

EMPIRICAL ASSESSMENT OF REGION SPECIFIC CLIMATE IMPACT ON CROPS PRODUCTION IN KHYBER PUKHTUNKHAWA, PAKISTAN

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ABSTRACT

Presumably, World faces sundry climate challenges contains often sporadic floods, ruthless droughts, severe thunder storms, infrequent rains, swamped plains and barren land, water assimilation & water scarcity. The broad aim of this study is to observe theoretically and empirically the intensity of climate changing events in Pakistan in general and Khyber Pakhtunkhwa (KP) in particular. The data on environmental analysis demonstrates that climate change put harsh impacts on crop production in the southern part of the province. For more robust analysis, an econometric model and the panel data regression method is also used, where the data covering the period from 1980 to 2010. The empirical results also confirm that climate change has some strong effect on the crop production in the southern part of the province in the country. The results further reveal that the central region faces relatively a moderate impact while, the northern part has a positive climate impact in terms of crop production. In light of the findings of the study some suggested policy measures would indubitably help the policy makers.

Keywords: *Climate Change, Crop Production, Khyber Pakhtunkhwa-Pakistan*

JEL Classification: C1, N15, Q10, Q54

INTRODUCTION

Climate change is a phenomenon that arises due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization, resulting variations in solar energy, temperature and precipitation (Upreti, 1999). The study of Parry et al. (2004) highlighted the main drivers of agricultural reactions to climate change are biophysical influence and socio-economic factors. Whereas, crop production is affected biophysically by meteorological variables, comprising on increasing temperatures, varying precipitation regimes, and enlarged atmospheric carbon dioxide levels. Though, the biophysical influences of climate change on agricultural production will be positive in some agricultural systems and regions, while may be negative in others, and these impacts will differ through time. Alongside, the socio-economic factors effects responses to changes in crop productivity, with price changes and shifts in comparative advantage. It is the most serious problem; sever than terrorism threat, faced by humanity. In a study Malla (2008) also shown that it is a real threat to life which largely affects water resources, agriculture, coastal regions, freshwater habitats, vegetation, forests, snow cover, and geological processes such as melting, land sliding, desertification and floods all of which have long-term effects on food security and human health.

Maplecroft (2010), a British risk assessment consultancy, ranks countries by their expected climate vulnerability over the last next 30 years, counts Pakistan in the 20 most climate-vulnerable countries worldwide. Pakistan has seen severe droughts of 1990's and extreme floods of 2010 all are the outcomes of climate change. Climate impact assessment has been done by various organizations and agencies to draw the concerned authorities' attention. For example, the most recent impact of climate change was seen in July 2010, when floods destroyed thousands of villages all over Pakistan. An estimated 14% i.e. 3.4 million hectare area of cultivable land has been destroyed. A loss of 1764 people, human injures of 2697 and houses damage of 1.85 million has been reported. The reconstruction& rehabilitation of the flood affected's cost approximately 8-9 billion rupees. The greatest hit among all the provinces of the country was KP. Out of the 2349 KP flood affected, 1156 lost their lives and 0.2 million houses damaged or destroyed (Mustafa, 2011). The country's social as well as economic setup suffered and resulted in a severe economic set back.

Perceptibly, climate change is a global issue; debated at all fronts whether it's political, social, economic or scientific. Measures be taken to ensure that climate must be prevented from further damages. Before nature

strikes back again, there is a need on all levels of society to understand climate, the factors behind change and its impact on our economy in general and agriculture sector in particular. Agriculture is extremely vulnerable to climate change. Higher temperatures ultimately reduce yields of desirable crops while encouraging weed and pest production. Changes in precipitation patterns elevate the short-run crop malfunction and declines long-run productions. Although there will be an increase in some crops production in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, intimidating global food security (International food Policy Research Institute, 2009). In a similar study Deressa and Hassan (2009) after empirical investigation of the impact of net crop revenue per hectare on climate, household and soil variables found that these variables have a significant impact on the net crop revenue per hectare of farmers under Ethiopian conditions.

It has been observed that climate has changed due to human-induced anthropogenic activities such as fossil fuel burning, livestock wastes and deforestation etc. The 4th Assessment Report (AR4) of the Intergovernmental Panel on Climate Change concludes that if anthropogenic activities continue with the same pace, it is expected to raise the global average temperature from 1.1 degree centigrade to 5.5 degree Celsius by 2100. Climate change impacts as increase in temperature accompanied by rise in precipitation rates has already altered United States agricultural production. This study is providing assessments to landlords for long term decisions in land use and crop mixes. It will assist in the future adaptation against climate change and agricultural productivity. It also noted that climate change is a massive threat to human development. United Nations Development Program (2008) has fully pointed out in one of the research reports, the causes and the effects of climate change on the world and the humanity itself. World temperature has increased at an average of 3 centigrade as compared to the preindustrial era. This resulted in an increase in extreme weather events as intensify floods and harsh droughts. Poor and developing nations are the one most affected form it. Their development process is also going to be hindered by it. United Nations considering the importance and urgency of the climate change issue is stressing on world influential states to take positive actions and help the humanity cope with the situation. Two of the United Nations agencies i.e. United Nation Environment Program and United Nation Development Program agreed to provide assistance in reducing vulnerability and capacity building for development, to the affected countries. The aim of this report is to unite and combine the world on a common ground i.e. climate change, for the benefit of human, humanity and future generations.

Likewise, Cline (2007) explains, in his book, the global impact of climate change on agriculture. The prime argument of this book is that global warming does not increase the yield of crops as suggested by others. He proved his argument by taking different countries current versus projected average temperatures and precipitation values. He came to the conclusion that the global warming might be affirmative for some countries but for developing countries it is untrue. He explains further that global warming might have minor effect in this century but if the countries did not take positive measure such as the use of carbon fertilizers and heat and drought resistant crops it will aggravate the results. Climate impact assessments must provide choices that which crops to be considered. Therefore, the most frequent crops considered in the past studies include are wheat, maize, rice, and soybean (White *et al.*, 2011). Perhaps these crops are the major sources of human and livestock calories worldwide as well as in many regions. Lobell and Gourdji (2012) exposed that climate trends during the past few decades have been honestly rapid in several agricultural regions nearby the world, and upsurges in atmospheric carbon dioxide and ozone levels have also been ubiquitous. Haddad *et al.* (2014) have examined the susceptibility of agricultural outputs to future climate change in the context of Lebanon, and the extent to which it propagates to the economic system as a whole. The study demonstrated that there are possible high costs and risks related with encumbrance to the poorer and more vulnerable regions of the country. Wile, the study of Siebert and Ewert (2014) has shown that climate change effects on crop production are intricate and diverse. Where, heat is considered to be a foremost stress restrictive crop growth and yields.

This study is an attempt to identify the climate change trend in various regions of Pakistan and then retrieving its impacts on Pakistan's agriculture sector. Therefore, the objective of the study is to find out the mean maximum temperature, mean minimum temperature, adequate rainfall and the relative economic variables which have certainly impact on wheat production in mixed zone of Punjab province of Pakistan. For empirical investigation, in order to analyze the effect of environmental changes on crop productivity in agriculture sector, the data used over the period from 1980-2010. The outcomes of this will help in future adaptation and mitigation against the climate changing incidents. Flash flood of 2010 was the compelling force to initiate the climate impact assessment KP was one of the provinces brutally affected by the flood event of 2010. Moreover, this study will contribute to the literature on the climate change impact on agriculture production on Pakistan.

The rest of paper is organized as follow: Section I presented introduction along with some previous studies. Section II deals with the materials and methods. Section III Interpret results and discussion. Section IV present conclusion and policy implications of the paper.

MATERIALS AND METHODS

Research Area

There are four provinces in Pakistan, where KP is one of it province which is the focal point in this study. It was previously called North West Frontier Province (NWFP) and among the regions in Pakistan hard hit by the stern environmental conditions. Selection of KP province is subject to versatility in weather due to its unique topography. Its climate ranges from the hottest and dry rocky areas in south to the colder and lush green forests and plains in the north. According to their climatic variability, KP can be divided into three regions such as the southern, the central and the northern regions. There are total 25 districts in KP, while, various districts are selected from these regions to access the regional climatic impact on crop production.

Model specification

In order to evaluate crop productivity, this study used two methods, first, adopting the Cobb Douglas production function, which is also used by some prior studies for example (Azam & Mukarram, 2010; Nazir *et al.*, 2013). It is estimated by the panel data regression technique and is used at different places having same variables but projecting different impacts of climate over crop productivity at different regions. Thus, this study uses panel data and random effect model as analytical techniques for empirical investigation.

Cobb Douglas Production function in its standard form is:

$$Y = AL^{\alpha}K^{\beta} \quad (1)$$

The general form of the model used in this research analysis is based on equation (1) is given follows;

$$\text{Crop's Output} = f \{ \text{Area sown, Climate variables, Climate variables squares} \} \quad (2)$$

Equation (2) can be expressed in symbolic form as below:

$$Y = f\{A^{\alpha} T^{\beta} m (N N^2)^{\gamma}\} \quad (3)$$

Area Sown = Area sown under Rabi and Kharif crops
 Crop's Output = Rabi and Kharif season Output. Wheat is taken as Rabi (winter) crop and Maize as Kharif (summer) Crop
 Climate variables = Mean temperature(Tm) and average Rainfall (N)
 Square of Climate = Square of average Rainfall (N²)

There is one visible hypothesis of the study as "climate changes have significant impact on farm productivity in KP".

The Second method of evaluation is comprised of time series trends technique (Malla, 2008). Its purpose is to check the weather variable trends with respect to the crop production in specific KP region with the specific season crop over the last three decades. The source of data collection is secondary in nature. The data used in this study ranging from 1980-2010 and of thirty years, secondary data of the selected districts representing the three regions, have been obtained from the various government and non-government organizations i.e. Pakistan Metrology Department, Federal Bureau of Statistics- Pakistan, various journals and related articles etc.

RESULTS AND DISCUSSION

Results of the study are divided into two categories such as the Econometric Analysis (Region Specific) and the Environmental Analysis (Crop Specific).

Empirical Analysis

The detailed empirical results of the various climate regions of KP are given in detail below:

Southern Region of KP

In this model KP's southern region Rabi (Wheat) and Kharif (Maize) crops are engaged. It is comprised of 60 observations having 2 season crops groups. The aim of this analysis is to check climate change impact on specific region of KP. Table 1 shows the coefficient of the various variables engaged in the random

effect model. The Hausman test's suggested using the random-effects model, while along with Ordinary Least Squares (OLS) estimation is also reported for more robust investigation purpose. There are two highly significant variables in the model. The first significant variable is area showing a positive impact on the crops. A one million hectare increase in the area of cultivated land leads to an increase in 960 tonnes of crop yield. The second, climate variable mean temperature, has a negative impact on the crop's production. A degree increase in the mean temperature of the crop will leads to a decrease in the crops yield by 2390 tonnes. This is an alarming fact. It leads to the conclusion that harsh impacts of climate change are observed in the southern regions of KP. Keeping other factors of the model constant, increase in the mean temperature of the southern region might leads to the decrease in the crop production. The R-square value of the model is .0967 showing 97% goodness of model fitted. Results are reported in Table 1.

Central Region KP

Central region of KP is moderate in terms of climate change impact on crops production. Random effect model is used having 60 observations and two groups of two season crops i.e. Rabi and Kharif. The details are given in the Table 2 below.

The random effect model gives R-square value of 0.93, showing the effectiveness of the model. This model gives four significant values. i.e., Area, Mean Temperature, Rainfall and the constant. The coefficient of area is 2.926. It shows that one million hectare increases in area under cultivation will leads to an increase of 2926 tonnes of crop yield. Similarly one degree increase in mean temperature of central region will increase the crop yield by 1933 tonnes. Average rainfall also have a positive impact on the crop production i.e. 1 mm increase in rainfall will leads to increase crop productivity by 212 tonnes.

Northern Region KP

The colder mountainous regions of KP are situated in its northern regions. Model explained below gives the climate change impact of the colder Himalayas of Pakistan.

The random effect model results are given in the above table 3. Three variables along with the constant intercept are significant in the model. This shows that climate change impact in the tropics are more

Table 1 Coefficient of the various variables engaged in the random effect model

Variables	OLS Estimates	Variance Inflation Factor (VIF)	Random-effects		95% Confidence Interval	
			Coefficient	Standard Error	Coefficient	Standard Error
Area	(0.96)***	(8.22)	(0.96)***	(0.764)	(0.1001)	(1.156)
Mean Temperature	(-2.39)***	(8.51)	(-2.39)***	(-3.47)	(0.553)	(-1.3)
Rainfall	(-0.0089)	(2.75)	(-0.0089)	(-1.52)	(0.073)	(0.134)
Rainfall Square	(-0.00000976)	(2.78)	(-0.0000097)	(-0.0017)	(0.00086)	(0.001)
Constant	(76.51)***		(76.51)***	(43.48)	(16.85)	(109.54)
R ²	(0.97)		R ² within	(0.65)		
Adj. R ²	(0.96)		Between	(1.00)		
Root MSE	(10.03)		Overall	(0.97)		

Note: ***significant at 1%, **significant at 5%, *significant at 10% level respectively

Table- 2 Coefficient of the various variables engaged in the random effect model for Central Regions of KP

Variables	OLS	VIF	Random-effects Coefficient	Standard Error	95% Confidence Interval
Area	(2.926) ^{***}	(10.78)	(2.926) ^{***}	(0.275) ^{***}	(2.386) (3.46)
Mean Temperature	(1.933) ^{***}	(10.81)	(1.933) ^{***}	(0.792) ^{***}	(0.38) (3.48)
Rainfall	(0.212) ^{***}	(2.17)	(0.212) ^{***}	(0.084) ^{***}	(0.046) (0.377)
Rainfall Square	(-0.00056)	(2.16)	(-0.000567)	(0.00077)	(-0.0021) (0.0009)
Constant	(-111.35) ^{***}		(-111.35) ^{***}	(35.36) ^{***}	(-180.65) (-42.05)
R ²	(0.93)		R ² : Within	(0.679)	
Adj. R ²	(0.92)		Between	(1.00)	
Root MSE	(13.56)		Overall	(0.93)	

Note: ^{***}significant at 1%; ^{**}significant at 5% and ^{*}significant at 10% respectively

Table 3 Regression estimates

Variables	OLS	VIF	Random Effect Co-efficient	Standard Error	95% Confidence Interval
Area	(2.36)***	(4.37)	(2.36)***	(0.815)	(0.762) (3.956)
Mean Temperature	(.523)***	(7.33)	(0.523)***	(0.145)	(0.238) (0.806)
Log of rainfall	(2.51)*	(4.02)	(2.51)*	(1.506)	(-0.435) (5.469)
Rainfall Square	(-0.000092)	(3.53)	(-0.000092)	(0.00034)	(-0.00076) (0.00058)
Constant	(-14.48)*		(-14.48)*	(8.23)	(-30.617) (1.66)
R-squared	0.2217		R-sq: Within	0.18	
Adjusted R-squared	0.1651		Between	1	
Root MSE	3.453		Overall	0.22	

Note: ***significant at 1%; **significant at 5% and *significant at 10% level respectively

pronounced and prominent. The coefficient of area 2.36 is highly significant. It is showing that a one unit increase in area will lead to the increased crop productivity by 2360 tonnes. The highly significant coefficient of mean temperature shows that a 1°C increase in temperature will result in the increased production by 523 tonnes. The third variable, rainfall is transformed into logarithmic form to rule out the occurrence of multicollinearity. It explains that 1 % increases in rainfall leads to increase crop production by 25 tonnes of yield.

Environmental Analysis

This analysis is divided into three regional categories as follows:

Southern Region Environmental Trends

The south of the KP region is termed as one of the hottest regions of the country and is greatly affected by climate change. The impact of change on crop produce is pronounced and definite. In the overall situation through trend analysis have been explained right from Figure 1 to Figure 10.

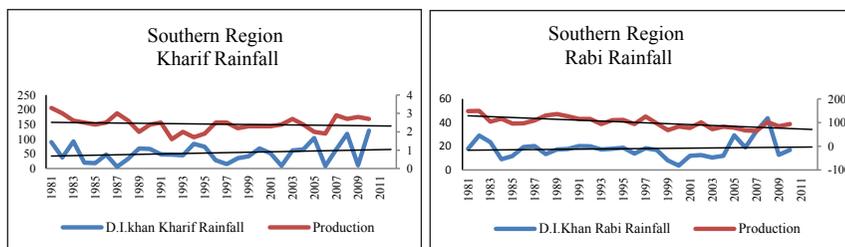


Figure-1

Southern Region Rainfall Trend

The rainfall trend in the southern part of KP is more prominent and intense. The graph below showing the kharif season rainfall and crop productivity trend. The rainfall regression line is depicting an increase of 25mm in average rainfall whereas the crop production is showing a slight decrease in the kharif crop productivity over the thirty years period. The other side of the graph is explaining the rabi season rainfall and cropping pattern. The rainfall regression line is almost stationary showing a slight increase of 2mm in rain over the thirty year period whereas the rabi crop productivity has remarkably reduced up to 50 thousand tonnes. The

inseasing trend of kharif rainfall explains the concepts of untimely rains in summer that results in floods, overflows and the loss of agricultural output.

Southeren Region Mean Temperature Trend

The southeren region mean temperature is different for the two cropping seasons. It is showing a decreasing trend of 0.4 °C for the kharif season whereas the other season is showing an increasing trend of 1.2 °C. The increase in mean temperature in rabi season is one of the reasons of low productive crops in the region.

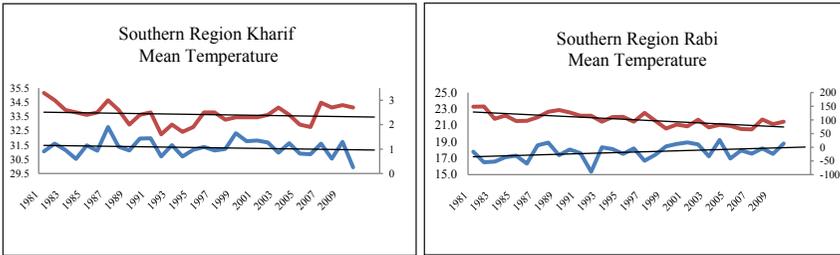


Figure-2

Southeren Region Maximum Temperature Trend

The southeren region maximum temperature trends are exactly opposite of one another. The graph below is showing an increasing trend of 1°C for rabi season whereas it is showing the same amount of decreasing trend of 1 °C in Kharif season. It shows the instance of gentle winters in Rabi cropping seasons. The Kharif crop productivity is also showing a downward trend whereas the rabi crop yields have decreased sharply.

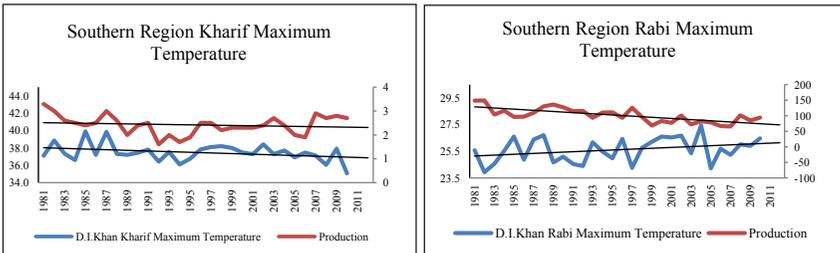


Figure-3

Southeren Region Minimum Temperature Trend

Minimum temperature for the two cropping season of the southeren region are showing an increasing trend. Rabi cropping season is showing a 1.6 °C increase in temperature whereas kharif crop is portraying a 0.6 °C increase in minimum temperture. The oppoeite trends of maximum temperature and minimum temperature is depicting a moderate weather i.e. pushing the temperature towards the middle and enhancing the possibilities to Green house effect and low agricultural productivity in the two cropping seasons.

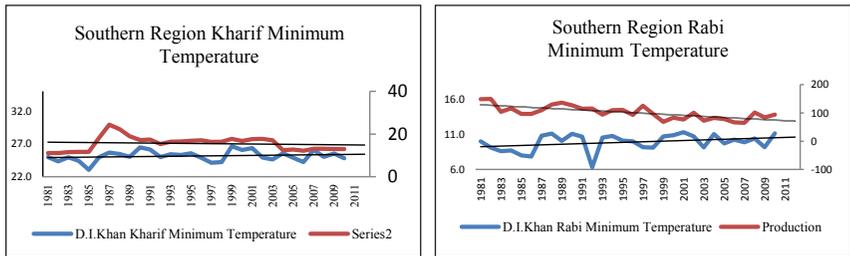


Figure-4

Central Region Environmental Trends

Climate change phenomenon arealso pronounced in the central region of Khyber Pakhtunkhwa. It is showing an overall increasing trends in all the envirnmental aspects. Below are given the details.

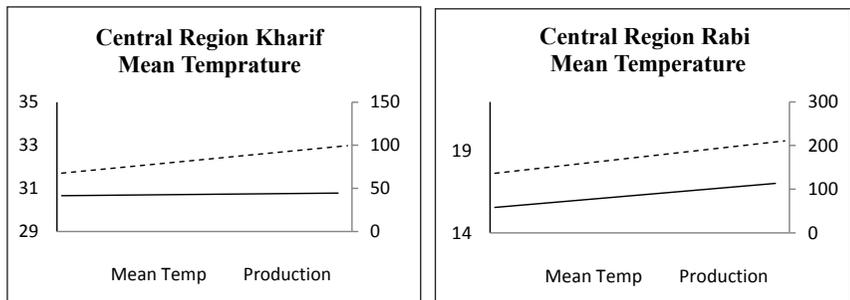


Figure-5

Central Region Rainfall Trend

The central region of KP is showing an increasing trends for its two cropping seasons. Kharif season is depicting an increased trend line of 16mm whereas rabi crop is portrying a remarkable increase of 30mm in the average annual rainfall. Looking at the crop productivity of the two seasons shows that it is positively related to the increase in rainfall at the central KP region.

Central Region Mean Temperature Trend

The central region of Khyber Pukhtunkahwa is showing an increasing trend of mean temperature for the two cropping seasons. Although the regression trend line for rabi cropping season is showing a marked increase of 1.5°C in mean temperature. On the other side it is showing a slight increase of 0.1 °C in Kharif season. This variation is depicting the change in the weather pattren on the region over the thirty year span. Moreover the crop productivity trend is showing a positive trend.

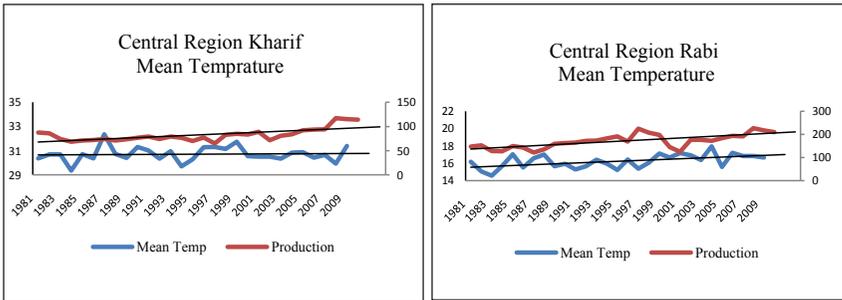


Figure-6

Central Region Maximum Temperature Trend

Just like the rainfall, central region maximum temperature is also showing a marked increase in the maximum temperature of the two cropping seasons. The regression line is depicting an increase of 0.8 °C & 0.9 °C for kharif and rabi cropping season respectively. This is one of the reasons of increased productivity in rabi as well as the kharif crop output at the central regions of KP.

Central Region Minimum Temperature Trend

Central region minimum temperature is also showing an increasing trend over the thirty year period. Kharif season trend line is showing a

degree increase whereas rabi season is showing a two degree centigrade increase in minimum temperature over the last three decades. This can be one of the reasons of mild winters and harsh summers leading to the increase in overall crop productivity.

Northern Region Environmental Trends

The colder regions of Khyber Pakhtunkhwa is at the north of the province. Below is given the climate impact analysis of the region.

Northern Region Rainfall Trend

Northern region of KP is depicting an increasing trend of rainfall at both the season crops i.e. Kharif and rabi. The increase in rainfall for the two crops is 4mm & 15mm respectively. As shown in the graphs below the intensity of rainfall has increased since 2009-10. This is the reason of increased vegetation at the northern part of the province.

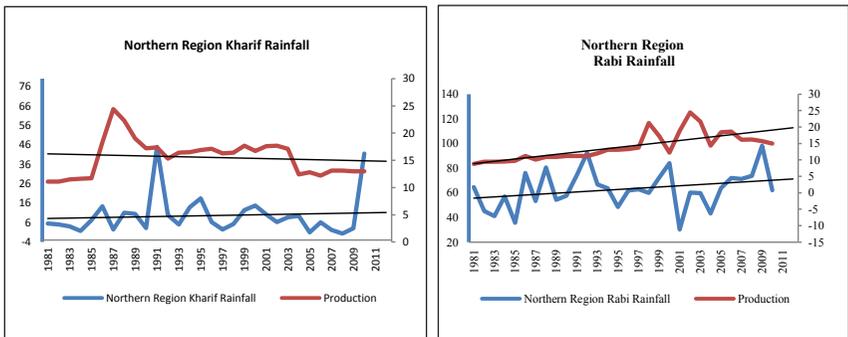


Figure-7

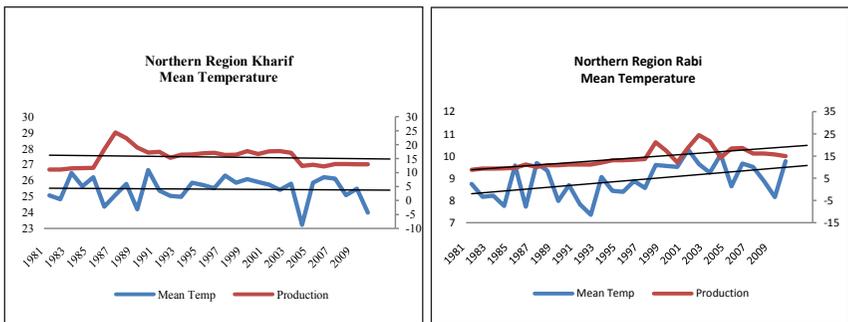


Figure-8

Northern Region Mean Temperature Trend

Mean temperature trend of the northern region is almost stationary for the kharif crop whereas it is showing a sharply increasing trend in case of rabi cropping season. An increase of 1.3°C is observed in the rabi mean temperature. The increase in temperature is having a favorable impact on vegetation growth. Hence positively effecting rabi crops.

Northern Region Maximum Temperature Trend

Maximum temperature of northern region is also showing an increasing trend in case of Kharif as well as rabi seasons. The kharif cropping season trend line shows a 0.8 °C increase whereas rabi crop is showing a 2.5°C increase in rabi season over the last 30 years. The overall increase in maximum temperature can be one of the factor causing increased rains ,melting of snows and glaciers that results in unalarmed floods in the lower part of KP. But the crop productivity trend in both the season is positive and faviourable.

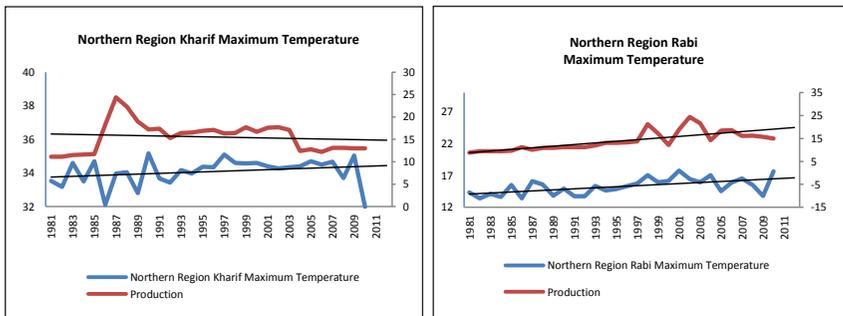


Figure-9

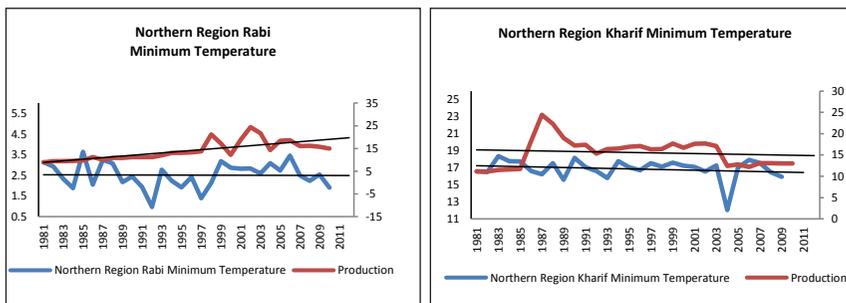


Figure -10

Northeren Region Minimum Temperature Trend

Looking at the minimum temperature of the northern region in the graphs below explains little or no change over the three decades. Kharif cropping season is showing a decrease in the trend of about 0.4 °C. On the otherside the rabi season is showing almost no impact.

IMPLICATIONS

The finding of this study suggests some policy implications include that climate knowledge should be shared at farm level. i.e. about the change in climatic conditions, shift in the tilling and harvesting timings, water and land management skills should be development, climate region specific crop incentives to the farmer should be introduced, disaster management strategies i.e. coping with extreme environmental conditions at farm level should be upgraded and improved, and importance of crop insurance policy, to safe guard farmer's future against climate risks, should be emphasized and implemented

CONCLUSION

The data demonstrates that majority of the grains output and economic prosperity is linked to the southern rain-fed plains of the province. Out of the total 2.7 million hector cultivable area, 1.8 million hector is cultivated area while 1.08 million hectares is cultivable waste. Moreover, 49% of the cultivable area entails the rain-fed region which is climate dependent. The analysis reveals in terms of region specific analysis that climate variables do have impact on crop production. Whereas, the magnitude of impact is relatively harsh on the southern part of KP, which is already short of water supply and untimely rainfalls. Moreover, high temperature has further aggravated the crop productivity situation. On the other hand climate variables impact on northern region of KP is positive and favorable; as elevated temperatures escalate the crops ripening processes. Most of the northern region of the province has embraced forests, thus contributing little to overall crop productivity of the province. The central regions of the province is also experiencing a positive impact of climate change, but to a certain limit, crossing the limit leads to a downturn. Moreover the conclusion from the specific crop perspective: the Southern part of the province is observing a decreased Kharif crop productivity with almost the same climatic conditions over the thirty year span. On the other hand, Rabi crop is hardly hit by the

changing climatic conditions in terms of a sharp increase in the maximum and minimum temperature accompanied by a little rise in the rainfall rate. A positive climate change impact is seen in the central and northern regions of KP. Kharif crop is showing increased productivity with more or less steady climatic variables. Whereas, the Rabi crop is experiencing a sharp increase in the crop output with a sharp increase in the climate variables of maximum, minimum temperature & rainfall. The overall climate change impact is negative as the southern part of the province mostly constitutes the area for crop cultivation & production. The climate impact and the extent of climate influence have been found out in this research study. It is now the time to do further research & exploration in the climate change adaptations and mitigation strategies to cope with the non-eluded situation. This study is opening new dimensions for future research in the climate impact & assessment arenas.

Pakistan as an agrarian country needs a robust and stable agricultural sector. Climate changing issues such as droughts impacts, flash floods, plant epidemics, restoration of roads, water management and maintenance of canals and water logging needs to be addressed in detail for the effective working of economy. This research work is an asset to assist the concerned authorities in solving the problems faced by Pakistan's agricultural sector. The mathematical and theoretical analysis made in this research will help in the identification of the variation in temperature and rainfall patterns at different regions of the province.

REFERENCES

- Asia Development Bank Institute. (2012). *Climate Change in Asia and the Pacific: How can Countries Adapt?*. Book highlights.
- Asian Development Bank Institute (2011). *Impacts of Climate Change on the People's Republic of China's Grain Output-Regional and Crop Perspective*. Research Paper.
- Aurbarcher, J., Lippert. C., and Kirmly. T., (2010). *Assessing the Impact of Climate Change in Agriculture in Germany-A Ricardian Analysis*. International Agricultural Trade Research Consortium (IATAC).
- Azam, M. and Mukarram, K., (2010). *Significance of the sugarcane crops with special reference to NWFP. Sarhad Journal of Agriculture, 26(2), 289-295*

- Cline, W., (2007). Global Warming and Agriculture: Impact Estimates by Country. The Peterson Institute for International Economics. pp.1-6.
- Deressa, T. T. and Hassan, R. M., (2009). Economic impact of climate change on crop production in Ethiopia: evidence from cross-section measures. *Journal of African Economics*, 18 (4), 529-554.
- Haddad, E.A., Nadim, F., Marina, C., Ricardo, L., and Vieira, F., (2014). Climate change in Lebanon: higher-order regional impacts from agriculture. TD Nereus 02-2014 São Paulo. Retrieved from http://www.usp.br/nereus/wp-content/uploads/TD_Nereus_02_2014.pdf
- Hope, S., (2008). Foreign Policy in Focus, Corporations Grab Climate Genes. Research paper.
- International Food Policy Research Institute. (2009). *Building Climate Resilience in the Agriculture Sector in Asia and the Pacific*. Philippines. Asian Development Bank, Philippines. pp. 23-65.
- International Food Policy Research Institute. (2009). *Climate Change Impacts on Agriculture and Cost of Adaptations*. Science Alert, Australia and New Zealand. Policy Report
- Lobell, D. B. and Gourdji, S. M., (2012). The Influence of Climate Change on Global Crop Productivity. *Plant Physiology*, 160(4), 1686-1697
- Maplecroft (2010). South Asia most Vulnerable to Climate Change. Retrieved from <http://socialissuesindia.wordpress.com/2011/07/26/south-asia-most-vulnerable-to-climate-change/>
- Malla, G., (2008). Climate change and its impact on Nepalese agriculture. *The Journal of Agriculture and Environment*, 9, 62-65.
- Mustafa, Z., (2011). Climate Change and its Impact with Special Focus in Pakistan. Pakistan Engineering Congress, Symposium. Working Paper No. 290.
- Nazir, A., Jariko, G.A., and Junejo, M. A. (2013). Factors affecting sugarcane production in Pakistan. *Pakistan Journal of Commerce and Social Sciences*, 7 (1), 128-140

- Parry, M.L., Rosenzweig, C., Iglesias, A., Livermore, M. and Fischer, G., (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change*, 14, 53-67
- Pretty, J., (2006). *Agroecological Approaches to Agricultural Development*. Background for World Development Report. pp.1-38.
- Pretty, J., (2005). *Farm, Costs and Food Miles: An Assessment of the Full Costs of the Weekly UK Food Basket*. Research Paper.
- Siebert, S. and Ewert, F., (2014). Future crop production threatened by extreme heat. *Environmental Research Letter*, 9 (2014), 1-4
- Upreti, D. C., (1999). *Raising Atmospheric CO and Crop Response*. South Asia Regional Research Center (SASCOM) Scientific Report. pp. 1-8.
- White, J.W., Hoogenboom, G., Kimball, B. A., and Wall, G.W., (2011). Methodologies for simulating impacts of climate change on crop production. *Field Crops Research*, 124, 357-368