

## Impact of Climate Change on Seasonal Crop Productivity in Khyber Pakhtunkhwa-Pakistan

Haidar A<sup>1</sup>, Shafi MM<sup>2</sup>, Idress M<sup>3</sup>, Laila S<sup>4</sup> and Iqbal M<sup>5</sup>

<sup>1</sup>Faculty of Rural Social Sciences, Institute of Development Studies, The University of Agriculture, Peshawar, Pakistan

<sup>2</sup>Faculty of Rural Social Sciences, The University of Agriculture, Peshawar, Pakistan

<sup>3</sup>Department of Agriculture Extension and Education, The University of Agriculture, Peshawar, Pakistan

<sup>4</sup>Biotechnology Department, Abdul Wali Khan University, Mardan, Pakistan

<sup>5</sup>Khyber Medical College, Peshawar, Pakistan

\*Corresponding author: Haidar A, Faculty of Rural Social Sciences, Institute of Development Studies, The University of Agriculture, Peshawar, Pakistan, Tel: +923339350722; E-mail: [haiderkpk59@gmail.com](mailto:haiderkpk59@gmail.com)

Received date: November 10, 2016; Accepted date: November 16, 2016; Published date: November 23, 2016

Copyright: © 2016 Haidar A, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

The major aim of this research study was to observe the impact of climate change on seasonal crop productivity in Khyber Pakhtunkhwa in general and in Peshawar Valley in particular. In Khyber Pakhtunkhwa and Peshawar Valley, there are two main cropping seasons (i.e., Rabi and Kharif). Peshawar valley was selected for the sole reason that most of the agricultural activities are carried out in this region of the province. The panel data regression of the study signified effect on the Kharif and Rabi crop productions of the Peshawar Valley in Khyber Pakhtunkhwa mainly caused by the climatic change. Under normal climatic conditions, climate variables revealed a highly positive impact on Rabi crops. Moreover, in Rabi season, a sufficient high temperature was depicted to be the source of high productivity in the Peshawar Valley of Khyber Pakhtunkhwa. However, the impact of climate on Kharif crop was though discovered to be negative. Furthermore, increased temperatures lead to decrease crop production due to the increased weed and pest proliferation. Similarly, due to the increase in temperature, crops got ripened in quick session that adversely caused the malnourished crops and less nutrient food. It is suggested that Climate knowledge should be disseminated among the farm level such as the change in rainfall and temperature patterns, shift in the tilling and harvesting timings. The current research is an asset to assist the concerned authorities by identifying the impact of climate on the two seasonal crops.

**Keywords:** Climate change; Kharif crop; Rabi crop; Temperature; Rainfall; Fixed effect model

### Introduction

Climate change traces its initiation due to the emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization, variations in the field of solar energy, temperature and precipitation [1]. Climate change can be assumed as jeopardy in the way of human development in its worst shape. This has been validated in one of the research reports issues by the United Nations Development Program that depicted the conspicuous causes and effects of climate change on the world and the humanity itself. World temperature has been increased at an average of 3 centigrade as compared to the preindustrial era. This resulted in the increase in extreme weather events such as intensifying floods and harsh droughts while, poor and developing nations are more susceptible to such catastrophe because it directly hampers the development process to a great extent. Valuing the importance and urgency of the climate change issue, the United Nations is stressing on world influential states to take positive actions and help the humanity to combat the situation accordingly. Two of the United Nations agencies i.e., United Nation Environment Program (UNEP) and United Nation Development Program (UNDP) have put their consensus to render their services

while reducing vulnerability and enhancing capacity building for development of the affected countries.

Climate change in its adverse shape is a big menace to human life which largely affects water resources, coastal regions, freshwater habitats, vegetation, agriculture, forests, snow cover, and geological processes such as melting, land sliding, desertification and floods. All of the above factors have long-term effects on food security and human health [2]. International Food Policy Research Institute-2013, in one of its climate assessment reports emphasized over the susceptibility of agriculture to the climate change while arguing that higher temperatures ultimately reduce yields of desirable crops that lead to weed and pest production.

The role of British Risk Assessment Consultancy (BRAC), is to rank countries by their expected climate vulnerability over the last 30 years<sup>1</sup>, and has ranked Pakistan among the 20 most climate-vulnerable countries worldwide. In retrospective, Pakistan encountered myriad catastrophes in shape of severe droughts in 1990s and devastated floods of 2010. They were all attributed to be the outcome of climate change. The 2010 floods destroyed thousands of villages all over Pakistan with an estimated of 14% (i.e. 3.4 million hector area of cultivable land) was destroyed. A loss of 1764 people, human injuries of 2697 and houses damage of 1.85 million was reported. The reconstruction and rehabilitation of the flood affected areas costed

<sup>1</sup> Maplecroft (2010) Climate Vulnerability News.

approximately 8 to 9 billion rupees [3]. One of the affected provinces of the country was Khyber Pakhtunkhwa (KP). Out of the 2349 Khyber Pakhtunkhwa (KP) flood affecters', 1156 lost their lives and 0.2 million of the houses were either damaged or destroyed [3]. The country's social-economic setup suffered badly and thus resulted in a severe economic set back. China while, supporting the above situation asserted that changes in precipitation patterns lofted the short-term crop malfunction and curtailed the long-run productions. Notwithstanding, an increase might be observed in some parts of the world in respect of crop production, the general implications of climate change on agricultural productivity are to be presumed negative i.e., intimidating global food security.

## Objective of the Study

The aim of this study is to analyze the impact of climate change on seasonal (Rabi and Kharif) crop productivity with respect to the climate variables under consideration.

## Methodology

The following four approaches while assessing the impact of climate change on agriculture are being adopted namely, Crop Simulation Models, Agro Economic Zone Models (AEZ), General Equilibrium models and Ricardian Models [4-6].

Month	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
<b>Kharif (Maize)</b>							Maize	Maize	Maize			
<b>Rabi (Wheat)</b>	Wheat	Wheat	Wheat	Wheat							Wheat	Wheat

**Table 1:** Kharif and Rabi crop production month's calendar.

As seen in Table 1, Kharif (maize) crop production months in Peshawar Valley of Khyber Pakhtunkhwa are from July to September while Rabi (Wheat) crop production is done between November to April. The climate variables of the two crops are selected according to the cropping month's calendar given above in Table 1. The source of data collection is secondary in nature. The thirty years (1984-2014) secondary data of the selected Peshawar Valley are collected from the various government and non-government organizations i.e., Pakistan Metrology Department, Federal Bureau of Statistics, various journals and related articles etc.

There are a number of other climate variables to be included in the model such as the daily sunshine, carbon dioxide concentration and humidity in atmosphere. Similarly, the agricultural data as the water availability, mode of irrigation, irrigated and unirrigated land, use of fertilizers, pesticides, types of seed any many more can be used. These variables can be incorporated in the model to get effective and efficient estimates. The problem arises in the attainment and the non-existence of thirty years' data for these variables [7-12].

### Kharif (Maize) crop

Peshawar Valley-Khyber Pakhtunkhwa kharif crop model effectiveness is shown by R-square value of 97% in Table 2. There are two highly significant variables in the model i.e., Area & Rainfall square. Keeping other factors of the model constant, a one-unit increase in the area of land cultivating the crop will lead the kharif crop production by 3.37 units. Similarly, the significant squared rainfall

Analyzing the Rabi & Kharif crop productivity of Khyber Pakhtunkhwa (KP), the panel data regression analysis was adopted considered to be the most suitable statistical analysis. The general form of the model used in this research analysis is given by;

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

$$P=\beta_0+\beta_1A+\beta_2Tm+\beta_3N+\beta_4N^2+\mu$$

Area Sown (A)=Area sown under Rabi and Kharif crops

Crop's Production (P)=Rabi and Kharif season Production. 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 (N<sup>2</sup>)

Peshawar Valley as a focal point for the current study was chosen as a university of the study. It was previously called North West Frontier Province and being considered as dynamic in respect of the stern weather conditions as times. Climate variables data has been opted according to the cropping months in KP. The crop production months of the two seasonal crops (i.e., Kharif and Rabi) are highlighted in Table 1.

coefficient also portrays a positive relation of crop productivity and rainfall. Here the rainfall relationship is U-shaped with a minimum at N=0. In other words, 0.006-unit increases in rain lead to increase crop production by one unit. Kharif cropping months mostly constitutes the summer season of Peshawar Valley, hence the importance of well timely rainfall for crop production cannot be ignored. Moreover, the insignificant rainfall coefficient ascertains the paper findings and confirms the positive relationship between rainfall and crop productivity. The second non-significant coefficient of mean temperature indicates that kharif crop productivity decreases with the increase in temperature. The increased temperature not only ripen the seeds prematurely by also adds to increased plant diseases, weeds production and pests' attacks [13-17].

### Rabi (Wheat) crop

The second analysis in Table 2 consists of Rabi crop model estimation. The model effectiveness indicator R-square is 0.90 showing the 90% goodness of fit to the model. This model shows four significant variables. The highly significant coefficient of area shows that one-unit increase in land area will lead to increase in the production of Rabi crop by 1.24 units. This model shows that climate variables positively effects Rabi crop production. The second significant variable of mean temperature shows that a one-unit increase in mean temperature will increase Rabi production by 4.465 units. Likewise, Rainfall has also a positive impact on Rabi crop production. The coefficient of rainfall is followed by its negative square

variable to capture the quadratic effect of the factor i.e.,  $(y=N_1t-N_1^2t)$ . The negative sign indicates an inverted U-shaped relationship between rainfall and crop production. This explains that an increase in average rainfall of one unit will increase wheat production until it reaches at its

peak of 0.80 units. The law of decreasing returns starts beyond that point. In other words, each millimeter of rainfall will decrease crop productivity by a factor of 0.004 [18-22].

Variables	KP Kharif Model Estimates	KP Rabi Model Estimates
Constant	-43.098*	-1.85*
	-31.29	-30.054
Area	3.37***	1.24***
	-0.42	-0.124
Mean Temperature	0.632	4.46**
	-1.04	-1.89
Rainfall	-0.01	0.643***
	-0.039	-0.135
Rainfall Square	0.006*	-0.004***
	-0.0002	-0.0017
R-Square	0.97	0.94
Adjusted R-square	0.97	0.93
***significant at 1%; **significant at 5%; *significant at 10%		

**Table 2:** Peshawar Valley-Khyber Pakhtunkhwa season-wise crop estimates.

## Conclusion

Climate change is the conglomeration of complex dynamic activities carried out by the nature, human and animal. The climate along with its instigating variables usually have deleterious 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 the prominent illustrations in this respect caused by climate change events. It has been detected on the basis of the current study while evaluating the recent past events of climate change and the country crop production statistics that climate variables had a noticeable effect upon crop production. Under normal climatic conditions, climate variables demonstrated a highly positive impact on Rabi crops (crops sown between the months of November and April). A timely sufficient rain showed an increase in the crop yield. Moreover, a sufficient high temperature was the source of high productivity in the Peshawar Valley of Khyber Pakhtunkhwa Province.

Unlikely to the Rabi crops, impact of climate change showed adverse effects on the Kharif crop (sown between the months of June and August). It was observed that increase in temperature lead to decrease the crop production due to increased weed and pest proliferation. Moreover, increased temperature quickly ripened the crop which resulted in malnourished crops and less nutrient food. The second climate variable of rainfall indicated that timely sufficient rain could increase the crop productivity but at a very minimum ratio. Additional rain evolved in increasing plant moisture content as well as accelerated crop rotting process.

## Recommendations

- Climate knowledge should be shared at farm level i.e., about the change in rainfall and temperature patterns, shift in the tilling and harvesting timings.
- Crop specific incentives to the farmer should be introduced i.e., by subsidizing heat resistant seeds, insecticides and pesticides.
- Research and development in the fields of new crop varieties which are resistant to high temperature and high land moisture should be encouraged.
- Water management skills should be development in cases of flash floods or droughts
- Disaster management strategies i.e. coping 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

1. Upreti DC (1998) Rising atmospheric CO<sub>2</sub> and crop productivity. Japanese Journal of Crop Sciences 67: 394-395.
2. Malla G (2008) Climate Change and its Impact on Nepalese Agriculture. The Journal of Agriculture and Environment 9: 62-65.
3. Mustafa Z (2011) Climate Change and Its Impact with Special Focus in Pakistan. Pakistan Engineering Congress.
4. Pervaz S (2012) Pak Climate Policy Approved Focusing on Environment. Technology, Weekly Times.
5. Pretty J (2006) Agro ecological Approaches to Agricultural Development. Background for World Development International Development Research Centre, Canada.

6. Ashfaq M, Zulfiqar F, Sarwar I, Quddus MA, Baig IA (2011) Impact of climate change on wheat productivity in mixed cropping system of Punjab. *Soil Environ* 30: 110-114.
7. Adger N, Aggarwal P, Agrawala S, Alcamo J, Allali A, et al. (2007) Climate change 2007: Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change.
8. Ahmad S, Khan MA, Dharejo NM, Khurshid A, Arshad MN, Bashir T, et al. (2010) Agricultural Census, Pakistan Report. Government of Pakistan.
9. Ahmed MN (2013) A structural Ricardian valuation of climate change impacts on agriculture in Pakistan. Peter Lang.
10. Aurbacher 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).
11. Batka M (2009) Building Climate Resilience in the Agriculture Sector in Asia and the Pacific. Asian Development Bank.
12. Beverly M, Hans RH, Wakhungu J, Robert TW (2008) Agriculture at a Crossroads. International Assessment of Agricultural Knowledge Science and Technology for Development. Island Press.
13. Amir P, Nazareth F (2009) Climate Change Vulnerabilities in Agriculture in Pakistan. International Union for Conservation of Nature.
14. International Fund for Agricultural Development (2008) Climate Change and the Future of Smallholder Agriculture.
15. Lin T, Guanghua W, Xian X, Yongsheng Z (2011) Impacts of Climate Change on the People's Republic of China's Grain Output Regional and Crop Perspective. Asian Development Bank.
16. Nelson G, Rosegrant MW, Jawoo K, Robertson R, Sulser T, et al. (2009) Climate Change-Impacts on Agriculture and Cost of Adaptations. International Food Policy Research Institute.
17. Pretty J, Ball AS, Lang T, Morison J (2005) Farm Costs and Food Miles: An Assessment of the Full Costs of the UK Weekly Food Basket. Food and Agriculture Organization of the United Nations.
18. Rehana S, Samad G, Nasir M, Jalil HH (2012) The Impact of Climate Change on Major Agricultural Crops: Evidence from Punjab, Pakistan. *The Pakistan Development Review* 51: 261-276.
19. Shakoor U, Saboor A, Ali I, Mohsin AQ (2011) Impact of Climate Change on Agriculture: Empirical Evidence from Arid Region. *Pak J Agri Sci* 48: 327-333.
20. Hanif U, Syed SH, Ahmad R, Malik KA, Nasir M (2011) Economic Impact of Climate Change on Agricultural Sector of Punjab. *The Pakistan Development Review*.
21. World Bank (2010) The Economics of Adaptation to Climate change. World Bank Publication.
22. World Bank (2009) Convenient Solutions to Inconvenient Truth: Ecosystem- based Approaches to Climate Change. World Bank Publication.