Asian Research Consortium

Asian Journal of Research in Social Sciences and Humanities
Vol. 11, No. 4, April 2021, pp. 1-6.

ISSN 2249-7315

Asian Journal of Research in Social Sciences and Humanities

www.aijsh.com

A Journal Indexed in Indian Citation Index
DOI NUMBER:**10.5958/2249-7315.2021.00007.1**
SJIF – SCIENTIFIC JOURNAL IMPACT FACTOR :7.615(2020)

Impact of Climate Change on Indian Agriculture: Some Recent Evidence

Pawan Mishra*

*Doctoral Fellow,

Department of Economics,

Dr. Harisingh Gour Vishwavidyalaya,

India.

Abstract

Climate change and other environmental hazards pose severe threat to agricultural production across the world. The developing countries like India are more vulnerable to climate change. This study aims to examine the impact of climate change on major crop yields in India using time series data over a period of 1980-2017. The estimated empirical outcomes show that climatic variables have substantial effect on major crop yields in general. An increase in rainfall has an adverse effect on rice and pulses. However, it has a positive relationship with wheat, cotton, groundnut and sugarcane crops during the study period. Further, except groundnut, the average maximum temperature has a positive influence on all crops. The average minimum temperature has an adverse impact on wheat and cotton crops but it has a positive association with rice, pulses, groundnut and sugarcane. Conclusively, this found that crop yields are impacted differently with different climatic variables in India. This study recommends taking adaptation activities to cope with the adverse impacts of climate change.

Keywords: Climate change, Precipitation, Temperature, Crop growing, Yield, India.

1. Introduction

In recent years, there has been growing interest in curbing the rapid rise of greenhouse gases in the atmosphere in order to control future climate change. Many observers are concerned that changes in climate will in turn lead to significant damages to both market and nonmarket sectors. In an effort to understand the entire picture of the effects of climate change, it is necessary to examine all sectors affected by climate change. One such area examined is the social effect of climate change focusing on several potentially affected sectors, among which are forestry and ecosystems, coastal zones, agriculture, fisheries water resources, and energy developments (Reilly and Thomas, 1993). Toman et al. (1996) suggest that while "the potential impacts of climate change are broad; some aspects of human society are more sensitive than others". Although several sectors have been studied, none have received more attention than agriculture.

Climate change is a matter of a global concern because of its impending threats to sustainable economic development. Compared to other economic activities, agriculture is more sensitive to climate change (Mendelsohn et al., 2006; Guntukula and Goyari, 2020b). Therefore, agriculture will be affected more by climate change. The impacts are likely to be severe for the developing countries, like India, because of their heavy dependence on agriculture, and lack of financial resources for mitigation and adaptation to climate change (Mendelsohn et al., 2006; Nelson et al., 2009; Guntukula and Goyari, 2020a).

The literature on climate impacts on Indian agriculture is limited but has been growing. In recent years, several studies have examined the impacts of climate change on agriculture. But their results vary widely probably due to differences in the estimation procedures and their underlying assumptions. Aggarwal (2009) reported that a 1.0°C rise in mean temperature would decrease yields of wheat, soybean, mustard, groundnut and potato by 3 - 7 per cent. By 2099, if temperature were to rise by 2.5°- 4.9°C, the damage to these crops will increase to 10 - 40 per cent, even after internalization of the positive effects of carbon fertilisation. Mendelsohn et al. (2001), Kumar and Parikh (2001), and Sanghi and Mendelsohn (2008) estimated that with a 2.0°C rise in annual temperature and a 7 per cent increase in annual rainfall (likely changes by 2099) the productivity of Indian agriculture, measured as net returns per hectare of cropped area, will be 8-12 per cent less than without such changes. Guiteras (2007) has reported that with a rise in annual temperature rises by 0.5°C and increase in rainfall by 4 per cent by 2039, the damage to agricultural productivity will be in the range of 4.5 to 9.0 per cent, and by 2099 with significant changes in climate the damage may increase beyond 25 per cent. However, with adaptation this could be reduced to about 3 per cent (Kumar, 2011).

In India, agriculture despite its declining share in national income, less than 15 per cent in 2012-13, continues to be an important sector of the economy because of its strategic importance to food security, employment generation and poverty reduction. The sector engages half of the country's total workforce, and is dominated by small holders; more than 85 per cent land holdings are of size less than or equal to 2 hectares. Thus, significant adverse impacts of climate change on agriculture would threaten livelihoods of a majority of the population dependent on agriculture. This study wishes to examine the impact of climate change on major crop yields in India using time series data over a period of 1980-2017. The paper is organized as follows. In the following section, study discuss the estimation strategy and the data set utilized for evaluating climate impacts on agriculture production. Section III discourses briefly the impacts of climate change on agriculture. Concluding remarks are discussed in Section IV.

2. Data and Methodology

The core aim of this study is to empirically explore the impact of climate change on the yields of major crops in India for the time period (1980 to 2017). To succeed this objective, this study uses the annual time-series secondary data collected from several sources. This study selected six food and non-food crops such as rice, wheat, pulses, cotton, groundnut and sugarcane. The data on agricultural productivity and crop-wise cultivated area were collected from Handbook of Statistics on Indian Economy, Reserve Bank of India. Information on Climatic variables viz. actual rainfall, maximum temperature and minimum temperature were gathered from the Ministry of Statistics and Programme Implementation, Government of India. The statistical explanations (summary statistics) of the of dependent and explanatory variables for India have reported in Table 1.

Table 1: Summary Statistics

Variables	Observations	Mean	Std. Dev.	Minimum	Maximum
Area	38	42.67158	1.647992	38.26	45.54
Rainfall	38	1149.182	103.3258	930.1	1401.4
Max.Temp.	38	29.73711	0.537566	29.05	31.63
Min.Temp.	38	19.62763	0.493051	18.96	21.28
Rice	38	1923.5	361.5541	1231	2578
Wheat	38	2532.605	452.7882	1630	3371
Pulses	38	609.9737	87.86491	473	841
Cotton	38	297.2368	125.1847	141	532
Groundnut	38	1081.868	278.5882	694	1868
Sugarcane	38	65963.21	5270.901	55978	79650

Source: Authors' own compilations from available secondary data.

The Intergovernmental Panel on Climate Change (IPCC) stated that change in climatic factors is emerging as one of the 21st century's serious problems. However, this study evaluates the effects of climatic factors on primary crop yields in India. To examine the impact of climate change on crop productivity, six important food and non-food crops have been taken. Those are rice, wheat, pulses, cotton, sugarcane and groundnut. These six crops largely cultivated based on monsoons and any change in climate, particularly precipitation and temperature would affect the yields of these crops significantly. Based on Sarker et al. (2012), the study uses Multiple regression analysis to assess the effects of climate change on crop yields. One of the most popular types of linear regression analysis (OLS) is multiple regression. This method is appropriate to assess the impact of climate change on crop productivity. Following Lobell et al. (2007) and Sarker et al. (2012), this paper used three climatic factors as explanatory variables: rainfall, maximum and minimum temperatures and crop yields as dependent variables. For the purpose of present study, the following regression model has been used:

$$Y_t = \alpha + \beta_1 rainf_t + \beta_2 maxtemp_t + \beta_3 mintemp_t + \beta_4 area_t + \varepsilon_t \quad \text{.........} \ (1)$$

Where,

Y_t = Crop yields (Kg per hectare)

$rainf_t$ = Actual Rainfall (mm)

$maxtemp_t$ = Average maximum temperature (°C)

$mintemp_t$ = Average minimum temperature (°C)

$area_t$ = crop wise cultivated area and ε_t is the error term. α is the intercept and β_1 to β_4 are the regression coefficients. This regression estimation has been done in STATA to fit the equation (1).

3. Results and Analysis

The following analysis deals with the empirical results and discussion of the study. Table 2 presents the empirical results of rice, wheat, pulses, cotton, groundnut and sugarcane crops. The R-squared value specifies that 73 % of the variation in the rice yield is explained by climate variables in India. Rainfall, minimum temperature and cropped area of rice are statistically significant. Moreover, area and minimum and maximum temperatures are positively associated with rice yield. Higher temperature leads to a higher yield of rice. However, rainfall is negatively related with the rice yield. This implies that higher rainfall would mean lower the rice yield rates. The rice results are not consistent with Gupta et al. (2014). The reason for not getting similar results might be the different data series and time periods.

The R-squared value specifies that climate variables in India explain 86 % of the variation in the wheat yield. The climatic variables namely maximum temperature and actual rainfall are statistically significant in the wheat model. The cropped area of wheat is statistically significant and positively related with wheat yield. Minimum temperature appears to be statistically significant and is negatively related with the wheat yield. Conversely, rainfall has a positive impact on wheat yield. The wheat results are consistent with Birthal et al. (2014). Furthermore, the R-squared value indicates that 53 % of the variation in the pulses yield is explained by climate variables. The climatic variables namely minimum temperature and rainfall are not statistically significant in the pulses model. But only maximum temperature is statistically significant at the 5 % level. However, except rainfall, all the explanatory variables are positively related with pulses yield. This implies that higher temperatures lead to a higher yield of pulses in India.

Table 2: Regression Results

Variables	Rice	Wheat	Pulses	Cotton	Groundnut	Sugarcane
Area	132.581***	144.356***	16.539***	57.458***	-121.165***	46.525***
Rainfall	-0.559**	0.290***	-0.046	0.254***	0.952***	40.269
Max.Temp.	2.591	49.323**	23.446**	100.661**	-99.307**	116.097**
Min.Temp.	23.503**	-37.259	49.059	-54.241**	37.506	48.326**
Constant	-856.473**	-867.239**	-131.894	-241.345**	-265.648**	-298.043
R-squared	0.736	0.862	0.532	0.751	0.510	0.615

Note: *** p < 0.01, ** p < 0.05.

The R-squared value specifies that climate variables in India explain 75 % of the variation in the cotton yield. The statistical significance and sign of the estimated coefficients for the regressors are found to be differ across the four non-food crop models. Rainfall and maximum temperature have a positive effect on cotton yields and these variables are statistically significant. Further, minimum temperature is adversely related to cotton yield in India. This implies that that cotton yields decrease due to increase in maximum temperature. The cotton results are somewhat consistent with Hebbar et al. (2013) and Guntukula (2020). Estimated R-squared at 0.51 indicate the overall significance of the groundnut model. The rainfall and minimum temperature have a positive effect on the groundnut yields in model but these variables are not statistically significant. Similarly, maximum temperature has an adverse impact on groundnut yields and it is statistically significant. Based on the empirical results of groundnut it can be said that the climatic variables have positive effect on productivity in India. The R-squared value specifies that climate variables in India explain 61 % of the variation in the sugarcane yield. The minimum temperature as well as maximum temperature have a positive effect on sugarcane yields and these variables are statistically significant. Furthermore, rainfall is positively related to sugarcane yield in India. However, mean rainfall is statistically insignificant.

4. Conclusions and Policy Implications

The study analyses the impact of climatic variables on the productivity of major crops in India during 1980-2017 using time series data. The present study taken six major crops namely rice, wheat, pulses, cotton, sugarcane and groundnut. These seven crops constituted approximately 60 % of the overall gross cropped area of India. Study found that the statistical significance as well as sign of the estimated coefficients for the explanatory variables are found to be differ across the study crops. An increase in rainfall has an adverse effect on rice and pulses. However, it has a positive relationship with wheat, cotton, groundnut and sugarcane crops during the study period. Further, except groundnut, the average maximum temperature has a positive influence on all crops. The average minimum temperature has an adverse impact on wheat and cotton crops but it has a positive association with rice, pulses, groundnut and sugarcane. Conclusively, this found that crop yields are impacted differently with different climatic variables in India. This study recommends taking adaptation activities to cope with the adverse impacts of climate change.

References

Aggarwal, P.K. (2009). "Vulnerability of Indian agriculture to climate change: current state of knowledge", paper presented at the National Workshop – Review of Implementation of Work Programme towards Indian Network of Climate Change Assessment. Ministry of Environment and Forests, New Delhi, http://moef.nic.in/downloads/others/Vulnerability_PK%20aggarwal.pdf.

Birthal, P. S., Khan, T. M., Negi, D. S., and Agarwal, S. (2014). Impact of climate change on yields of major food crops in India: Implications for food security. Agricultural Economics Research Review, 27(347-2016-17126), 145-155.

Guiteras, R. (2007). The Impact of Climate Change on Indian Agriculture. Working Paper, Department of Economics, MIT.

Guntukula, R. (2020). Assessing the impact of climate change on Indian agriculture: Evidence from major crop yields. Journal of Public Affairs, 20(1), e2040.

Guntukula, R., & Goyari, P. (2020a). Climate Change Effects on the Crop Yield and Its Variability in Telangana, India. Studies in Microeconomics, 8 (01), 119–148. (https://doi.org/10.1177%2F2321022220923197)

Guntukula, R., & Goyari, P. (2020b). The impact of climate change on maize yields and its variability in Telangana, India: A panel approach study. Journal of Public Affairs, 20 (03) e2088 (https://doi.org/10.1002/pa.2088).

Gupta, S., Sen, P., and Srinivasan, S. (2014). Impact of climate change on the Indian economy: Evidence from food grain yields. Climate Change Economics, 5(02), 1450001.

Hebbar, K. B., Venugopalan, M. V., Prakash, A. H., & Aggarwal, P. K. (2013). Simulating the impacts of climate change on cotton production in India. Climatic change, 118(3-4), 701-713.

Kumar, K.S.K. (2011). “Climate Sensitivity of Indian Agriculture: Do Spatial Effects Matter?” Cambridge Journal of Region, Economy and Society, Vol. 4, pp. 221-235.

Kumar, K.S.K. and J. Parikh (2001), “Indian Agriculture and Climate Sensitivity”, Global Environmental Change, Vol. 11, pp. 147–154.

Lobell, D. B., Cahill, K. N., & Field, C. B. (2007). Historical effects of temperature and precipitation on California crop yields. Climatic change, 81(2), 187-203.

Mendelsohn, R., A. Dinar and A. Sanghi (2001), “The Effect of Development on the Climate Sensitivity of Agriculture”, Environment and Development Economics Vol. 6, pp. 85–101.

Mendelsohn, R., A. Dinar and L. Williams (2006). “The Distributional Impact of Climate Change on Rich and Poor Countries. Environment and Development Economics, Vol.11, pp. 159–178

Nelson, G.C., M.W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler, S. Msangi, A. Palazzo, M. Batka, M. Magalhaes, R. Valmonte-Santos, M. Ewing and D. Lee (2009). Climate Change: Impact on Agriculture and Costs of Adaptation. Food Policy Report. International Food Policy Research Institute, Washington, D.C. September.

Reilly, J. M., & Thomas, C. K. (1993). Toward economic evaluation of climate change impacts: a review and evaluation of studies of the impact of climate change. Cambridge, MA: Center for Energy and Environmental Policy Research, MIT.

Sanghi, A. and R. Mendelsohn (2008). “The Impacts of Global Warming on Farmers in Brazil and India”, Global Environmental Change Vol. 18, pp. 655–665.

Sarker, M. A. R., Alam, K., & Gow, J. (2012). Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data. Agricultural Systems, 112, 11-16.

Toman, M. A., Firor, J., and Darmstadter, J. 1996. "Climate Change and Its Consequences." Resources (124, Summer): 10-13. University Press.