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Impact of Climate Change on Water Availability for Agriculture in Pakistan

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Abstract

This paper attempts to study the impacts of climate change on the water availability for agriculture of Pakistan. Water is crucial to be used in agriculture in all agro-climatic regions of Pakistan which depends upon irrigation because the major part of the country lies in arid to semi-arid climate. The climate change has decreased snow and ice in the Himalayas region which reduces water in the river basin of the Indus River and its tributaries. In this study, secondary data has been used to assess impacts of climate change on water availability for Pakistan's agriculture. Results show that there is remarkable decline in the water in major rivers in Pakistan which are fed by the glaciers and rainfall from Monsoons. With the implications of water harvesting and watershed management schemes the threat of decrease water availability can be minimized to avert any economic loss and food security in Pakistan.

Key words: water availability, climate change, agriculture, yield, irrigation, variability.

1. Introduction

Climate change is considered as global phenomenon which is caused mainly by human activities and it affects agriculture, human health, water resources, forestry and glacier melt down in several ways (IPCC, 2007). Climate Change has been affecting in many parts of the world but most vulnerable regions are less developed countries like Africa with fragile infrastructure and limited resources of adaptation to cope with climate change (Ziervogel et al., 2006). A large proportion of the world population is under constant threat of water stress in various countries due to climatic variability and this situation would be more worse by the end of 2025 (Charles et al., 2000). Global climate change is affecting hydrological cycle in several ways by increasing the rate of evapotranspiration under temperature increase. This phenomenon would lead towards drier seasons with stress on water resources and increasing demand of water for agriculture in future (Steven & Quang Fu, 2014). The warmer Earth is being considered as one of the main reasons for

the intensity and severity of droughts in different ecological zones of the world. Droughts not only decrease soil water balance among plants but it also increase the demand of water required for plant growth during its various phases (Abigail et al., 2016). Human interventions and climate change are altering the hydrological cycle in parts of Asia particularly in India and Pakistan and Western United States which depend upon irrigated water for agriculture. It has been assumed that water demand would be increased more than double as these factors affect water balance in this region (Haddeland et al., 2014). Civil conflicts would be triggered on the issue of water management in many parts of Africa and South Asia which has been hardest hit by climate change induced droughts and this situation would lead to civil war (Nina et al., 2016). Climate Change is likely to increase sufferings of 50 to 170 million people worldwide by the end of 2080 due to increasing level of poverty and hunger as yield of various crops reduces yearly (Schmidhuber et al., 2007).

The impacts of climate change are likely to be greater on South Asian countries which are most dependent on agriculture. These impacts may include reduction of water availability for crops and other sectors, changes in extreme events like floods, typhoons, droughts and unreliable rainfall (Easterling et al., 2005). Climate change is being considered as main reason to reduce renewable surface water and ground water significantly in most sub tropical regions increasing competition for water among all sectors (IPCC, 2007). Climate change will drastically put pressure on water availability in the river basins of Asia region due to drastic change in rainfall pattern in this belt. As these countries are largely dependent on agriculture these changes in climate would induce more poverty of South Asian belt (James L.&Westcoat, 2000, Doll, 2002). The loss of glacier melt and deflection in rainfall would cause reduction of water availability caused by climate change will be miserable for those people who live in already water stressed areas of the world and the poor groups would be the most affected (Annina et al., 2006) . The Himalayan glaciers are retreating at faster rates due to temperature increase. This situation has mainly resulted reduction of inflow of water to major rivers which supply water for agriculture and vast population in Asian region. (Messerli, 1989). Glacier retreat due to climate change would reduce water to ten largest rivers of Asia region particularly South Asia and East Asia. Climate change would induce poverty to these basins as water for agriculture shrinks in future (Penland, 2005; Gosain et al., 2006). Rising temperature would lead to an alternation of hydrological cycle, resulting in drier seasons and risks of extreme and frequent floods and droughts. Changing climate would also have negative effects on the availability of water for agriculture and domestic sectors (UNFCCC, 2007; Wateraid, 2008). The effects of climate change put pressure on the densely populated regions of Asia (Indo-Gangatic Rivers Basin System) and rest of the world lowland areas that depend on mountain water for their domestic, agriculture and industrial needs (Middelkoop et al., 2005). Changes in rainfall pattern its amount, intensity and distribution over time and space has a direct impact on total and peak rivers runoff, potentially moving it away from agriculture and dry season demands and intensifying Monsoon flash floods in lowlands of South Asia(Graham et al., 2005). In Asia particularly India, China and Pakistan climate change induced glacier melt would drastically affect fresh water for various sectors and it would also affect half a billion people in the Himalayas region overall and a quarter a billion people in China, who all depend on glaciers for their water supply for agriculture and domestic usage (Stern, 2007).

Pakistan agriculture is mostly dependent on irrigation water and more than 95 percent of the country's water is consumed for agriculture. Any change in rainfall pattern due to climate change would make Pakistan a desert as fresh water sources deplete due to unreliable rainfall pattern (Chaudhary et al., 2004; World Bank, 2009). Agriculture largely depends on irrigation water which fulfils requirement of water for crops. The country is facing onslaught of heat waves and El -Nino effects which are resulted by climate change and this situation would create panic for whole Indus Basin Irrigation System which would ultimately lead towards failure of crops at gross root level (Ahmed et al., 2004).

2. Materials and Methods

In this paper secondary data was used to analyze possible effects of climate change on water availability for crops in Pakistan. Climatic data regarding glacier melting was obtained from Meteorological Department of Pakistan and temperature warming and cooling from 1951-2000 and precipitation of the same period. Agriculture data was obtained from agriculture census of Pakistan and Bureau of Statistics of Pakistan. Data of water availability 1990-2011 was taken from Indus River System Authority of Pakistan year book and it was shown in graph. Data of glaciers and river basin inflow was collected from the international Union Conservation and analyzed in SPSS.



Figure 1 Location Map of Pakistan showing Administrative Units

3. Results and Discussion

It is noted that heat waves and Monsoon floods are becoming more danger to the agriculture sector and growing population of the country where different parts have no access to pure water for both agriculture and domestic sectors and in this situation the tug of war on water will be more intensive if these conditions prevail in Pakistan.

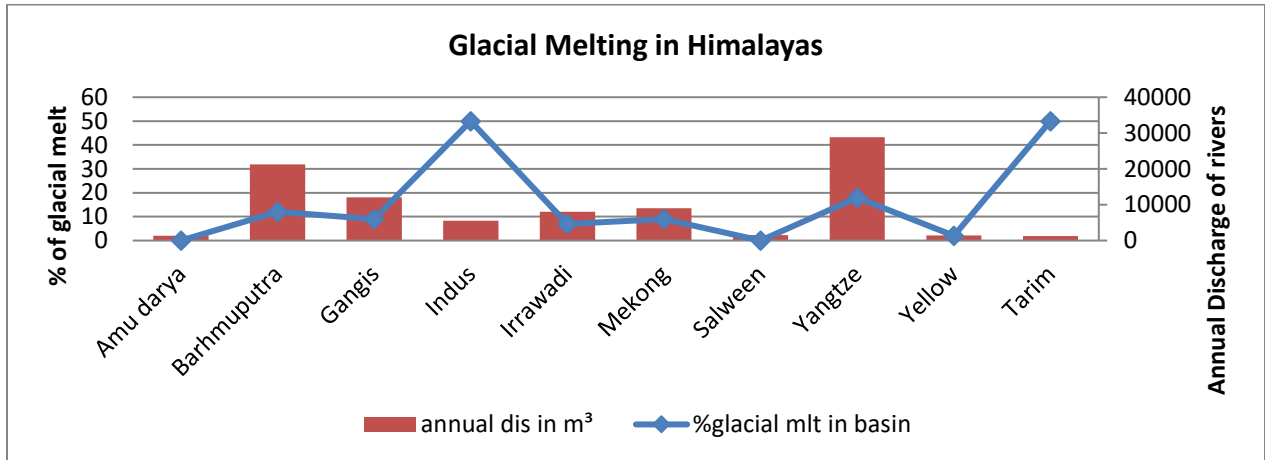


Figure .3 Comparison of Glacier melt in Himalayas and River discharge.

This figure.3 shows that glaciers are melting at fast rates and the inflow of water in Asian region has drastically reduced and it will also be very scanty as temperature increases at present stage. There will be water shortage in near future and it will affect on economies of the Asian region which depend upon irrigation for crops cultivation

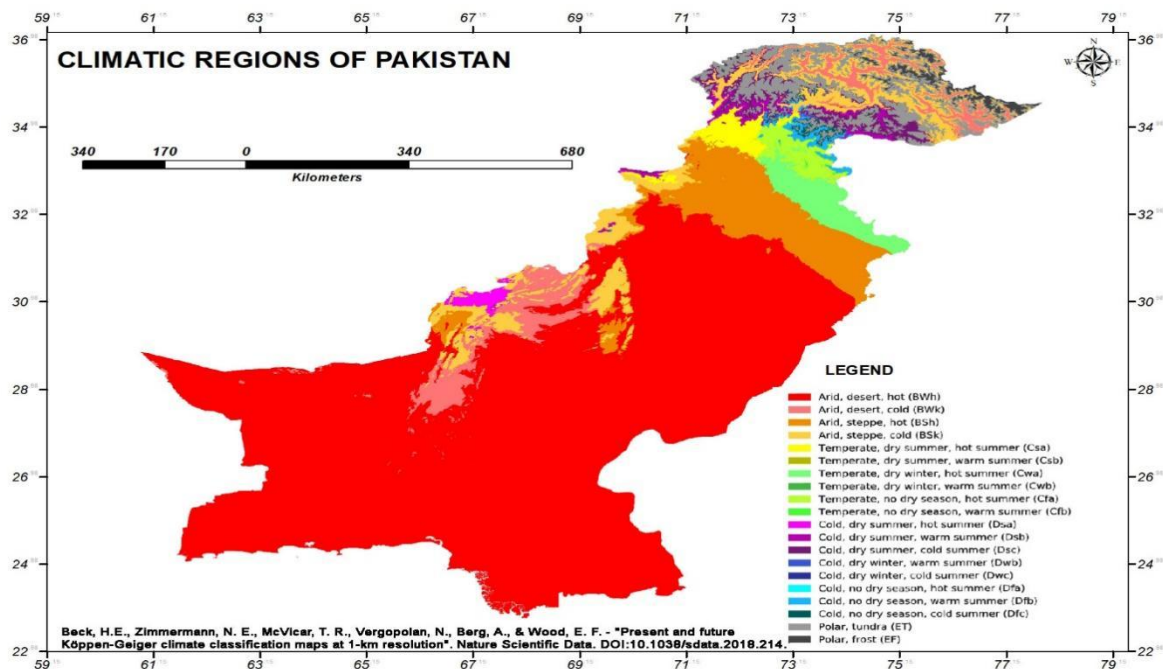


Figure.4 Climatic Regions of Pakistan

The Indus, the Irrawadi, the Mekong, the Yangtze, the Salween and other major rivers would reduce their inflow due to glacier retreat thus causing loss of agriculture in this belt (Messerli, 1989; Penland, 2005; Gosain et al., 2006). Himalayan glaciers are melting at faster rate due to increase of temperature increase in this region. In the last half of the century, 82 percent of glaciers in western china have reduced on the Tibetan Plateau. The glacier area has decreased by 4.5 percent over the last twenty years (Adel, 2001, Sorg et al., 2012). There is great relationship between temperature increase on the warming and cooling of the climatic regions of Pakistan as shown in figure 4.

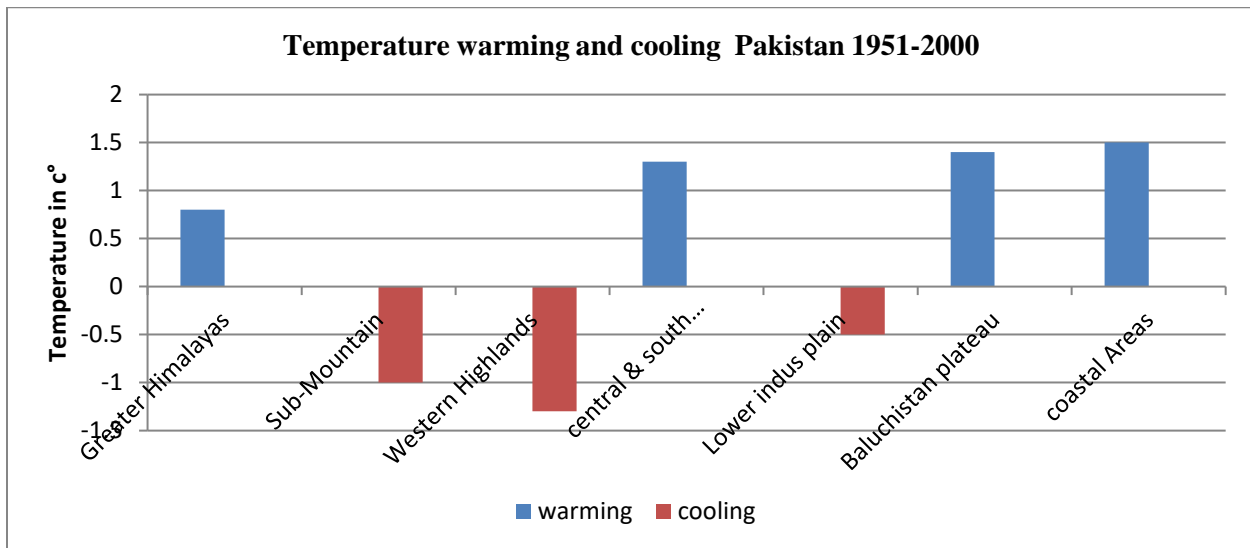


Figure.5 Temperature variations in Pakistan

Figure 5 shows data of temperature of various climatic zones of the country. The warming and cooling of temperature has some anomalies in different parts of the country. It shows plain areas, Baluchistan plateau and coastal areas have warmed significantly. The Himalayas have been warming over the years due to climate change that would speed up glacier melting which ultimately increases risks of floods and less amount of water after glacier retreat (Rasool&Q.Chaudhary, 2009). This condition would be very fatal for various sectors including agriculture which depends upon water from the Himalayan Rivers. The increases in temperature in Pakistan will not only increase glacier melting in the Himalayas but it would also be very fatal for crops yield and productivity as agriculture in Pakistan largely depends upon irrigated water.

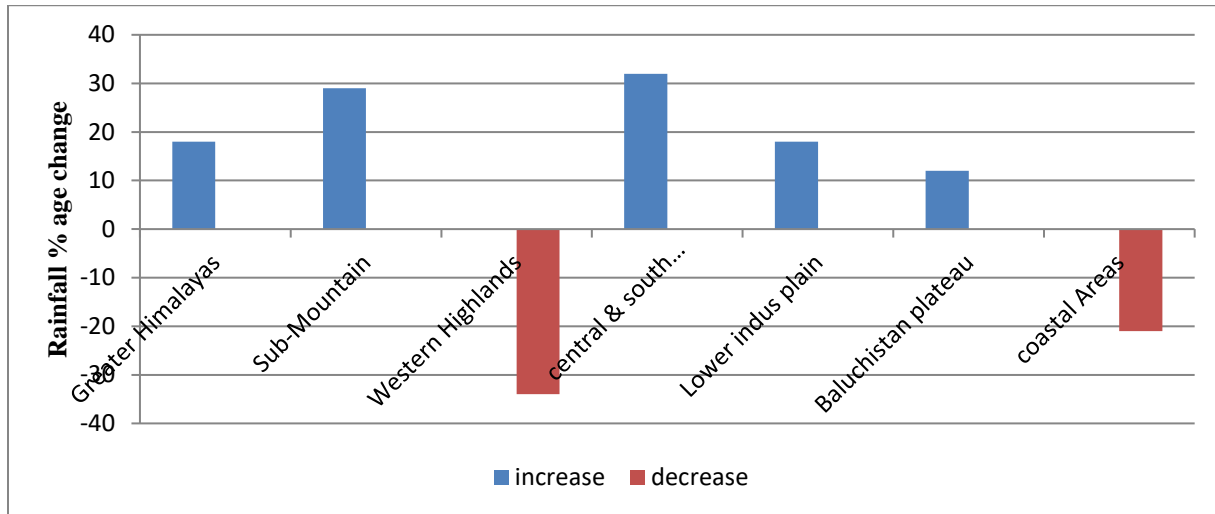


Figure.6 Precipitation Variability in Pakistan 1951-2000.

The precipitation trend has changed in different climatic regions of the country with the passage of time. It is evident that Western Highland and coastal areas of Pakistan registered decrease in precipitation which makes them more vulnerable to water stress areas in near future due to climate change scenario.

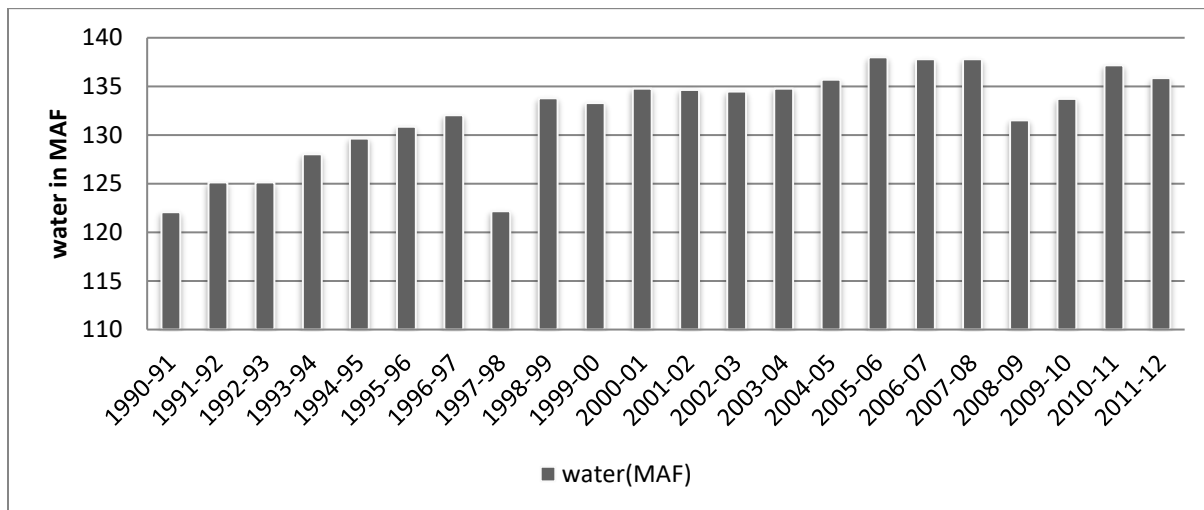


Figure.7 Decrease in water availability in Pakistan 1990-2012 in (MAF) for Agriculture

Figure 7 shows water availability fluctuations in different periods as the Monsoon rainfall hit the country and apart from Monsoon other sources of rainfall in Pakistan has witnessed unreliable change in their pattern. Climate change would be very fatal for the Himalayan region as temperature increases in this belt.

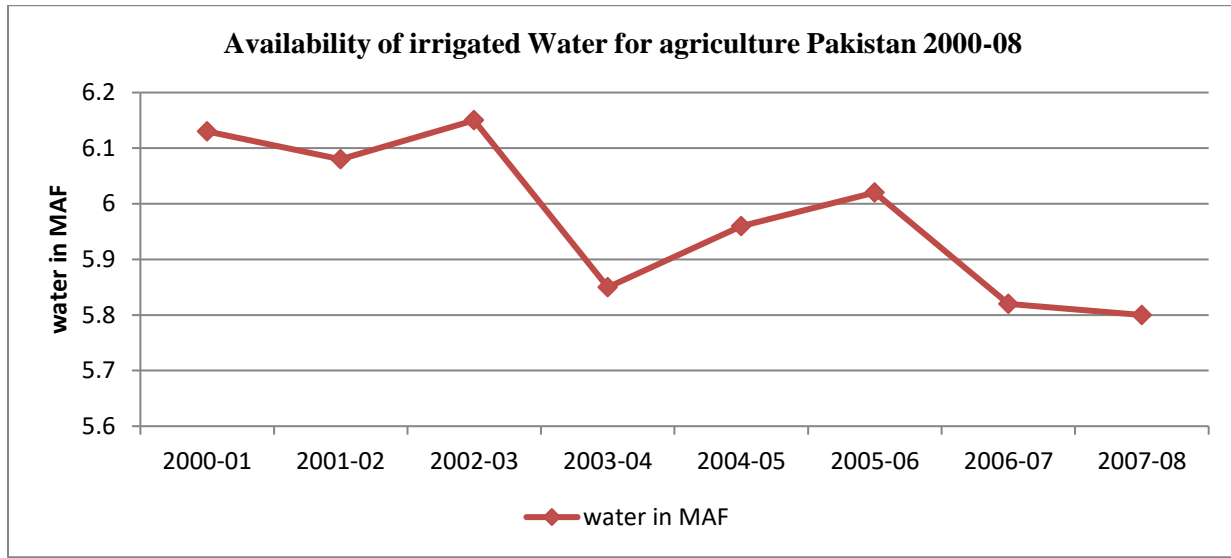


Figure.8 Water Availability for Agriculture under climate change

Figure.8 stats decline of irrigated water due to rainfall variability in the country and loss of water due to poor water management programs in Pakistan. Any change in temperature would affect water resources in Pakistan which is facing water shortage in recent years. Water availability in Africa and Asia particularly in Central, Eastern, South and South Asia(India & Pakistan being dependent on river system) in larger river basins is projected to decrease and there would be little water for domestic and agriculture use as climate change adversely affects on glaciers and rainfall on this region. It is estimated that climate change would displace more than a billion of people in Asian region by 2050 (Barrent et al., 2005; Aggarwala et al., 2007).

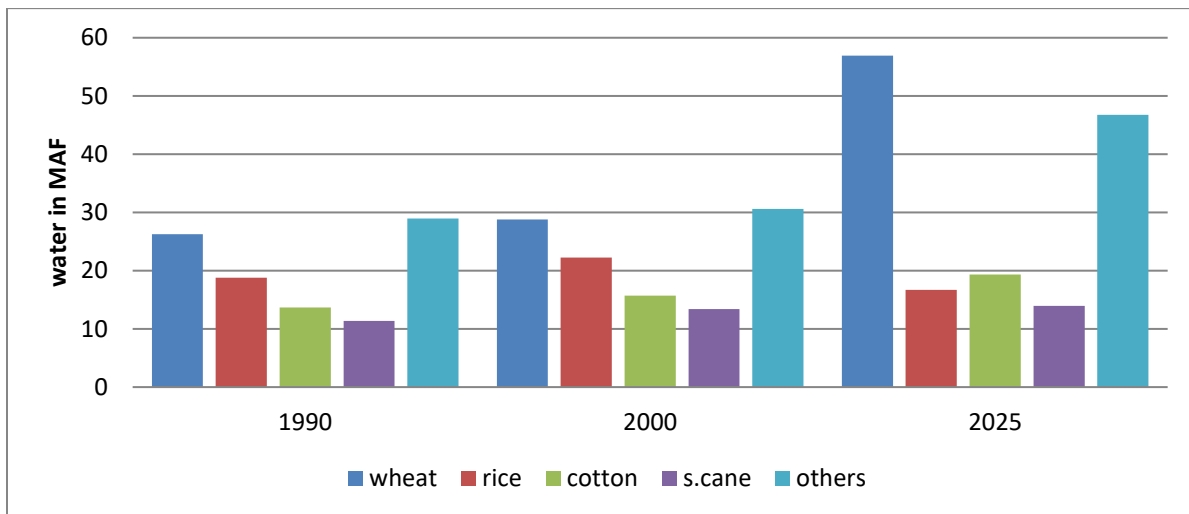


Figure.9 Future Water Demand of water by various crops

It shows that water demand of various crops has increased. Wheat, sugarcane, and cotton consume more water during their different phases of reproduction. Under climate change scenario the water demand of various crops in Pakistan will become more than double by 2025. It is estimated from various studies that agriculture share of water consumption would be increased to 95 percent in 2020 as temperature increases and rainfall becomes unreliable in the catchment areas of the rivers in Pakistan.

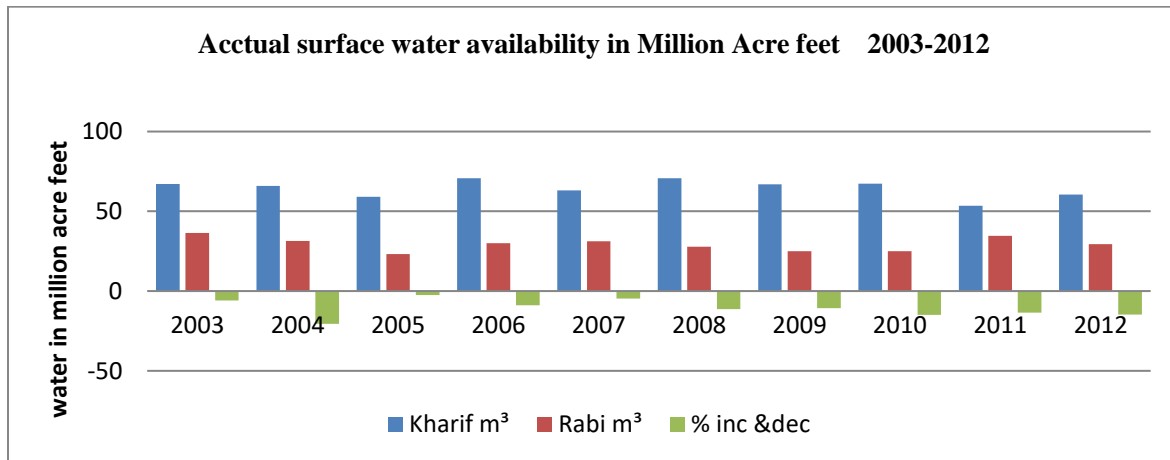


Figure.10 Decrease of Water for agriculture in Pakistan

Figure.10 indicates gradual decrease of water from reservoirs of the country. Decline in water for both crops in Kharif (summer season) and Rabi (winter season) has been noticed from various studies in Pakistan. Change in rainfall pattern and siltation of reservoirs can be attributed to this decline. During 2011-12 the availability of water as a basic input for kharif has been 10 percent less than normal supplies as the major crops production registered low growth. The water during Rabi season was low as 19 percent less than previous year thus increasing burden on national economy (Ahmad, 2011).

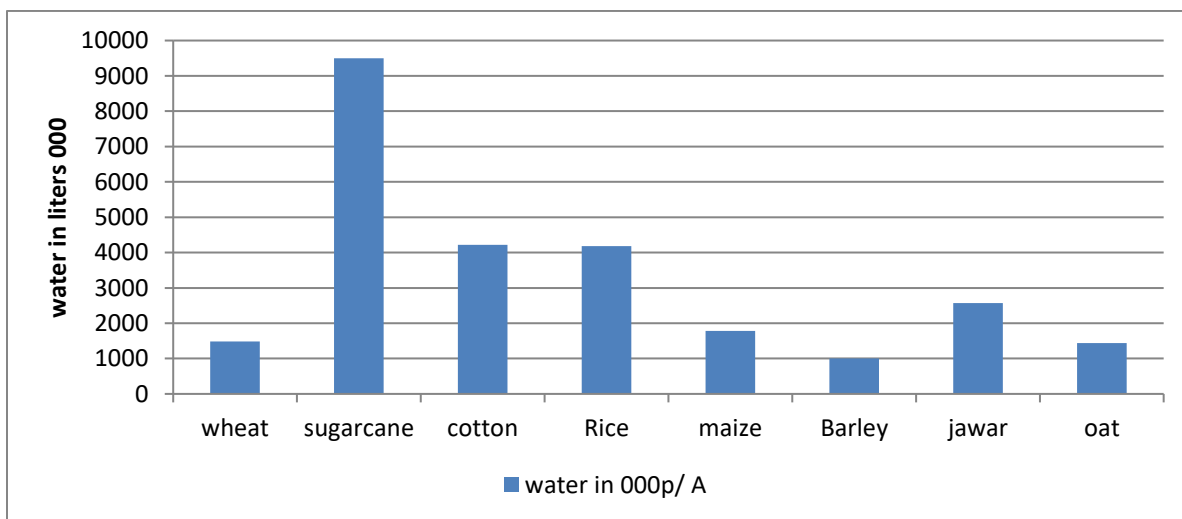


Figure.11 Consumption of water by crops in Pakistan

It is evident from figure 8 sugarcane, rice cotton and fodder crops require more water. The climate change will destroy these crops which would be very disastrous for the national economy of the country and the problem of food security will be emerged in Pakistan.

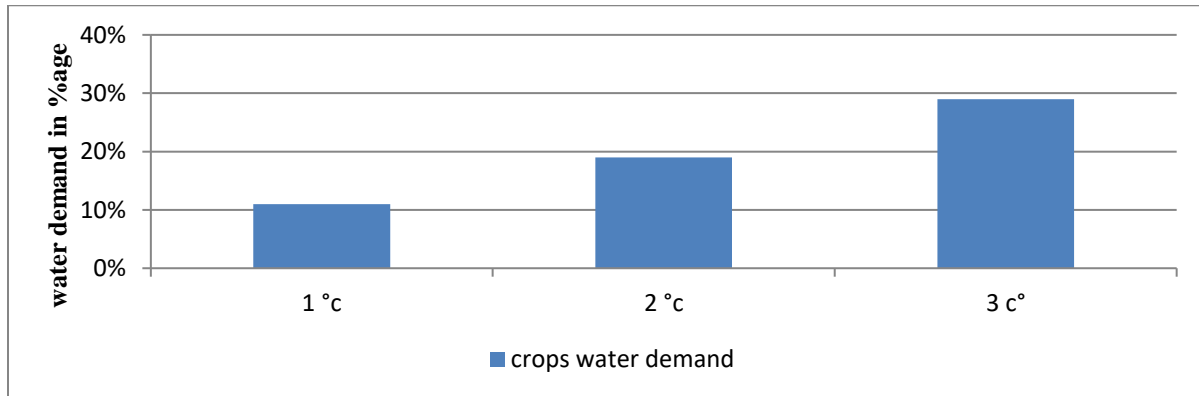


Figure12 Water requirement at increasing temperature in Pakistan

According to figure 12, temperature increase will also increase water demand of various crops in the agro-ecological zones of the country. It is evident that crop water demand will be more than double when there is increase in temperature up to 3°C thus making agriculture more dependent on irrigated water in the country. Temperature has increased due to global warming and it is estimated from various climate models that crop would require more water in near future .It is a common fact if temperature increases at 1°C, 2°C, and 3°C respectively than the crop water demand will also be increased at 11percent, 19 percent and 29 percent in future (Gzal et al ., 2010). An increase in agriculture demand by 6 to 10 percent or more is projected for every 1°C rise in temperature. As a result, the net cereal production in South Asian countries is projected to decline by at least between 4 to 10 percent by the end of this century thus causing food security to already increasing population of this belt (IPCC, 2007).

4. Conclusion

According to this study the climate change is becoming very fatal to agriculture sector of Pakistan which is contributor of providing of largest labor force and generating job opportunities to vast people. The increasing temperature is reducing water availability to agriculture which depends upon irrigation of the Indus River Basin. This situation will be more critical as the water availability declines for agriculture in future. If this situation prevails in the country, crops will decline growth and productivity in case of tough competition among various sectors for water. This condition would lead towards to food security in Pakistan. Any temporal change in the glaciers will decrease water flow to the Indus River Basin System which is the major source for collecting and distributing water to agriculture. The crops like sugar cane and cotton would

consume more water in future as temperature increases and rainfall decreases due to climate change in the country. The growing population of the country is making it water scarce country as major source of water comes from Monsoons, Westerly winds and river inflows from melting of Himalayas glaciers. Per capita availability of water for agriculture and population is decreasing at faster rates under the changing climate. The irrigation system in Pakistan will have to be made modernized and the capacity of the reservoirs will have to be increased to collect surplus of water. In this regard various new techniques are required to be introduced in agriculture sector like laser land leveling and switching to practice drip and furrow irrigation. The Government of Pakistan will have to make comprehensive plans for watershed management and local rain harvesting schemes to store water for agriculture and growing population in future.

5. Recommendations.

In order to minimize the risk of water availability for agriculture sector the study recommends some measures have to be taken at earliest level. These are as follow;

- a. By promoting renewable energy sources like solar. Wind, Hydro and Biofueles in Pakistan is the need of the hour to mitigate Green House Gases in the atmosphere. These technologies are being utilized in many developing countries of the world such as China, India, Egypt, Malaysia etc.
- b. Introducing watershed management schemes to collect more water in the catchment areas of the rivers in Pakistan.
- c. To check deforestation in the Himalayas region to avert siltation of the reservoirs and to enhance storage capacity of the reservoirs to store surplus water from rainfall and melting of glaciers.
- d. By up gradation of canal system to carry water for crops during water shortage days in winter season. In this way lining of canals is recommended to avoid water logging and salinity in irrigated areas of Pakistan.
- e. To introduce rain harvesting schemes by building large reservoirs to collect flooded water in Monsoon season in the country.
- f. Introduction of Remote Sensing and GIS techniques to detect temporal changes in the glaciers and Gross River flows during the flood season in the country.
- g. By introduction of crop simulation computerized models in agriculture to observe changes in physiology of the crops and assessment of climate change on agriculture in Pakistan.
- h. Improve crop yield and productivity by providing more irrigated water to the agriculture land.
- i. To introduce laser techniques for land leveling and adopting furrow irrigation and drip irrigation to avoid water deterioration in the fields.
- j. To introduce high yield varieties which can resist to heat stress and pest attack under climatic conditions in all agro-ecological zones of the country.

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