- Food Grain Productivity, Weather Variables, Climate Trend and Regression Analysis

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Introduction

About 65 per cent of Indian population directly depends on agriculture and it accounts for around 14.2 per cent of the GDP. The examination of food grain production from each year, between the two seasons (*Kharif and Rabi*), the highest production of 53 per cent comes from *Kharif* season (June-Oct) as compared to *Rabi* season (Nov-Feb) where the production is around 47 per cent. The constraint for food grain production during *Kharif* in India is soil moisture as influenced by the seasonal rainfall from Southwest monsoon season, while it is minimum temperature and stored soil moisture as prevailed during *Rabi* season. The total food grain production in India has gone up from 50 million tonnes in 1950 to 175 million tonnes in 1990 to around 230 million tonnes in 2008 and 264.38 million tonnes in 2013-14. Today India produces 106.29 million tonnes of rice, 95.85 million tonnes of wheat and 42.67 million tonnes of coarse grains and 19.57 million tonnes of pulses (GOI, 2014-15) [1].

Uttar Pradesh is one of the most agriculture sectors of the economy with 2/3rd of the workforce of the state dependent on agriculture for their livelihood. Utter Pradesh is the largest producer of food grain in India and offers a diverse agro climatic condition which is conductive for agricultural production. Mirzapur is the leading district of U.P. from the point of agricultural development consisting 4 Tehsils and 12 development blocks with 795 revenue villages. Paddy and wheat are the major *Kharif* and *Rabi* crops, that account for the largest food grain basket in UP. During 2011-12 and 2012-13, paddy production and productivity stood at (14 million tonnes and 2,358 kg/hectare) and (14.41 million tonnes and 2,459 kg/hectare) respectively (GOI, 2013-14) [2].

Study area

The study has been conducted for Mirzapur district of Uttar Pradesh, India which is situated between 23°52′ to 25°32′ North latitude and 82°07′ to 83°33′ East longitude. It lies in the Vindhyan Zone (EPZ) of Uttar Pradesh.

Materials and Methods

The productivity data have been collected from Directorate of Economics and Statistics, Government of Uttar Pradesh and weather data was collected from Department of Geophysics, Banaras Hindu University, Varanasi, and website of Indian Meteorology Department used to fulfil the objective.

Statistical Analysis

Trend analysis was done to see the pattern of change in climate variables. Trend analysis of a time series consists of the magnitude of trend and its statistical significance that is expressed as:

$$Y = a+bT$$

Where,
Y= average seasonal temperature (^{0}C) or rainfall (mm)
a= intercept
b= coefficient
T= Time (independent variable)

Multiple linear regression analysis was done in the present study to estimate impact of weather variables on food grain productivity. Regression analysis approach is useful in providing quite effective estimates of crop yield when crop yield is affected by weather factors such as rainfall or temperature (Parry *et al.*, 1988a) [3]. The relationship between response variable (yield) and independent variables Cobb-Douglas production functions were estimated. The mathematical form of Cobb-Douglas function is expressed as:

$$Y = a\, X_1^{b1}\, X_2^{b2}\, X_3^{b3}\, X_4^{b4} X_5^{b5}\, X_6^{b6} e^{\mu}$$

Where,
Y= Yield of crop (Kg/ha)
X_1 = Fertilizer in Kg/ha
X_2 = Total irrigated area in ha

X_3= Total area in ha
X_4 = Mean minimum temperature during crop season (°C)
X_5 = Mean maximum temperature during crop season (°C)
X_6= Total rainfall during crop season (mm)
a = Constant term
b_1 to b_6 = Elasticity coefficients of respective inputs or regression coefficients of factor input
e^{μ} = Error/disturbance term
u =Random variables

Results and Discussion

Trend Analysis

[Table-1] presents the summary statistics of weather variables for rice and wheat cropping seasons. The rice period is a hot and humid season. During the study period of 1950 to 2014, daily mean minimum temperature was 23.99 °C with a maximum of 33.23 and received about 928.97 mm rainfall. The minimum *Rabi* temperature for wheat was 10.99 °C and maximum 25.87 °C with 62.15 mm rainfall. It is clear from the [Table-1] that during the *Kharif* and *Rabi* seasons maximum temperature indicated negative trend while minimum temperature was found positively increased.

Table-1 *Mean and trends of monthly temperature and annual rainfall during crop-growing periods, 1950-51 to 2013-14.*

Variables	Minimum temperature (⁰C)	Maximum Temperature (⁰C)	Rainfall (mm)
Kharif season			
Mean Annual change	23.99 0.0049 (0.0039)	33.23 -0.0045 (0.0037)	928.97 -3.420** (1.41)
Rabi season			
Mean Annual change	10.99 0.0127*** (0.0046)	25.87 -0.0058 (0.0043)	62.15 0.191 (0.244)

*** and ** denote significance at 1 per cent and 5 per cent levels, respectively. Figures within the parentheses are standard errors.

However rainfall indicated negative trend in monsoon season. Increasing temperature trends of the order of 0.60°C during last 112 years (IMD 2012) [4] and increase in heavy rainfall events and decrease in low and medium rainfall events (Goswami *et al*. 2006) [5] over India have been observed. Changes in rainfall and temperatures have also been reported by Dash *et al.* (2009) [6], Arora *et al.* (2005) [7], De *et al.* (2005) [8].

Regression Analysis

The crop-wise results of regression analysis are presented in [Table-2], that 64 and 71 per cent of the variation in the yield of rice and wheat were explained by the selected explanatory variables in Mirzapur district. It was found that impact of fertilizer use and temperature on productivity of both rice and wheat to be positive and significant at the 5 per cent level. Irrigated area on the productivity of rice was found positive and significant at 5 per cent level.

Table-2 *Estimates of parameters influencing Rice and Wheat yield in Mirzapur district, Uttar Pradesh (1989-90 to 2013-14)*

Variables	Rice	Wheat
Intercept	0.7004 (3.8196)	-5.9099* (3.0792)
Fertilizer (Kg/ha)	0.2691** (0.1051)	0.4986*** (0.0892)
Irrigated area (in ha)	2.1043** (0.8088)	1.3909 (0.8308)
Total area (in ha)	-1.3034 (0.9545)	-0.2792 (1.2494)
Mean min temp during crop season (degrees centigrade)	2.5216** (1.1221)	-0.6855* (0.3882)
Mean max temp during crop season (degrees centigrade)	-3.5594 (2.4242)	2.3772** (1.1314)
Total rainfall during crop season (mm)	0.0494 (0.1350)	0.0406 (0.0270)
No. of observations	25	25
R^2	**0.64**	**0.71**

*, ** and***indicates significant at 10%, 5% and 1% levels respectively. Figures within parentheses are standard errors.

The fertilizer use and temperature was found to be positive and significance at one per cent and five per cent level of significance, respectively. One per cent increase in fertilizer use and maximum temperature indicate 0.498 and 2.377 per cent increase in wheat yield, respectively. Reported by Greg *et al.*(2011) [9] studied high variation in environmental factors such as temperature, rainfall and others get affect to crop growth negatively and certain crops get positively affected due to change in these environmental factors.

Conclusions

Climate is one of the most important factors for the agriculture productivity in all over the world. Climate change can affect crop yields both positively and negatively as well as the types of crops that grown in different seasons. The regression results shows that changes in average climate conditions cause changes in crops yield, over the time. During the *Kharif* and *Rabi* season maximum temperature indicated negative trend while minimum temperature was found with positive trend. The rainfall indicated significant and negative trend in monsoon season. Regression function indicated that increase in mean minimum temperature may increase the rice yield significantly. However increase in mean minimum temperature may decrease the wheat yield at 10 per cent level of significant.

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Conflict of Interest: None declared

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