

Climate Change and Agricultural Productivity in India¹

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Abstract

India and other South Asian countries are highly susceptible to adverse climate impacts, present predominantly in hotter and less rich parts of the world. The mean annual temperature in India is estimated to go up by 2 degrees Celsius by 2050, mean precipitation is predicted to increase by 46.5mm in 2050 as predicted by World Bank (2019). Climate and weather shocks are detrimental to agricultural productivity, which in turn is a crucial determinant of agricultural incomes and food security. The agriculture sector in India contributes 16% to the GDP and offers 49% employment. This paper aims to establish a correlation between key climate variables- minimum and maximum temperature, precipitation, and CO₂ emissions- and agricultural productivity. It does so for two key crops in India- wheat, and rice.

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Introduction

Over the last couple of years, climate change and its impact on economies have been garnering attention. Climate change has the potential to drastically alter the traditional ways in which economies function. One threat that climate change and resultant weather variabilities pose is a decline in agricultural productivity. Agricultural production is directly tied to weather and climatic conditions. Understanding how climate change impacts agriculture becomes crucial, especially in the case of India, as it accounts for a large share in its GDP (16%) and an even larger share in employment (49%).² It is now clear that India and other South Asian countries are highly susceptible to adverse climate impacts, present predominantly in hotter and less rich parts of the world. The mean annual temperature in India is estimated to go up by 2 degrees Celsius by 2050, mean precipitation is predicted to increase by 46.5mm in 2050.³ This paper aims to establish a correlation between key climate variables- minimum and maximum temperature, precipitation, and CO₂ emissions- and agricultural productivity. It does so for two key crops in India- wheat, and rice.

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² <https://bit.ly/38DcANq>

³ <https://bit.ly/38G1k2R> accessed on 23rd Oct 2019

Literature Review

Numerous studies have been carried out to measure the degree of impact of climatic variables on agricultural production in monetary and quantity terms. In India, it is expected that total farm net revenue may decline between 9-25% for a temperature rise of 2–3.5% (Masters et al, 2010). There have been several micro-level studies that map the local, regional or state-wise impacts of climate change on agriculture. Based on a cross-section analysis of crops, Ninan and Bedmatta (2012) suggested that climate change will vary across crops and regions and temperature increase is the most significant cause for declining agricultural production of crops in different parts of India.

According to Gupta et al (2012), a macro-level study of the impacts of climate change on agriculture, climate change is likely to reduce the yields of rice, sorghum, and millet crop productivity in 16 major agriculture intensive states of India. Another study by Kumar (2009) suggested that climate change will lead to a 9% decline in agricultural revenues in 13 states of the country. A rise in seasonal temperature is shown as the reason for declining productivity wheat, mustard, barley, and chickpea by Kalra et al. (2008). Geethalakshmi et al. (2011) found similar results for rice and mentioned that the productivity of rice has declined by 41% with a 4-degree increase in temperature in Tamil Nadu (India). Kaul and Ram (2009) studied the impact of rain and temperature on productivity of jowar production and found that excessive rain and extreme variation in temperature is adversely affected the jowar production, leading to negative consequences on the incomes and food security of farm-based families in Karnataka (India). Kar and Kar (2008) observed that low rainfall in Orissa affects the crop production and income of the poor farmers and concluded that investment in irrigation would improve farm income. Asha et al (2012) reported that the production of sorghum, maize, tur, groundnut, wheat, onion, and cotton had declined by 43.03, 14.09, 28.23, 34.09, 48.68, 29.56, and 59.96 kilograms per hectare respectively in the rainfed area in Dharwad district in Karnataka (India). This study also reported that almost 100% and 92.22% small and marginal farmers respectively suggested that the declining level of rainfall was the major reason for the reduction in the yield levels. Further, this study represents that changes in temperature and seasonal patterns were reasons for the reduction in the yield by 42.22%. Guiteras (2009) reports that crop yields will decline by 4.5-9% in the short-run (2010-2039) and by 25% in the long run (2070-2099) in the absence of adequate adaptation by farmers. Further, Burgess et al (2014) conclude that a one standard deviation increase in high-temperature days in a year decreases agricultural yields and real wages by 12.6 % and 9.8%, respectively, and increases annual mortality among rural populations by 7.3 % in India.

Methodology

Most studies on the impact of climate change on agriculture exclude CO₂ emissions as a variable. This study takes into consideration per capita CO₂ emissions along with the annual minimum and maximum temperature (all India) and annual rainfall. Data on per capita CO₂ emissions have been sourced for the years between 2002-03 to 2013-14 from World Bank. Temperature and rainfall data were taken from the Ministry of Earth Sciences, Indian Meteorological Department (IMD). Agricultural production

data was procured from the Agricultural Statistics released in 2018 by the Ministry of Agriculture and Farmers Welfare, Government of India.

The study uses an ordinary least squares (OLS) regression model to establish a correlation between per capita CO₂ emissions (in metric tonnes), minimum and maximum temperature, rainfall, and agricultural production for the years between 2002-03 to 2013-14. It studies this correlation for two crucial food grains in India- wheat and rice. Both wheat and rice are staple food items in India.¹

Results and Discussion

Table 1 shows the effects of changes in climatic variables on the productivity of rice and wheat in India.

These results show that CO₂ emissions have a statistically significant positive effect on agricultural productivity. This sees some explanation in literature, wherein high levels of CO₂ emissions are observed in agricultural fields.² Thus we see that a 1% increase in CO₂ emissions leads to a 39.24% increase in agricultural productivity for rice and 46.46% for wheat. We also observe that as maximum temperatures rise by 1%, the quantity produced of rice falls by approximately 13%, whereas wheat production increases by 6%. A reverse trend is seen when minimum temperatures increase by 1%, wherein rice production increases marginally (by 0.622%), and wheat production falls by 7.5%. The direction of these trends could be explained by the fact that rice is a Kharif crop- so any increase in temperature beyond the norm during summers adversely affects the quantity produced. Similarly, any decrease in temperatures beyond the norm during winters adversely affects the quantity of wheat produced.

Table 1: Results

Variable/Crop	Rice	Wheat
No. of Observations	12	12
R-squared	0.944	0.945
Adjusted R-squared	0.9115	0.921
Annual Min Temp	0.622	-7.5
Annual Max Temp	-13.12	6.98
Co2 emissions	39.24***	46.46***
Annual Rainfall	0.0365	0.032
***= p value < 0.05		

¹ Saini and Gulati (2016)

² Pathak et al. (2005)

Limitations

While the regression model fits the data well, the study is limited in its scope due to a lack of data on the variables considered in this model. Climate and weather vary from region to region and the use of all-India aggregate values for temperature and rainfall might lead to a skewed picture of reality. However, these were considered only because the district and state-wise data were not available for use at the time of the study.

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