Climate Change: Region and Season Specific Agriculture Impact Assessment (Thirty Year Analysis of Khyber Pakhtunkhwa i.e.1980-2010)

Samreen Babar
Iqra University Islamabad

Safia Gul
Higher Education Department, Khyber Pakhtunkhwa

Amjad Amin
University of Peshawar

Israr Mohammad
Preston University, Peshawar

The world is confronting the changing climate conditions in the form of flash floods, severe droughts, forceful thunder storms, sporadic rains, flooded plains, desolate land, water accumulation and water dearth. The objective of this research study is to perceive the intense climate change in Pakistan and find out the ways for future adaptation and mitigation against it. Flash flood of 2010 was the compelling force to initiate the climate impact assessment study. Khyber Pakhtunkhwa was among the provinces viciously distressed by the flood event of 2010. Khyber Pakhtunkhwa by ecological topography can be divided into three regions i.e. the northern, the central and the southern regions. This study attempts to quantify the climate changing impacts on the three ecological regions of the province, in terms of crop production. The environmental as well as the econometric analysis of the study indicates that climate change put punitive impacts on crop production in the southern part of the province. Central region is facing a temperate impact and the northern part shows a definite positive impact.

Key words: Climate Change, Rabi Crop, Kharif Crop, Temperature and Rainfall.

Climate change is a condition that has evolved due to release of greenhouse gases i.e. from fuel combustion, urbanization, industrialization and deforestation. It has subsequently caused alterations in solar energy, temperature and precipitation patterns. (Upreti, 1999) It is a real threat to life, which greatly distresses water resources, freshwater habitats, coastal regions, agriculture, flora, forests and snow cover. It has also affected the geological processes of snow cover melting, land sliding, land desertification and heavy floods. All of which have long-term consequences on food security and human health. (Malla, 2008) It is one of the most fierce problem, sever than terrorism menace, faced by nations. (King, 2004)

Maplecroft (2010) is a British risk assessment consultancy, ranks countries by their anticipated climate susceptibility over the next 30 years. It ranks Pakistan in the 20th most climate-vulnerable countries globally. The stern droughts of 1990`s and intense floods of 2010 all are the aftermaths of climate change in Pakistan. Climate impact assessment is performed by numerous organizations and agencies, to draw the concerned authorities' attention towards the issue.

Correspondence concerning this article should be addressed to Samreen Babar, Lecturer, Management Science Department, Bahria University Islamabad Email: samreenbabar@hotmail.com

The utmost current impact of climate change is seen in floods of 2010 & 2011.It demolished thousands of villages of Pakistan. An estimated 14% i.e. 3.4 million hector area of cultivable land was shattered by 2010 floods. A loss of 1764 human life, human injures of 2697 and 1.85 million of houses damage was reported. The re-establishment and restoration of the flood effectees costed approximately 8-9 billion rupees (Mustafa, 2011). Statistics shows that the greatest hit among the provinces of the country was the Khyber Pakhtunkhwa (KP) province. The total people effected by the flood were 2349 in KP, among them 1156 lost their lives and 0.2 million houses wrecked. (Mustafa, 2011) The country's social, political and economic system suffered and thus instigated an economic impediment.

Climate change is a universal dispute; questioned at all fronts, whether it's social, political, scientific or economic. Concrete actions must be executed to ensure climate prevention and protection. There is a need on all stratums of society to comprehend climate, the issues of climate change and its influence on our economy as a whole and agriculture sector in particular. The agriculture sector is highly susceptible to climate change. Higher temperatures while encouraging weed and pest production, ultimately decrease yields of desirable crops. Fluctuations in precipitation patterns raise the short-run crop malfunction and drops long-run production yields. Though there is an escalation in some crops production in certain regions of the world, the

overall impacts of climate change on agriculture are anticipated to be negative, threatening global food security. (International food Policy Research Institute, 2009)

Pierre (1997) explains the potential impacts of climate change on agriculture in United States as well as on global scale. His paper argues about the scientific fact that intensification in "heat trapping" gases i.e. Carbon dioxide, in the atmosphere might leads to Greenhouse effect. It has resulted in the temperature increase by an average of 1 to 3.5 degree centigrade. He further enlightens that warmer atmosphere store more water vapors, that ultimately raises the precipitation rate by 10 to 15 percent. The author is a strong supporter of the global circulation Models (GCMs) for the explanation & elaboration of climate change impact assessment.

Smith et.al (2007) in his study is providing assessments to landlords for long term decisions in land use and crop mixes. He strongly discloses the fact that climate has altered due to human-induced anthropogenic activities such as, livestock wastes, fossil fuel burning and deforestation.

The Fourth Assessment Report (AR4, 2007) of the Intergovernmental Panel on Climate Change also presumes that if anthropogenic activities continue with the same pace, it is anticipated that the global average temperature will rise from 1.1 degree centigrade to 5.5 degree Celsius by 2100. The report further proves that climate change impacts of increased temperature along with the rise in precipitation rates, has already distorted United States agricultural production.

United Nations Development Program (2008) indicated in one of the research reports about the triggers and the consequences of climate change on the world and the humanity itself. This reports mentions that world`s temperature has raised at an average of 3 centigrade as compared to the preindustrial era. It has caused an increase in severe weather events as intense floods and harsh droughts. The most affected are the poor and developing nations. It is also causing hindrance in their developmental progress. United Nations contemplating the seriousness and urgency of the problem is accentuating on world`s influential states to take positive actions in helping the poor humanity in coping with this unwanted situation. The report mentioned that two of the esteemed United Nations agencies i.e. United Nation Development Program (UNDP) and United Nation Environment Program (UNEP) have approved in providing assistance in reducing vulnerability against climate change and capacity building for development. The purpose of this report is to cartel and combine the world on a common ground of climate change impacts. It is not only beneficial for humanity but also for the future generations.

Cline (2007) further elaborates, the global impact of climate change on agriculture, in his book. The major disagreement of this book is that global warming does not escalates the crop yield as advocated by others. He verified his claim by comparing various countries current verses projected average temperatures and precipitation values. He approached to the argument that the effects of global warming might be positive for some countries but for developing countries it is untrue. He further argues that the effects of global warming might be minor in this century but might be disastrous in the future eras. He suggested that the countries must take positive measures in controlling the use of carbon or non-organic fertilizers and pesticides, might help in the subsiding of the climate change impacts.

Aurbacher, J., Lippert, C. & Kirmly, T., (2010) in their paper assess the impact of climate change on German agricultural districts. As per their findings, the world weather is changing, in comparison to historical trends, and that the upcoming years are expected to be harsher with more precipitation in winters and higher temperature in summers. The authors employed the ricardian analysis for spatial autocorrelation in the data. The variables that were considered were land rental prices, mean temperature and precipitation rates. The cross-sectional analysis showed a significant correlation between land rents and increases in mean temperature except in the case of East Germany. The study concluded that the increase in temperature and precipitation rates accelerated land rental prices and people were moving to areas having more favorable weather conditions. This paper suggested different approaches to compare and consider farm soil qualities at district level. This paper also identified various farmers' adaptation strategies and the rental costs associated to land use.

Baig et.al (2011) showed in their study that mean maximum temperature, mean minimum temperature, sufficient rainfall and the relative economic variables have a definite impact on wheat production in mixed zone of Punjab province. The aim of the study is to find out the impacts of climate change on wheat production in Punjab. The study outcomes demonstrated that climate change has quantifiable effects on wheat productivity at the various germination stages i.e. sowing, vegetation and maturity stages of wheat growth.

Climate change is a substantial menace to human development. Concerns regarding vulnerability to extreme climate conditions must be tackled with solemnity to save Pakistan's agricultural sector and subsequently its economy. Pakistan`s agriculture has an extensive versatility in its vegetation due to its variable climate in different parts of the country. Its land is enriched to bear various kinds of fruits as oranges, mangoes, apples, pears and plums etc. It can grow maize, gram, rice, sugarcane, barley, tobacco and various kinds of pulses. This research study is an effort in finding the climate change trend in various ecological regions of the country and retrieving its impacts on Pakistan's agriculture sector.

Method

Research Techniques and methods are the instruments employed in the analysis for the exploration of various issues. There are four general approaches commonly used in assessing the climate impact on agricultural production i.e. Crop simulation models (Pervaiz, 2010), Agro economic zone Models (AEZ) (Pretty, 2006), General equilibrium models (Baig, 2010) and Ricardian land price models (Uzma, 2010 & Ahmad, 2013).

Crop simulation models and Agro economic zone models are commonly used to evaluate the climate impact on agricultural produce without taking into consideration the economic factors as human capital, employment, GDP etc. (Pervaiz, 2010 & Pretty, 2006). Moreover, these approaches are mostly used by the environmentalists to assess climate impact. The other approach is the Ricardian model, used by Uzma, 2010 and Agha, 2010. The downside of Ricardian approach (Mendelson. et.al, 1992) is that it explores the climate relationship with agricultural land value at a specific place and specific time. Additionally, land prices are effected by non-climate variables as agricultural subsidies to specific area, accessibility to market, water availability etc. This approach overlooks the direct impact of climate variables as temperature and rainfall on farm yield.

Further, it is the technique used in identifying the modes of adaptation and mitigation by farmers in dealing with climate change. The only approach left, is the general linear regression model (Lin et.al, 2011). The advantage of this approach over the others is that it explores the direct impact of agricultural output with climate variables. This research study is adopting the general linear regression model (Lin et.al, 2011), for the evaluation of the crop productivity. It is estimated by the panel data regression technique. The objective of the study is to analyze the impact of environmental changes on crop productivity in agriculture sector for a period of past thirty years. The hypothesis tested in this research is that “climate changes have significant impact on farm productivity in KPK”

Research Area

Pakistan`s province Khyber Pakhtunkhwa (KP), formerly named North West Frontier Province (NWFP), is the area designated for this study. It has a versatile weather and a unique topography. Its climate varieties from the dry and hot rocky zones in south to the cool and lavish green forests in the north. It has twenty five (25) districts in total. Khyber Pakhtunkhwa (KP) by ecological topography can be divided into three regions i.e. the southern hottest region, the central moderate and the northern cooler regions. The three climate regions i.e. Northern is symbolized by Chitral district, Central region by Nowshera , Charsada and Peshawar districts and Southern region by Dera Ismail Khan and Tank Districts. The selection of these districts in various ecological zones of KP elucidates two constraints. First is the availability of data and second is the constant area boundaries of the selected districts for the thirty year analysis period.

The northern, colder region of Khyber Pakhtunkhwa is represented by Chitral district. The selection of Chitral district is subject to the approachability of secondary data. Both sets of secondary data for analysis i.e. climate and output is available for this district. Its weather station was established in 1960`s (Director Provincial Meteorology, 2012).

The Central, temperate region of Khyber Pakhtunkhwa is symbolized by Peshawar, Nowshera and Charsada districts. The selection of three districts are based on the change in the district Peshawar boundaries since 1981 till 2010. The previous Peshawar district now contains these three different districts. Farther, these three districts fall in the central region of KP. Climate and weather is not limited to the man-made borders. That is why, the secondary climate data of district Peshawar is taken, as it is the only district having data record available for the last 30 years i.e. 1981-2010. Its weather station was established in 1960`s. (Director Provincial Meteorology.2012).

The Southern, warmest region of Khyber Pakhtunkhwa is represented by Dera Ismail Khan (D.I. Khan) and Tank districts. The selection of these districts is based on the observation that it is amongst the hottest regions in South Asia with the temperature as high as 50°C (Statistics Division of Pakistan, 2011). Moreover, D.I .Khan district boundaries has also been modified. It was divided into D.I.Khan and Tank district in the recent past. The two districts occurs in the same southern region of KP. D.I.Khan district weather station is one of the old weather stations originated in 1960`s. (Director Provincial Meteorology.2012). Furthermore, the rabi and kharif crops production statistics is obtained from the Federal bureau of Statistics and the Provincial Agricultural Statistics Department.

Data Analytical Technique

This research study investigates the KP crop productivity by two methods. One method is the time series trends analysis (Malla. 2008). The climate trends analysis of the various KP ecological zones with respect to the crop production is examined and compared. It helps in clearly depicting the climate change trend over the last thirty years in the two cropping seasons.

The other method of analysis is the panel data regression technique. The purpose of carrying out another analysis is to evaluate the climate variables impact in quantifiable terms. Each distinctive region`s climate variables along with the crop production statistics are unique. In order to capture this impact, separate regression analysis is carried out at regional level.

The general form of the model used in this analysis is given below:

Crop`s Output = f {Area sown, Climate variables, Climate variables squares}

$$CO = ß0 + ß1AS + ß2CV + ß3(CV)^2 + u$$

AS = Area sown under Rabi and Kharif crops in million hectors.

CO = Rabi and Kharif season crop production in thousand million tons. Wheat is taken as Rabi (winter) crop and Maize as Kharif (summer) Crop

CV = Climate variables = Mean temperature(Tm) in degree Centigrade and average Rainfall (N) in millimeters

$(CV)^2$ = Square of Climate variable = Square of average Rainfall (N^2)

The source of data collection is secondary in nature. The thirty years climate data i.e. temperature and rainfall, is obtained from of Pakistan Metrology Department Islamabad. The secondary data of agricultural i.e. area cultivated under the Rabi and Kharif crop is obtained from Federal Bureau of Statistics Pakistan. There are various other climate variables which can be integrated in the model such as the carbon dioxide concentration, aerosols concentration, daily sunshine and humidity content in atmosphere. Similarly, the agricultural data as the mode of irrigation, the water availability, unirrigated and irrigated land, and amount of pesticides, quantity of fertilizers, seed types and many more can be considered. These variables can be included in the model to get more efficient and unbiased estimates. The problem arises in the realization and the non-availability of thirty years district level data for these variables.

Result and Discussion

This section analysis the overall impact of climate change on agricultural crop production. This analysis is divided into two categories i.e.

1. The Econometric Analysis (Region Specific)
2. The Environmental Analysis (Crop Specific)

Econometric Analysis

The detailed econometric analysis results of the various climate regions of Khyber Pakhtunkhwa are given in detail below:

Southern Region of Khyber Pakhtunkhwa

In this model Khyber Pakhtunkhwa`s southern region Rabi (Wheat) & Kharif (Maize) crops are incorporated. The purpose of this analysis is to examine climate change impact on specific region of KP. Below table is showing the coefficient of the various variables engaged in the random effect model. There are two highly significant variables in the model. The first significant variable is area showing a positive impact on the crops. A one unit increase in the area of cultivated land leads to an increase in 960 units of crop yield. The second, climate variable mean temperature, has a negative impact on the crop`s production. A degree rise in the mean temperature of the crop will leads to a decrease in the crops yield by 2390 units. This is a distressing fact. It leads to the conclusion that harsh impacts of climate change are spotted in the southern regions of KP. The non-significance of rainfall coefficient in the model indicates that area considered for analysis is irrigated by canals and tube wells. The R-square value of the model is 0.097 showing 97% goodness of model fitted. The details are given in the below table 1.

Table -1

Coefficient of the various variables engaged in the random effect model for Southern Region

Variables	OLS Estimates	Variance Inflation Factor (VIF)	Random-effects Coefficient	Standard Error	95% Interval	Confidence
Area	(0.96)***	(8.22)	(0.96)***	(0.1001)	(0.764)	(1.156)
Mean Temperature	(-2.39)***	(8.51)	(-2.39)***	(0.553)	(-3.47)	(-1.3)
Rainfall	(-0.0089)	(2.75)	(-0.0089)	(0.073)	(-1.52)	(0.134)
Rainfall Square	(-0.00000976)	(2.78)	(-0.0000097)	(0.00086)	(-0.0017)	(0.001)
Constant	(76.51)***		(76.51)***	(16.85)	(43.48)	(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

Central Region Khyber Pakhtunkhwa

Central region of Khyber Pakhtunkhwa is temperate in terms of climate change impact on crops production. Random effect model is used for the panel data regression analysis i.e. Rabi & Kharif. The particulars are given in the table-2 below.

Table 2

Coefficient of the various variables engaged in the random effect model for Central Region

Variables	OLS	Variance Inflation Factor (VIF)	Random-effects Coefficient	Standard Error	95% Interval	Confidence
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)
ß2	(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

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 hector increases in area under cultivation will leads to an increase of 2926 tons of crop yield. Similarly

one degree centigrade increase in mean temperature of central region will increase the crop yield by 1933 tones. The significance of rainfall also confirms that fact that most of the central KP agriculture is rain-fed. The variable of average rainfall have a positive impact on the crop production i.e. 1 mm increase in rainfall will leads to increase crop productivity by 212 tones. The second negative coefficient of rainfall square depicts the decreases effect of ample rain. It is a scientific fact that plants needs water up to a certain limit i.e. too much water is harmful to the plant as well as crop output.

Northern Region Khyber Pakhtunkhwa

The colder mountainous regions of Khyber Pakhtunkhwa (KP) is situated in its northern regions. Model explained below gives the climate change impact of the colder Himalayas of Pakistan. The following table-3 gives the estimates.

Table 3

Coefficient of the various variables engaged in the random effect model for Northern Regions of KP

Variables		Variance Inflation Factor	Random Effect		95% Interval	Confidence
	OLS	(VIF)	Co-efficient	Standard Error		
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)
Rainfall	(2.51)*	(4.02)	(2.51)*	(1.506)	(-0.435)	(5.469)
Rainfall Square	(.000092)	(3.53)	(-0.000092)	(0.00034)	(-.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

Random effect model results are given in the above table. Three variables along with the constant intercept are significant in the model. This shows that climate change impact in the tropics are more pronounces and prominent. The coefficient of area 2.36 is highly significant. It is showing that a one unit increase in area will leads to the increased crop productivity by 2.360 units. The highly significant coefficient of mean temperature shows that a 1°C increase in temperature will result in the increased production by 0.523 units of crop production. The third variable, rainfall is transformed into logarithmic form to rule out the occurrence of multicollinearity. It explains the increasing effect of rainfall in increasing crop production. All the above regression equations shows that rainfall has quadratic impact on crop production process. It peaks up till a point and then slopes downward i.e. the law of diminishing marginal productivity holds true here. This explains the phenomenon of decreased crop productivity by intensified rainfall.

Environmental Analysis

This analysis is divided into three regional categories below:

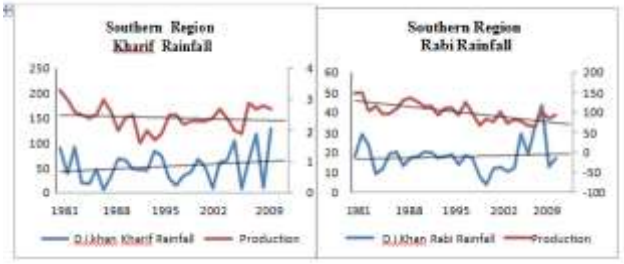
The Southern Region Environmental Trends

The south of the Khyber Pakhtunkhwa region is termed as one of the hottest regions of the country and is greatly effected by climate change. The impact of change on crop produce is pronounced and definite. Below graphs are explaining the situation in much detail.

i. The 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 remarkable reduced up to 50 thousand tones. The increasing trend of kharif rainfall explains the concepts of untimely rains in summer that results in floods, overflows and the loss of agricultural output.



ii. The Southern Region Mean Temperature Trend

The southern 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 a decreasing trend of 1.2 °C. The decrease in mean temperature in rabi season is one of the reasons of high productive crops in the region.

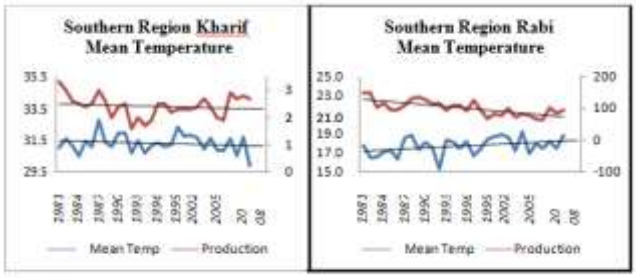


Figure-2

iii. The Southern Region Maximum Temperature Trend

The southern region maximum temperature trends are shown below. The graph below is showing an increasing trend of 0.7°C for rabi season whereas it is showing the

decreasing trend of 1.3 °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 increased sharply due to mild temperatures.

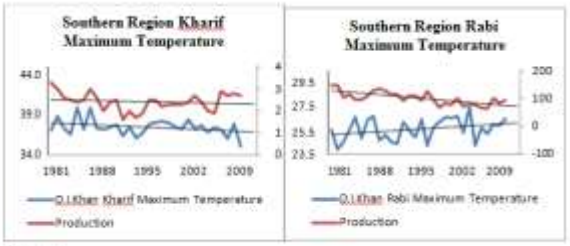


Figure-3

Iv. The Southern Region Minimum Temperature Trend

Minimum temperature for the two cropping season of the southern region are showing an increasing trend. Rabi cropping season is showing a 1.6 °C increase in temperature whereas kharif crop is portraying a 0.3 °C increase in minimum temperature. The opposite 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 Greenhouse effect and low agricultural productivity in the two cropping seasons.

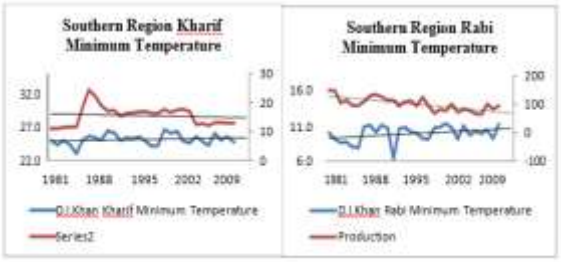


Figure-4

The Central Region Environmental Trends

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

i. The 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 38mm whereas rabi crop is portraying a remarkable increase of 25mm 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.

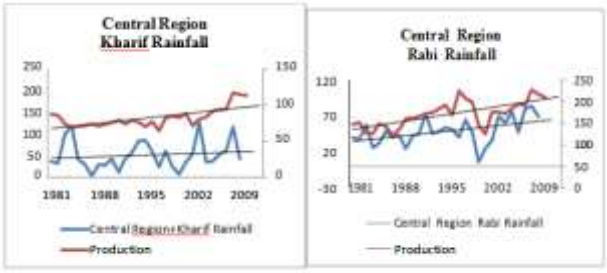


Figure-5

ii. The Central Region Mean Temperature Trend

The central region of Khyber Pakhtunkhwa 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 1.2°C in mean temperature. On the other side it is showing a slight increase of 0.3 °C in Kharif season. This variation is portraying the change in the weather pattern on the region over the thirty year span. Moreover the crop productivity trend is showing a positive trend.

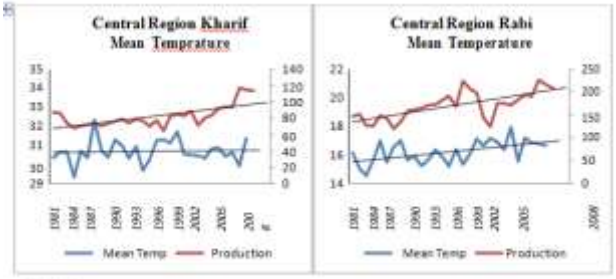


Figure-6

iii. The Central Region Maximum Temperature Trend

Just like the rainfall, central region maximum temperature is also showing a marked increase in the maximum temperature of rabi season. The regression line is depicting an increase of 1.3 ° C in rabi season whereas a 1.6 °C increased maximum temperature trend in kharif cropping season. This is one of the reasons of increased productivity in rabi as well as the kharif crop output at the central regions of KP.

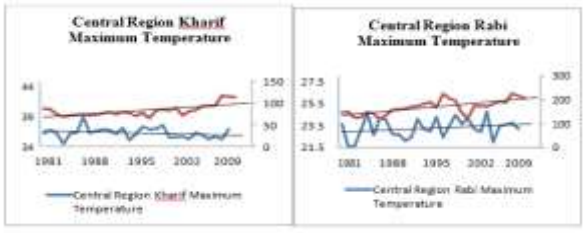


Figure-7

iv. The 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 0.7 degree increase whereas rabi season is showing a 1.2 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.

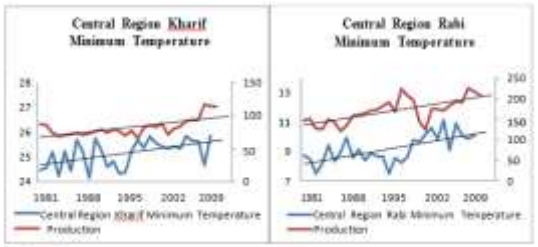


Figure-8

The 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.

i. The Northern Region Rainfall Trend

The 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.

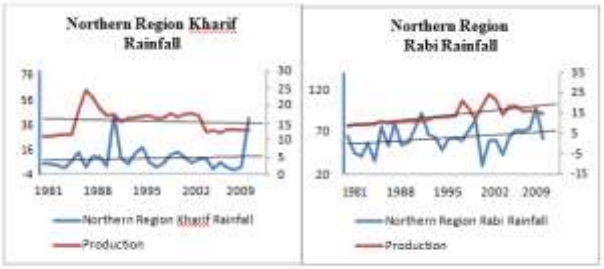


Figure-9

ii. The 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°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.

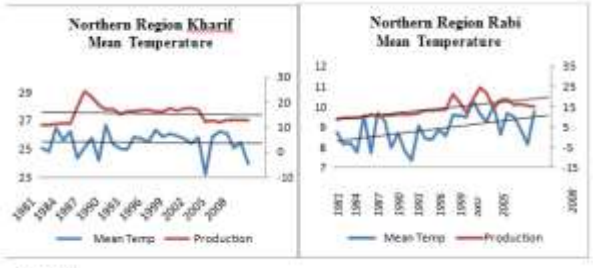


Figure-10

iii. The Northern Region Maximum Temperature Trend

Maximum temperature of the 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 0.7 °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 favorable.

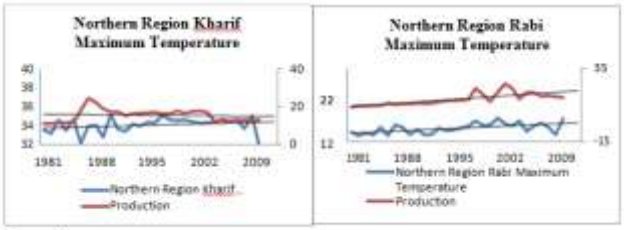


Figure-11

iv. Northeren Region Minimum Temperature Trend

Looking at the minimum temperature of the northern region in the graphs below explains a huge or no change over the three decades. Kharif cropping season is showing a decrease in the trend of about 1.3 °C. On the other side the rabi season is showing almost no impact.

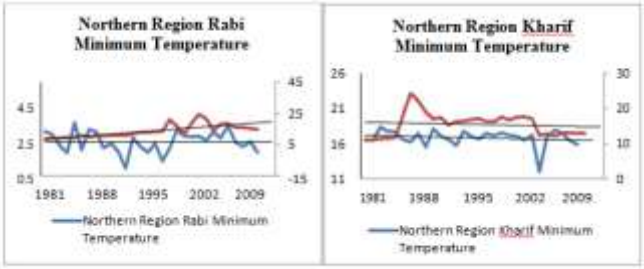


Figure-12

Conclusions and Recommendations

Summarizing the above investigation in terms of region specific analysis; it can be concluded with certainty that climate variables do affect crop production. It puts severe impacts on the southern part of KP, which is already short of water supply. Furthermore, high temperature has intensified the crop productivity issue. Observing the climate variables impact on northern region of KP, is positive and favorable, as elevated temperatures strengthen the crops ripening processes. But the actual fact is that, most of the northern region of the province has comprised of 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. Majority of the grains output and economic prosperity is linked to the central and 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 hectors is cultivable waste. Moreover, 49% of the cultivable area entails the rain-fed region which is

climate dependent. (KP, Statistics 2011).

Summarizing the whole trend analysis concludes that climate change in KP has been perceived in the form of increased rainfalls and increased mean temperature. Khyber Pakhtunkhwa rainfall trend, for both the kharif and rabi cultivation period, has amplified over the last thirty years span. This intensified rainfall trend i.e. 3mm-38mm, is physically seen in the form of flash floods, unproductive agricultural land and human loss.

KP mean temperature in rabi season is displaying an increased trend of 1-1.2 degree centigrade whereas the kharif mean temperature is screening a falling trend of 0.3 degree centigrade. Moreover, majority of the climate change is witnessed in the rabi cropping season, which mostly comprises the KP winter season. It appears that moderate winters will be observed in the coming future. Warm winters are the clear indication of intensified greenhouse effect. This has led to variation in crop strewing and reaping patterns, early crop development, low crop productivity, low nutritional food and intensified weed and pest outbreaks. Furthermore, the increased temperature fact is understood and acknowledged by the scientist and general public in the form of melting glaciers and depleting water reservoirs. The overall climate change impact is negative as the southern part of the province mostly constitutes the area for crop cultivation and 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 and 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. A few of the recommendations drawn from all the above research is as under:

- Climate knowledge should be shared at farm level. i.e. about the transformation 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. copping with extreme environmental conditions at farm level should be upgraded and improved.
- Importance of crop insurance policy, to safe guard farmer's future against climate risks, should be emphasized and implemented

References

Ahmad, S., et al. (2010). *Agricultural Census*, Pakistan Report, Retrived from www.statpak.gov.pk. 12 Dec 2012.

Ahmed, M. (2013) A Structural Ricardian Valuation of Climate Change Impacts on Agriculture in Pakistan. *Series: Schriften zur internationalen Entwicklungs- und Umweltforschung* .31. ISBN 978-3-631-65014-1

Agricultural Statistics of Pakistan. (2010). Retrieved from www.pbs.gov.pk.

Aurbarcher, J., Lippert, C. & Kirmly, T. (2010).Assessing the Impact of Climate Change in Agriculture in Germany-A Ricardian Analysis. *International Agricultural Trade Research Consortium (IATAC).*

Ashfaq, et al. (2011*).* Impact of climate change on wheat productivity in mixed cropping system of Punjab.*Soil Environ.* 30(2): 110-114, retrieved from www.se.org.pk.

Baig, et al. (2011).Impact of climate change on wheat productivity in mixed cropping system of Punjab. *Soil Science Society of Pakistan.* 30(2): 110-114

Cline, W. (2007). Global Warming and Agriculture: Impact Estimates by Country. *The Peterson Institute for International Economics.*

Dawn, (2012).Agri Expo; Issues and Prospects*. Article.* 1-33.

Director Provincial Meteorology. (2012). Personal CommunicationDepartment of Agricultural Statistics Khyber Pakhtunkhwa. (2011). Personal Communication.

Smith, et.al. (2007). Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press.* Cambridge, United Kingdom and New York, NY, USA.

Goddard Institute of Space Studies. (2012). Retrieved from http://www.giss.nasa.gov/research/news.

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.* Asian Development Bank Philippines. 23-65.

Intergovernmental Panel on Climate Change. (2007).*Fourth Assessment Report (AR4) on climate change impact assessment.*

International Union for Conservation of Nature. (2011). Community Perception on Climate Change in Bagrote Valley, Pakistan. *A Case Study.*

International Union for Conservation of Nature. (2008). Community Perception on Climate Change in Shigar Valley, Pakistan. *A Case Study*.

International Union for Conservation of Nature. (2009). Climate Change Vulnerabilities in Agriculture in Pakistan. *A study.*

King, D. (2004). Climate Change Science: Adapt, Mitigate, or Ignore? *Policy Forum Environment.* 303 .Retrieved from Science. www.sciencemag.org.Khyber Pakhtunkhwa Map (2010).Retrieved from Pakhtoon.com.

Lin, et al, (2011). Impacts of Climate Change on the People's Republic of China's Grain Output—Regional and Crop Perspective. Asian Development Bank Institute. *Research Paper.*

Neil, L. and Kulkarni, J. (2007). Climate Change Vulnerability and Adaptation in Developing Country Regions. Nairobi, Kenya. The United Nation Environment Program, *Discussion Paper*.7-30.

Malla, G. (2008). Climate Change and its Impact on Nepalese Agriculture. *The Journal of Agriculture and Environment* .9(62).62-65.

Maplecroft. (2010) Climate Vulnerability News. Retrieved from http://maplecroft.com/themes/cc/

Mendelson, et al. (1992) The Impact of Global Warming on Agriculture: A Ricardian Analysis. *The American Economic Review*. 84(4). 753-771. Published by: American Economic Association. Retrieved from URL: http://www.jstor.org/stable/21180

Mustafa, Z. (2011). Climate Change and Its Impact with Special Focus in Pakistan. *Pakistan Engineering Congress, Symposium*. 33. 290.

Nelson, et al. 2009. Climate change impact on agriculture and cost of adaptation. *International food and Policy Institute report*.

Nyong, A. (2008).Climate Change, Agriculture and Trade: Implications for Sustainable Development. *A background Paper for the International Centre for Trade and Sustainable Development.* 1-10.

Santiago, O. (2001). Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods. *The Climate Change Knowledge Networks*. 2-15.

Organization for Economic Cooperation and Development Joint Working Party of the Environment Policy Committee and the Committee for Agriculture. (2002). Agriculture Practice that Reduce Greenhouse Gas Emissions. *Research Paper*.

Rukhsan, et al. (2009). Trend Analysis of Climate Change and Investigation on Its Probable Impacts on Rice Production at Satkhira, Bangladesh. *Pakistan Journal of Meteorology.* 6. (11).

Pierre, C. (1997). Impacts of Climate Change on Agriculture. *Resources for the Future*Climate Issues Brief No. 4. Retrieved from http://www.rff.org/rff/Documents/RFF-CCIB-04.pdf

Planning Commission of Pakistan. (2008). Glaciers Behavior under Climate Change and its Impact on Agriculture in Pakistan. *Research paper.*

Pretty, J. (2006). Agro ecological Approaches to Agricultural Development. *Background for World Development Report.*1-38.

Pretty, J. (2005).Farm, Costs and Food Miles: An Assessment of the Full Costs of the Weekly UK Food Basket. *Research Paper.*

Pervaz, S. (2012).Pak Climate Policy Approved Focusing on Environment. Technology, *Weekly Times.*

Pervaz et. Al (2010). Impact of Climate Change on Wheat Production. A Case Study of Pakistan. *PIDE Journal.* Retrieved from http://www.pide.org.pk/psde/pdf/agm26/day3/Pervez%20Zamurrad%20Janjua.pdf

Rehana, et al.(2012).The Impact of Climate Change on Major Agricultural Crops: Evidence from Punjab, Pakistan. *The Pakistan Development Review*51(4). 261-276.

Ritchie, J. and Smith, D. (1991). Temperature and Crop Development. In Modeling Plant and Soil Systems. (ed) Hanks, J. Ritchie, J. and Madison, T. *American Society of Agronomy*. 5-29.

Rasheed et.al. (2010). Wheat Production in Pakistan: *Saga of Policy Disincentives*

Shand, H. (2008).Cooperation's Grab Climate Genes. *Foreign Policy in Focus. Washington, DC*. Retrived from www.fpif.org.

Shrybman.S. (2002). Trade, Agriculture and Climate Change: How Agricultural Trade Policies Fuel Climate Change. Institute of agriculture and Trade Policy. *Assessment Report.* 1-17.

Shakoor, et.al. (2011).Impact of Climate Change on Agriculture: Empirical Evidence from Arid Region. *Pak. J. Agri. Sci*. 48(4), 327-333; Retrieved from http://www.pakjas.com.pk.

Smith et.al (2007). Agriculture. In Climate Change. *The fourth Assessment Report of Intergovernmental* Panel on Climate change. Cambridge University Press, United Kingdom and New York.

Upreti, D.C. (1999). Raising Atmospheric CO and Crop Response. *South Asia Regional Research Center (SASCOM) Scientific Report*.1-8.

United Nations Conference on Trade and Development & United Nations Environment Programme, UNEP-UNCTAD. (2008).*Organic Agriculture and Food Security in Africa. Research Study.* 1-61.

United Nations Development Programme. (2008). Fighting Climate Change: Human Solidarity in a Divided World. *Human Development Report*. 1-18.

United Nations Food and Agriculture Organization (2006). Livestock`s Long Shadow: Environmental Issues and Options. Livestock, Environment and Development Initiative. *Research study.*

Uzma et.al (2011) Economic Impact of Climate Change on Agricultural Sector of Punjab. Retrieved from *www.pide.org.pk/psde/25/pdf/agm26/day3/Uzma%20Hanif.pdf.*

World Bank. (2003). Climate Change and Agriculture: A review of Impact and Adaptations.*Research Paper*. 1-106.

World Bank (2009). The Economics of Adaptation to Climate change. *Final Methodology Report.*

World Bank (2010). *Convenient Solutions to Inconvenient Truth: Ecosystem- based Approaches to Climate Change*. 1-7.

World Bank Data (2012). Retrieved from http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2012

Woodward and Kelly. (1995).The influence of CO2 concentration on stomatal density. *New Phytologist*. 131(3).

Zeb, et.al (2013).Analysis of climatic change and its negative impact on agriculture**.** *Scholarly Journal of Agricultural Science.* 3(6). 233-237. Retrieved from http:// www.scholarly-journals.com/SJAS ISSN 2276-7118 © 2013 Scholarly-Journals.

Received: Dec, 12th, 2014
Revisions Received: April, 23rd, 2015