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Impact of Climate Change on Pigeon Pea

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ABSTRACT

Climate change and global warming poses threat to the living beings. The developing countries like India, are facing the problem of producing sufficient food for the ever increasing population. Apart from cereals, pulses are the main constituent of the Indian food platter. The present study was undertaken to find out the impact of change in climatic variables, viz. temperature and rainfall on yield of Pigeon Pea by using district-level panel data for Gujarat from 1980-2011. An increase in temperature was found to have a negative impact on the yield of crop whereas rainfall had a favourable impact.

Keywords: Climate change, yield, Pigeon pea, marginal effect, Gujarat

Climate change, production of food, food security are all interlinked. The long term changes shift the whole weather pattern leading to changes in climate and as a result there is increase in temperature, erratic rainfalls, floods, rise in sea level etc. It's a matter of global concern. Sustainable measures are required to mitigate this impact. The impact of change in climate varies from crop to crop and region to region.

India is the largest producer (17-18 m t), consumer (22-23 m t) and importer (4-5 m t) of pulses. Chickpea, lentil and pigeonpea account for 39, 10 and 21% of the total pulse production in the India (Anonymous 2009). Pigeonpea and chickpea are major pulses, which contribute about 60% of total pulse production. The changing climatic conditions have a major impact on rainfed crops including pulses (Basu *et al.*, 2009). Pulses are reported to be particularly sensitive to heat stress at the bloom stage; only a few days exposure of high temperature (30-35ºC) can cause heavy yield losses through flower drop or pod damage (Siddique *et al.*, 1999). According to the study of Aggarwal, 2009 a 1ºC rise in mean temperature would reduce yields of wheat, soybean, mustard, groundnut, and potato by 3-7%. Pigeon pea or red gram (*Cajanus cajan*) is a major source of protein supplement for most Indians. This study has been undertaken to examine the impact of change in weather variables, viz. temperature and rainfall on yield of Pigeon pea.

Methodology

Gujarat was purposively taken as study area. Panel data approach suggested by Deschenes and Greenstone (2007) is followed to establish a relationship between crop yield and weather variables. State level panel data was constructed to estimate the impact of weather on yield of pigeon pea. The panel consisted of district level data on pigeon pea yield, rainfall and temperature from 1980-2011 for all the districts of Gujarat at their 1980 boundaries. The data on area and production were taken from district seasonal reports, Department of Agriculture, GoG (Various years). The data on rainfall and temperature were extracted from 1 × 1 degree high resolution daily gridded data

obtained from Indian Meteorological Department, Government of India. Pigeon pea is a long duration *kharif* season crop. The crop growing period was taken from June to February.

The fixed effect panel model (Birthal *et al.*, 2014) for climate impacts is specified as:

$$\ln y_{it} = D_i + T_t + \beta X_{it} + \varepsilon_{it} \quad \ldots(1)$$

The subscripts i and t in Eq. (1) denote district and time, respectively. The dependent variable y is the crop yield and D represents the district fixed effects. It is presumed that district fixed effects absorb all the unobserved district specific time-invariant factors and also reduce bias due to omitted variables. T represents time fixed effects controlling the difference in crop yields which could be due to the changes in technology, infrastructure, human capital, etc., X is a vector of weather variables. The effect of temperature and rainfall on crop yield is generally non-linear (Schlenker and Roberts, 2006; Guiteras, 2007; Jacoby *et al.*, 2011) for that we have included the average minimum and average maximum temperatures, and the squared-term of rainfall in Eq. (1). Eq. (1) was estimated as log-linear to reduce excessive variation in the dependent variable that is crop production per hectare. To test for stationary panel unit root test, viz., Levin-Lin-Chu was employed and the null-hypothesis for all the series were rejected. The marginal effect of a single variable were calculated at their mean values to quantify the true effect of changes. The expected marginal impact of a single climate variable, X_i on yield evaluated at the mean is:

$$E\left[\frac{dy}{dx}\right] = \alpha_{1,i} + 2\alpha_{2,i} * E[xi] \quad \ldots(2)$$

RESULTS AND DISCUSSION

Table 1 presents the result of trend estimation for the study period. The mean temperature in the crop growing period is 26.33ºC with a maximum of 32.33 ºC and minimum of 20.33 ºC. The difference between the average maximum and average minimum temperature is 12 ºC.

The average annual rainfall is 916.6 mm for the crop growing period. It is evident that there is although increasing, but negligible change in temperature. The temperature increased by 0.01 ºC which is insignificant. On the other hand there was a significant upward trend in rainfall. The rainfall increased by 0.625 mm during the period.

Table 1: Trends analysis of Climatic Variables, 1980-2011

Particulars		Gujarat
Annual Temperature	Mean	26.33
	SD	0.795
	Change	0.01
	Trend	0.0003 (0.0003)
Annual Rainfall	Mean	916.6
	SD	441.8
	Change	0.625
	Trend	0.0195** (0.008)

Notes: *Figures in parentheses represent the cumulative change during 1980-2011.*

****, ** and * denote significance at 1%, 5% and 10% level, respectively. Change in temperature is in 'oC' and in rainfall is in 'mm'*

Table 2: Regression Estimates of the Impact of Rainfall and Temperature for Pigeon Pea

Variable	Pigeon pea
Minimum Temperature	0.1431026*** (0.0451)
Maximum Temperature	-0.2354*** (0.0520)
Rainfall	0.0008*** (0.00019)
Rainfall(Square)	-2.63E-07*** (7.48E-08)
Constant	10.802*** (1.568)
District	Yes
Time	Yes
No. of observations	352

Note: *Figures in parentheses represent Standard errors.*

****, ** and * denote significance at 1%, 5% and 10% level, respectively.*

The result of regression of yield of Pigeon Pea on climatic variables after controlling district and time fixed effects are presented in Table 2. The coefficient of maximum temperature has a negative and significant value which indicates that there is a negative impact of rise in maximum temperature on yield of crop. On the contrary, the rise in minimum temperature has a positive and significant impact on yield of crop.

The effect of rainfall has been found positive and significant. The quadratic term of rainfall is negative and significant which indicates that its effect is

non-linear with excess rainfall having a damaging effect on the crop yield (Birthal *et al.*, 2014). District fixed effects are significant, suggesting that it is important to control for the time-invariant location-specific factors that could be correlated with climate variables. The time fixed effects are also significant, implying the importance of farmers' responses to climate change, in terms of adjustments of their crop mix, crop varieties, input use etc.

Table 3: Estimated Marginal Effects of Temperature and Rainfall

Variable	Pigeon Pea
Minimum Temperature	-0.0448** (0.0229)
Maximum Temperature	-0.2078*** (0.0285)
Rainfall	0.0004*** (0.0001)

Note: *Figures in parentheses represent Standard errors.*

****, ** and * denote significance at 1%, 5% and 10% level, respectively.*

Table 3 presents the marginal effect of climate change in terms of temperature and rainfall. The above figures indicates that a 1 ºC rise in maximum temperature will reduce the yield by 20.8%. The negative and significant coefficient of minimum temperature suggests that as it increases by 1 ºC there will decrease in the yield of Pigeon pea by 4%. So as the minimum temperature moves towards mean temperature it will have a negative impact on the crop yield. The impact of change in maximum temperature on yield of crop is much more than the impact of change on minimum temperature. The impact is 5 times more than the impact of change in minimum temperature. The marginal effect of rainfall has been found positive and significant. The figure suggests that the impact of rainfall on yield of crop is much less than of temperature.

CONCLUSION

The study has assessed the sensitivity of Pigeon pea due to change in climatic variables by using panel data approach for the period of 32 years. The regression of yield on weather variables show that increase in maximum temperature is harmful for the crop whereas the minimum temperature and rainfall show a positive effect. Marginal effects show that a decrease in minimum temperature will have positive impact. In case of rainfall the results reveal the positive impact but the magnitude is very low which will not be able to counteract the negative effect of temperature. This means better irrigation facilities are required. More temperature hardy varieties are required.

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