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Impact of Climate Change on Major Crops of Pakistan

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Abstract:-

The study is attempts to examine the impacts of weather changes on production of major crops like cotton, maize, rice, sugarcane and wheat of Pakistan. For this study, secondary data on cop production, precipitation and temprature were collected from various sources during 2005-2014, due to its availability. Results revealed that increase in one degree celcius temperature, can bring change of 149.47 thousand tons in rice production, 3493.39 thousand tons in sugarcane production, which may declined 378.76 thousand tons in wheat production, 381.157 thousand tons in maize production and 55.27 thousand tons in cotton production. On the otherhand, one additional milmimeter rainfall can bring significan changes in all the cash crop productivity. While checking the reliability of the variables. It was found that R-square for rice, sugarcane, wheat, maize and cotton was about 0.6786, 0.6463, 0.6339, 0.6576 and 0.7143 respectively, which is considered as good fit to the model. This research suggests that technical information regarding the climate change should be disseminated to the farmers by Agriculture Extension and Research departments, sicne it has also impacts on the cropping calender in the country.

Keywords: Climate change, Major Crops, Pakistan

1. Introduction

Weather change may be defined as the variation of climate change on the earth, including, fluctuations in temperature, wind and rainfall, which might be the result of augmentation in the temperature of the atmosphere and/or reaction of particular gases (Kandel, 1992). Such reactions have longstanding modifications in the numerical dissemination of other forms completed eras of period that vary since decades to lots of centuries, which might transformation in the usual, e.g. greater otherwise less life-threating meteorological conditions happenings. Thus, the weather condition variations can be inadequate towards an exact constituency, or may perhaps happens through the nations. There are economic implications that changes in climate will have on agricultural production patterns, land use, migration and occupational change linked to agriculture and allied economic activities in the primary sector of an economy. The gas emission resulted in sea level rise up to 2 feet (Wei *et al*., 2008). Recently, it is found that industrial aerosol also playing a key role in climate change, basically they are responsible for acid rain action. When industrial aerosols have releases in an environment bring with some hazardous gases which are responsible of acid rain sometimes (IPCC, 2012).

Moreover, fluctuations in rainfall and temperature have not only influenced the carbon dioxide level, but also mounted frequencies of climatic disasters like droughts, cyclones, and floods in Sout Asia, which is adversely affecting agriculture production. However, improved irrigation facilities, highly genetically modified seeds and increases amount of fertilizers and pesticides have restricted negative trends, but imbalance use of fertilizers and pesticides have further major responsible reason for declining soil fertility. Thus, several researchers have concluded that climate change have adverse impacts for agricultural production in developing countries (Cline, 2007; Evnson, 1999; Lobell *et al.,* 2008; Mendelsohn *et al.,* 2007). In India, the performance of the agricultural sector is important in determining socio-economic outcomes for a large section of the population and is identified as a high priority area for inclusive growth (GOP, 2016). Environmental variation forecasts for the area resultant from universal climate ideal driven by socio-economic situations (Intergovernmental Panel on climate change, 2001; Iglesias *et al*. 2000) outcome and rise of temperature (1.5 to 3.6^0C in the 2050s) besides rainfall reductions in furthermost of the zone (nearly 10 to 20 percent) declines, reliant on the time in the 2050s). Joshi (2008) have reported that on over-all the world level poorest calamity were dearth and acute deficiency of flood (as per over crops letdown) causing in fierce starvation and hunger and demise (45 percent), shadowed by high-tech cataclysm (14 percent), deluges (16 percent), cyclone (10 percent), volcanic activity (12 percent), hotness and else (3 percent). Environment change disclosures these zones to jeopardies of ice-cold retreat, ocean level increase, temperature increase, extra frequent floods and droughts.

In India, like Pakistan, the temperature has also increased, which led a significant impact on the country's agriculture (Singh and Nayak, 2014; Dasgupta et al. 2013). In fact, last three decades have been significantly warmer than all preceding decades since 1850s. This is also an ageing, more feminized population growth, Reason behind these fluctuations is climate change, and climate is changing by both natural and anthropogenic causes. Where this study has to identify climate change impacts on production of major crops with following objectives: to appraise the growth rate of major crops' productionchanges temperature and rainfall during last 10 years in the country; and to appraise weather change impacts on major crops (Wheat, Rice,

Cotton, Maize, and Sugarcane). Thus, this study will be helpful to policy makers regarding the agricultural extension in the country.

2. Methodology

For present study, secondary data were collected from various public and private sources, e.g. Pakistan Economic Survey, Pakistan Bureau of Statistics, Agrometeorological department of Sindh Pakistan and Social Science research Institute Tandojam. The data comprised over the production of the majorcrops in the country from 2005-2014, as well as the temprature and rainfall during the time period. The time period was selected due to availabity of the data specially on precipitation and the temprature.

2.1. Model specification:

The parameters from this estimation have been used along with data on projected rain fall, temperature and other natural vulnerability to calculate projected changes in gross cropped area, yield and production for major crops. Thus, the growth performance was analyzed by using following model:

Growth rate model

$$g = \left(\frac{x_T}{x_t}\right)^{\frac{1}{T}} - 1$$

Where: g = Average growth rate, X_t = Initial value of variable X, X_T = Final value of variable X, t = Base year, and T = Final year

In order to investigate what changes occurred due to weather changes in, the regression results was used to interplead the impacts as follows:

Regression:

$$y = \beta_0 + \beta_1 MxT + \beta_2 MnT + \beta_3 MxR + \beta_4 MnR + \varepsilon$$

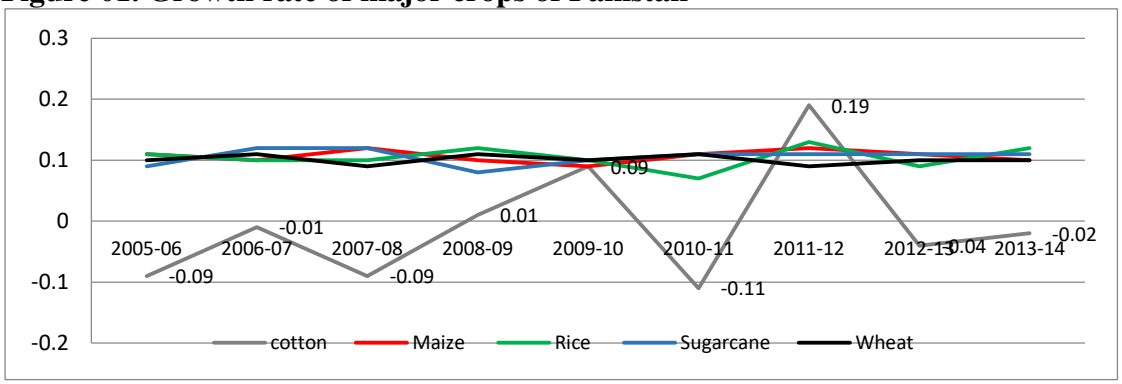
Where: y = Productivity of major crops in the country, MxT. = Maximum average temperature, MnT = Minimum average temperature, MxR = Maximum average rainfall, MnR = Minimum average rainfall, ε = error term including other inputs, and $\beta_0, \beta 1, \beta 2, \beta 3,$ *and* β_4 are the parameters of the model.

The regression model will show that productivity level of major crops to be a function of maximum average temperature, minimum average temperature, maximum average rainfall, minimum average rainfall and other parameters etc.

3. Results and discusssion

The findings of this research have been provided, which include growth performance of major crops in the country; crop weather links and weather changes as well as its impacts on the production of the crops. The growth performance of major crops have been provided, the results can be seen through the following figures.

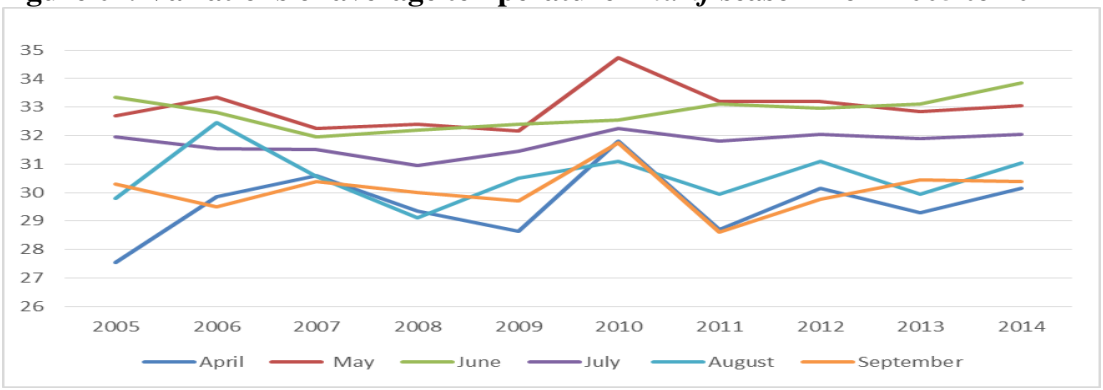
Figure 01. Growth rate of major crops of Pakistan



Source: *Author's calculation based on the data from GoP, 2012 and 2016*

Above figure shows the growth rate from 2006-14, where it reveals that during the 2006 to 2013-14 all major crops have positive growth rate (Maize, Rice, Sugarcane, wheat) except one the cotton, which shows major fluctuations in the figure which reveals that in 2006 where it was about -0.09 to 0.01 the production was increased in 2006-07, above figure also reveals that about -0.09 up to 0.09 in 2007-2009, it declined -0.11 in 2010 due to the reason that area of production was increased about 0.19 in 2011, while the reason was that the area of production was declined due to area reduction in the cotton productivity which was dwindled because decrease in the area sown was fewer rates of cotton countrywide and worldwide, the growers succeeded throughout last two years that some growers were dispirited that is to placed additional areas under crop and fluctuating the part to rice, and maize crops in different areas of Punjab due to their better market returns in it also again reveals about 0.19 increased production in 2012, the reason was usage of BT cotton, controller completed extensive attack of cotton leaf curl virus (CLCV) and giving suck pestilence which assisted step up in production each hector as associated to previous year 2011-2012.

Figure 02. Variations of average temperature *Kharif* season from 2005 to 2014

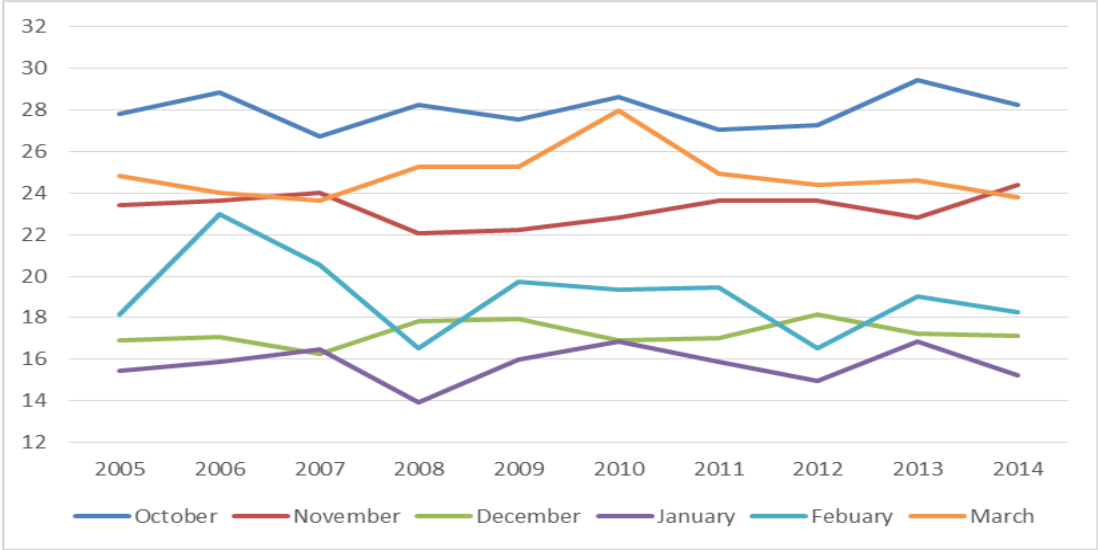


Source: *Author's calculation based on the data from Agrometeorological department of Pakistan*

The figur 02 and 03 show that during last decade the average temperature in the month of october was increased up to 0.45 ^{o}C. In the month of November it was increased up to 1 ^{o}C. Moreover it was estimated the average temperature for the month of December has increased up to 0.25 ^{o}C. Furthermore it was estimated the average temperature for the month of January it was decline 0.2 ^{o}C. Again it was estimated that the average temperature for the month of February it was increased 0.1

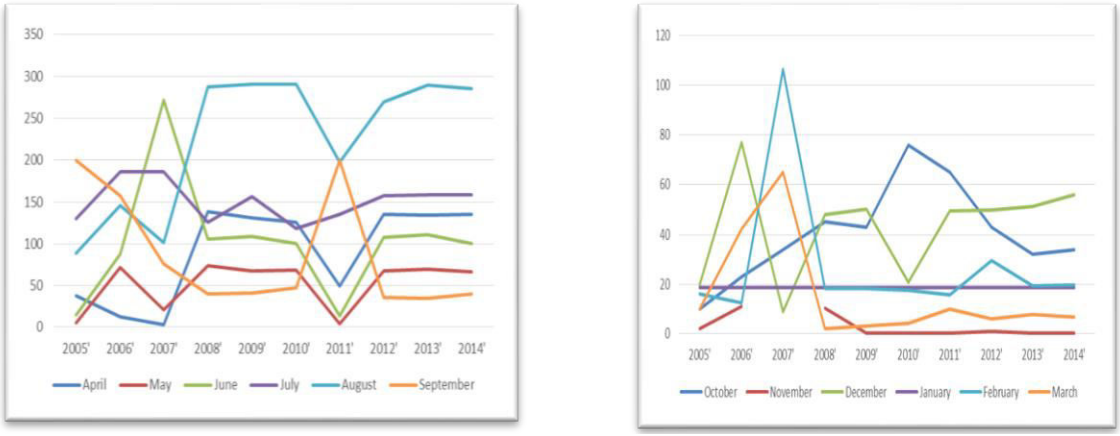
°C. It was estimated that during last decade the average over all temperature has been declined up to 1.05 °C.

Figure 03. Variations of averages temperature *Rabi* season from 2005 to 2014



Source: Authors calculation based on the data from Agrometeorological department of Pakistan

Figure 04. Variations of averages rainfall kharif and Rabi seasons



Source: Authors calculation based on the data from Agrometeorological department of Pakistan

Above graph shows that average rainfall for the month of April (2005 to 2014) has increased up to 97.1 mm, while in May it the average rainfall was increased 62.3 mm. Moreover it was estimated the average rainfall for the month of June it was increased up to 85.3 mm. Furthermore it was estimated the average rainfall for the month of July it was increased up to 27.6 mm. Again it was estimated that the average rainfall for the month of August it was increased up to 196.7 mm. It was estimated that during last decade the average rainfall was declined up to 158.8 mm.

On the other hand, it was also estimated that during October the average rainfall was increased up to 24 mm, while in November it was decline up to 2 mm. Moreover it was estimated the average rainfall for the month of December it was increased up to 36.2. Furthermore it was estimated the average rainfall for the month of January it

was constant. Again it was estimated that the average rainfall for the month of February it was increased 3.5 mm. It was estimated that during last decade the average rainfall was declined up to 3.5mm.

Table 01. Multiple regression results with maximum and minimum temperature and maximum and minimum rainfall averages

Cropping season	Kharif			Rabi	Annual
Crops	Rice	Cotton	Maize	Wheat	Sugarcane
Intercept	-2654.56	2786.893	7973.538	20207.24	-41231.2
β_1 (max temperature ^{0}C)	149.469	-55.274	-381.157	-378.764	3493.398
β_2 (min temperature ^{0}C)	25.455	12.245	548.159	1323.805	-
β_3 (max. rainfall mm)	41.365	-8.068	-35.623	-243.51	17.217
β_4 (min. rainfall mm)	-83.002	56.353	50.985	449.307	-
R-squared	0.679	0.714	0.658	0.634	0.646

Source: Author's calculation's

Above table reveals that if 1 ^{0}C maximum average temperature increases, which will increases about 149.4695 thousand tons of rice production in the country. Moreover, if 1 ^{0}C minimum average temperature rises then 25.45536 thousand tons of its production will increased, if 1 mm maximum average precipitation increases about 41.36492 thousand tons of its production will increased; similarly, on average 1 mm minimum additional rainfall can decrease 83.0022 thousand tons of its production. While checking the reliability of the variables, it was found that R-square was about 0.678636, it further indicates that if 1 ^{0}C maximum average temperature increases that -55.2739 thousand tons cotton production will be dwindled, if 1 minimum average temperature increases that 12.245131 thousand tons cotton production will be greater than before, if 1mm maximum average precipitation increases approximately have negative impacts 8.06845 thousand tons of its production will be dwindled; similarly, on average 1 mm minimum rainfall can increase 56.352606 thousand tons of its production.

While checking the reliability of the variables, it was found that R-square was about 0.714345, if 1 ^{0}C maximum average temperature increases that -381.157 thousand tons of maize production will be dwindled. Moreover, if 1 ^{0}C minimum average temperature increases then 548.1589548 thousand tons of its production will be increased, if 1 mm maximum average precipitation increases about -35.6228 thousand tons of its production decreased; similarly, on average 1 mm minimum average rainfall can increased 50.98492 thousand tons of its production. While checking the reliability of the variables, it was found that R-square was about 0.657686, if 1 ^{0}C maximum average temperature increases that -378.764 thousand tons of wheat production will be decreased. Moreover, if 1 ^{0}C minimum average temperature increases then 1323.805 thousand tons of its production will be increased, if 1 mm maximum average precipitation increases about -243.5 thousand tons of its production will be dwindled; similarly, on average 1 mm minimum rainfall can increase 449.3077 thousand tons of its production will be increased. While checking the reliability of the variables, it was found that R-square was about 0.633954, if 1 ^{0}C

maximum average temperature increases that 3493.398 thousand tons of sugarcane production will be increased, if 1 mm maximum average precipitation increases about 17.21651 thousand tons of its production will be increased. While checking the reliability of the variables, it was found that R-square was about 0.646375. If R^2 is > 50% then the added is considered as good model.

Pakistan is agricultural country, where about 70 percent of population is directly and indirectly depends upon agriculture. Pakistan is the sixth most populace country of the world, with 193 million. It is commonly accepted that the climate change impact on agriculture production, warming temperature decrease crops yield in Pakistan. The normal (1961-90) rain fall in monsoon period is 125 mm and is extremely flexible (85 mm) especially in southern province (Sindh) of the country. Therefore, this research study has been designed to carry out the climate change impacts on production majors crops (Wheat, Rice, Cotton, Maize, Sugarcane) in Pakistan, during last 10 years from 2005 to 2014.

The different parameters were estimated, like: perception, temperature, and their influence on production of major crops (rice, sugarcane, wheat, cotton and maize) in the country. Results revealed that if 1 ^{0}C maximum average temperature increases can lower 149.47 thousand tons of rice, while increase by 1 ^{0}C minimum average temperature can bring about 25.45 thousand tons; where if 1 mm maximum average rainfall may increase, will cause 41.36 thousands ton to increase in its production, while 1 mm minimum average rainfall may decrease 83.01 thousand tons. Sugarcane is an annual cash crop, results show that one ^{0}C temperature increase can decline the production by 41231.2 thousand ton, where one mm rainfall can bring more 17.22 thousand tons in the total productivity.

The wheat in Pakistan is cultivated in Rabi season, results show that if one ^{0}C maximum temperature increases, which will reduce the production by 378.76 thousand tons; while one ^{0}C minimum average temperature can increase production by 1323.81 thousand tons; on the other hands, one 1 mm maximum average rainfall will reduce 243.5 thousand tons dwindled, moreover 1 mm minimum average rainfall increase, which will be 449.31 thousand tons of the produce. Results for maize crop shown that if one ^{0}C maximum average temperature increases, which will decline the production by 381.157 thousand tons; while one ^{0}C minimum average temperature may increases, which will rise 548.1589 thousand tons; while one 1 mm maximum average rainfall can decrease 35.6228 thousand tons, moreover one mm minimum average rainfall will be increase 50.98492 thousand tons produce. In case of cotton crop, if one ^{0}C maximum average temperature can reduce production by 55.27 thousand tons; while one ^{0}C minimum average temperature will decline production by 12.24 thousand tons, on the other hands, one 1 mm maximum average rainfall can reduce 8.06845 thousand tons. Moreover, it reveals that one mm minimum average rainfall can increase 56.35 thousand tons of cotton. While checking the reliability of the variables, it was found that R-square for rice, sugarcane, wheat, maize and cotton was about 0.6786, 0.6463, 0.6339, 0.6576 and 0.7143 respectively. Statistically, if the value of R^2 is greater than 0.5, the variables can be considered as good fit to the model.

4. Conclusion and suggestions

Climate change is aggregation of complex dynamic activities, caused by Nature, human and animal activities. The climate and climate induced variables have harmful impacts on crop`s output in one way or the other. Pakistan is also among the countries

that are at the receiving end of the climate change impacts. High temperatures, heavy rains and flash floods of 2010, 2011 and 2014 are examples of the climate change events. Concluding from the above evaluation, the recent past events of climate change and the country crop production statistics, Climate variables do effect crop production in both ways positive as well as negative. Under normal climatic conditions, climate variables show a highly positive impact on kharif crops. These are summer crops. A timely sufficient rain results in increased crop production. Moreover, a sufficient high temperature is the source of high productivity in the country.

Based on the results it is suggetsed that temperature rainfall have significan impacts on the production of crops like wheat, cotton, maize and rice, but with increase in temperature the water requirement will be increased for the crops. Thus, technical information regarding the climate change should be disseminated to the farmers by Agriculture Extension and Research departments of Government of Pakistan. Moreover, it is also suggested that a kind of long term project should be laubched, during that period to measure the temperature as well as rainfall impacts on the major crops, as well as other parameters should also be included. There is also need of weather stations at taluka lelvel, which must be build by the government to aware the farmers.

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