



IMPACTS OF CLIMATE CHANGE ON PAKISTAN'S AGRICULTURE: A REVIEW

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ABSTRACT

Climate change is the phenomenon of rise in average surface temperatures on Earth, mostly due to anthropogenic activities such as burning of fossil fuels (oil and coal), which emits greenhouse gases (GHGs) into the atmosphere mainly carbon dioxide (CO₂) and its long term process usually takes 40 years. Developing countries like Pakistan agriculture sector accounts for a large share in its gross domestic product (GDP). Pakistan is basically an agro based country and climatic situations are very drastic in Pakistan as climate of Pakistan is humid. The agriculture sector consists of several sub sectors like crops, livestock, fishing and forestry. Rising temperatures, intense rains, droughts and production losses in agricultural sector are expected in Pakistan is due to climate change. On the basis of above background the objective of this study is to review the impacts of climate change on agriculture of Pakistan. Systematic review of literature method is used and descriptive analysis is done to narrate the results. Previous studies show that climate change has large impact in agriculture production and shows negative impact on productive and reproductive performance of livestock, increased incidence of livestock diseases and parasitic infestation, decreasing trend of feed and fodder resources and water availability. Climate change poses to be a serious threat to agriculture and aqua culture in Pakistan. Hilly and mountainous regions of Northern Khyber Pakhtun Khwa (KPK) province are more vulnerable to climate change in Pakistan. Little information is available on the impact of climate change on agriculture in the mountainous regions of KPK. Adaptation should be made to cope with seasonal variations as seasons emerge with each other and behavioral modifications should also be done.

1. INTRODUCTION

Climate change is the phenomenon of rise in average surface temperatures on Earth, mostly due to anthropogenic activities like burning of fossil fuels such as oil and coal, which emits greenhouse gases into the atmosphere mainly carbon dioxide (CO₂). Other human activities as agriculture and deforestation, also contribute to the increase of greenhouse gases that cause climate change (IPCC, 2007). Empirical studies of last few years using the partial equilibrium approach suggested that climate change brought yield losses in agriculture are becoming a serious issue (Bandara *et al.*, 2014). IPCC 2013 claimed increase in temperature of 2°C above preindustrial levels leads to fatal risk of severe climate change impacts and current rate of global temperature is increased from 0.2 to 0.3°C (EPA, 2006). The current level of CO₂ concentration is 430 ppm and is rising by more than 2 ppm per annum (Stern, 2006).

Food production and food prices are directly affected by climate change and ultimately become problem of food security. World projection about population shows that by the year 2080 world population become 9.2 billion, now a days its 5.9 billion, so food demand is predicted to increase by about 300% by the year 2080 because of higher population and this rise is likely to create an inverse proportional relationship between food supply and demand (Cline *et al.*, 2008). Decline in food production will increase pressure on food prices (IASC, 2010).

The evidence of different studies showed that agriculture sector contributes for a large share in their gross domestic product (GDP) in developing countries (Siddiqui *et al.*, 2012). Thus the development of the economy cannot be achieved without improving the agriculture sector. Pakistan is located in south Asia between 61°0 East to 75.5 East longitudes on 24°0 North to 37°0 North (Ahmad and Schmitz, 2011). Precipitation and humidity are two key factors in the yield of agriculture commodities. Economic Survey of Pakistan (2013-14) shows agriculture sector's contribution to the GDP is 21 percent. Pakistan is basically an agro based country and climatic situations are very drastic in Pakistan as climate of Pakistan is humid (NDMC, 2011). The agriculture sector of Pakistan consists of various sub sectors including crops, livestock, fishing and forestry. Wheat, cotton, rice, sugarcane and maize are major crops of Pakistan's agriculture. *Kharif* and *Rabi* are two agricultural seasons in Pakistan. Summer growing period from May to November are called Kharif season, and its major crops are rice, corn and cotton. The rabi or winter growing season starts from November/December ends up to April, with the major crops as wheat, barley and millet (USDA, 2010). Weather and climate are key factors which influencing agricultural productivity. Climate is a direct input into the agricultural production processes and the agricultural sector has been a natural focus for research (Sanghi *et al.*, 1998). In developing countries agriculture is most vulnerable to climate change and reduces the economic benefits of the country. The Agricultural Sector in Pakistan is most important sector of the economy which is responsible for almost 67% of the livelihoods of the population, directly or indirectly linked to this sector. (ESP, 2007) said Pakistan is large population country of which approximately 32% living below the poverty line has serious challenges to overcome. As agriculture is the main stay of livelihood in Pakistan and more than 47% people directly or in directly engaged in agriculture sector so climate change has drastic effect on agriculture and directly effects the income of rural people. Pakistan is more vulnerable to climate change as its environment is most suitable for disease attack and agriculture markets are more volatile in price fluctuations. So this review aims to study the impacts of climate change on Pakistan's agriculture.

Economy of any country depends on its major sectors growth and developing countries have agriculture as its economies major sector and fluctuations in its growth have heavy impact on economy of a country. Pakistan is agro based country no matters industry is also have important sector now where every kind of raw material is provided by agriculture sector so change in agriculture sector effects the whole economy. Climate is major factor as humidity and precipitation rate which effects the production and consumption patterns of agriculture, in other words a major variable which has great influence on agriculture. During last two and half decade climate of Pakistan is changing and it has drastic effects on all the sectors of agriculture in different ways. There is limited work done on climate change and its impact on sub sectors like livestock, fisheries and poultry.

Therefore, the main objective of the study is to review the impacts of climate change on Pakistan's agriculture sector. Followings are sub-objectives

- 1) To review the previous studies for the estimation of impacts of climate change on agriculture sector of Pakistan
- 2) To high light the production trends of different major crops of agriculture

2. Methodological Framework

Methodology guides the researcher to complete the process of collection, analysis and interpretation of data. There are 14 types or reviews and their respective methodologies (Grant and Andrew, 2009). The aim of this research work is to review the past studies for the estimation of impact of climate change on agriculture in Pakistan. Study is based on systematic review of literature and descriptive analysis is used which highlight the importance of agriculture in Pakistan and how climate effects the agriculture sector. 20

papers are selected on this topic which shows that how much impact of climate change on agriculture sector. Systematic reviews seek to estimate together all known knowledge on a topic area and it covers quantitative, qualitative and mixed method studies (Grant and Andrew, 2009). Climate change has important effect on agriculture that's why this study is selected because agriculture is important sector for the economy of Pakistan.

3. Impacts of climate change on Pakistan's Agriculture

According to CoP 21st meeting held in Paris, Pakistan is included in top 3rd highly exposed countries to climate change out of 10 (Rehman, 2015). Rising temperatures, intense rains, droughts and production losses in agricultural sector are expected to increase more in Pakistan due to climate change. Pakistan has been bearing the impact of climate change without having prior knowledge of it as no serious attention is paying to climate change and farmers are unaware of it. IPCC Fourth Assessment Report (2007) mentioned that climate change effects are more in hilly areas as rains would intensify in the northern region of Pakistan. The heavy and irregular rains caused current floods in Pakistan.

3.1. Impacts on crops productivity

Changing climate has threatened the productivity of agriculture sector making it vulnerable both economically and physically to climate unevenness and change. Productivity of crops is being affected heavily by a number of variables including rainfall pattern, temperature hike, changes in sowing and harvesting time, water availability and land suitability (Hanif *et al.*, 2010). On the whole, climate change may not have huge effects as slightly increase in temperature but region wise effects are more extensive. Especially vulnerability of the poor to food insecurity will increase as an indirect effect of decreasing food crops yields.

The countries climatic situation can be classified as continental and region wise with great diversity due to different topology and altitude (Khan *et al.*, 2010). Heavy rains and floods have damaged all of the crops completely as it decreased the yield per acre. Economics survey (2014-15) indicated that all the major crops have sharp decline in production.

This fig shows an incidence of drought situation in Pakistan. All provinces showed drought situation in rabi season specially in the period of 1998 to 2002.

3.2. Impacts on fishery sector

Aquatic and marine life is damaged to great extent as well. Most of the population in Pakistan is dependent on agricultural production specially the people growing crops and fishers the rest of the rural population as well, they have suffered a lot due to these climate extremities. Many new diseases of fish and aqua culture have been seen in last 10 years. Karachi which has the coastal area of 1246 Km and experienced severe damage to aquatic life due to high temperatures, climate change pose to be a serious threat to agriculture and fishers in Pakistan (Khan, 2015). Arabian Sea is severely damaged to climate change as severe storms, shoreline erosion, tropical cyclones and floods all impacts coastal areas of Pakistan and huge losses occur to marine life (NCCP, 2012).

3.3. Impacts on livestock production

Livestock shows negative production due to climate change and it also effect the reproduction of farm animals, increased incidence of livestock diseases and parasitic infestation, decreasing trend of feed and fodder resources and water availability (Singh *et al.*, 2012). Climate change has both direct and indirect effects on livestock. (Houghton *et al.*, 2001) concluded the direct effects of climate change are from air temperature, humidity, wind speed and other climate factors influence animal performance like growth and reproduction, milk and wool production. Animal health is affected by climate change in several ways like heat related diseases and stress, extreme weather happenings, variation of animal production systems to new environments, and emergence or recurrence of infectious diseases especially vector borne diseases which are seriously dependent on environmental and climatic conditions.

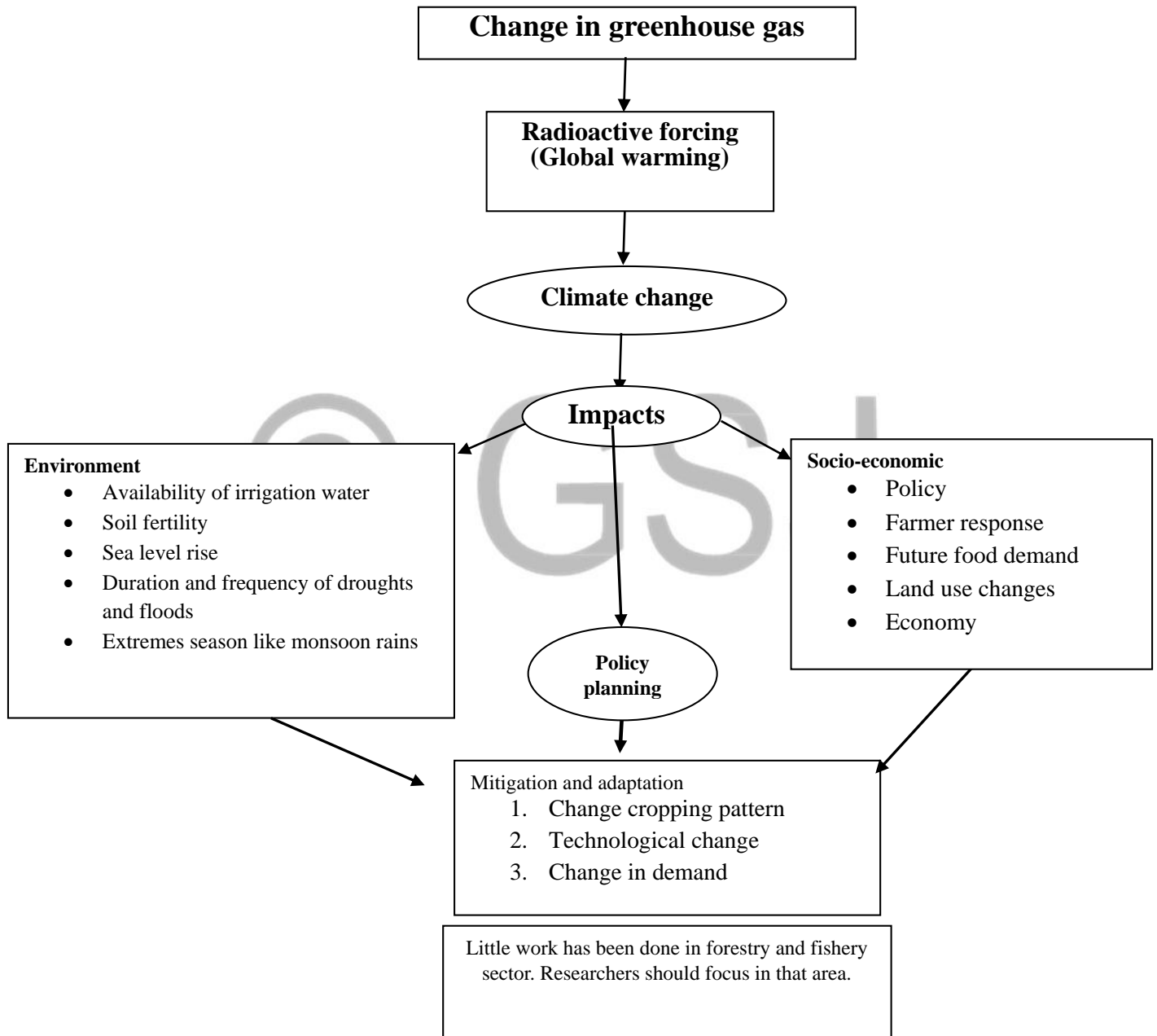


Fig 1: Driving forces of assessment of the vulnerability of Pakistan agriculture production to climate change. (Source: Mall *et al.*, 2007)

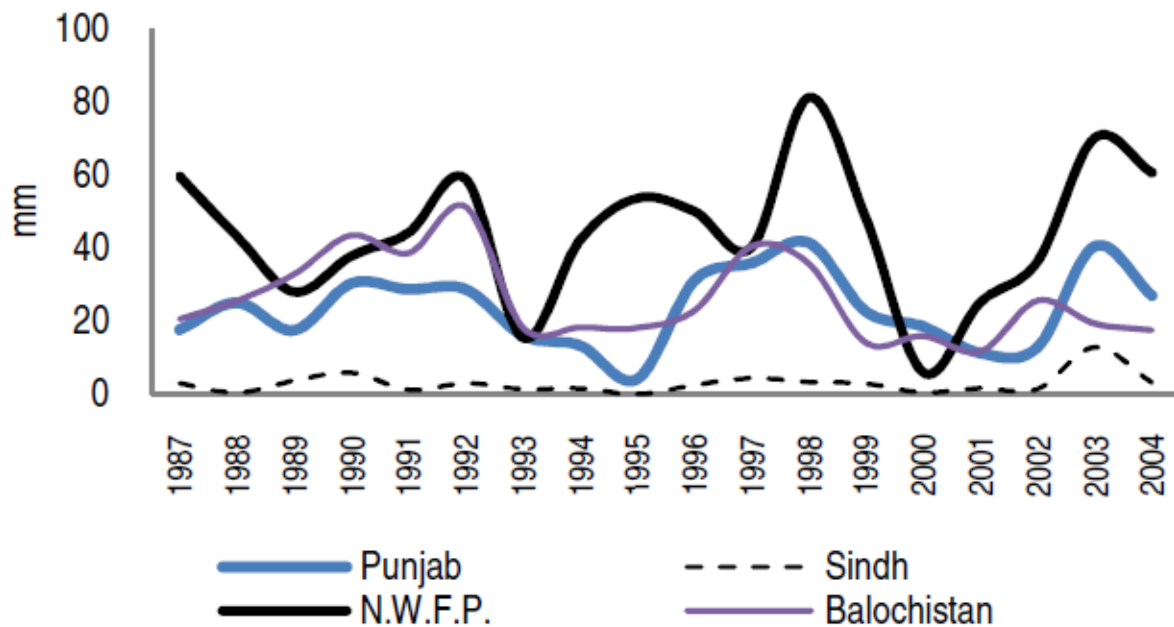


Fig. 2: Average rabi rainfall (1987-2004, Nov- Apr) (source: Ahmad and Schmitz, 2011)

3.4. Impacts on forestry sector

Each province has its own particular types of forests. Punjab is famous for pine forests located mainly in the Northern Murree mountain ranges. Balochistan has two types of forests, first is the Zarghoon Juniper Forest situated about 30 km away from Quetta and one of the most fragile ecosystems in Pakistan. The forest has an extremely slow growth rate and faces very harsh climatic and geophysical conditions. The second is the Suleiman Range the largest pure stand of Chilghoza pines in the world and a critical habitat for the endemic Suleiman markhor. Sindh and Balochistan are also home to mangrove forests, which cover about 257,500 hectares in the country. Those found in the Indus Delta in Sindh are the world’s sixth largest contiguous mangrove forests. Khyber Pakhtunkhwa is home to 1.3 million hectares or about 30 per cent of Pakistan’s forests. Seventeen percent of the province is covered by forests, with the largest concentration of forest area found in the Malakand and Hazara divisions (Ali, 2009). (NCCP, 2012) shows climate change impacts on forestry sector as change in species composition, forest area reduced, decreased productivity and unfavorable condition for biodiversity. Deforestation leads to a higher incidence of disasters such as floods and landslides and causes soil erosion, increasing the risks that vulnerable forest communities are exposed to. Cutting down forests on sloping hills disrupts the absorption of water and weakens soil cohesion, leading to disasters such as floods in downstream areas and landslides. Climate experts agree that erratic precipitation, soil erosion of the watershed and reduced flow in the Indus River, is causing the expansion of the country's heat zone and shrinkage of the Indus Delta. This change in climate could eventually have an impact on human health and agricultural productivity in the region (Mallick and Masood, 2011).

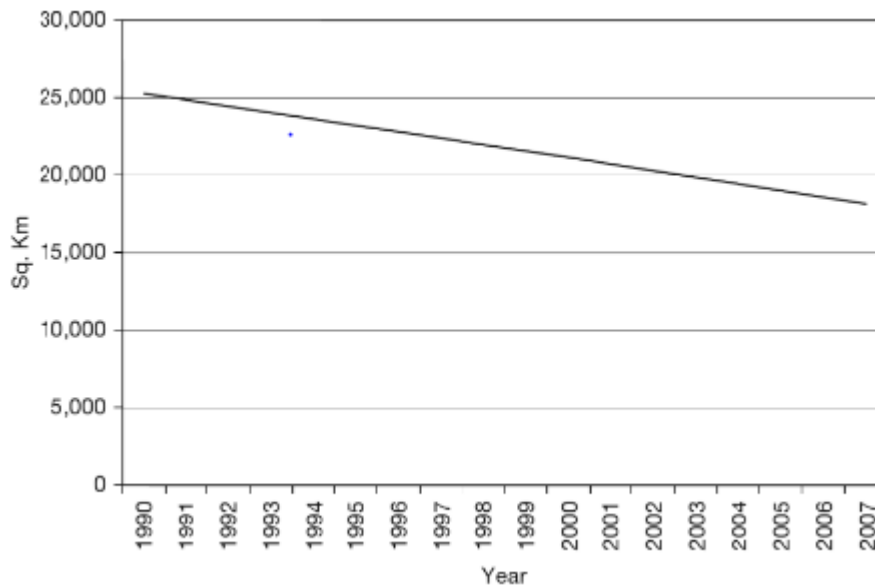


Fig. 3. Forest area in Pakistan (source: Jha, 2011)
This figure shows gradual decrease in area under forest cultivation.

Table 1: Impact of climate change on whole Pakistan and its effect on agriculture (Current and future scenarios)

Country	Temperature	Rainfall	Reference
All Pakistan	Average temperature change is predicted to be in the range of 2.33–4.78°C with a doubling in CO2 concentration	Increase in the frequency of heavy rainfall events	Lonergan 1998
All Pakistan	Increase in annual mean temperature by 1.3–1.7°C	6–13% increase in kharif season rainfall	Rupa <i>et al.</i> , 2001
All Pakistan	Increase in winter (Rabi crop growing season) temperature by 1–4°C with increased CO2 concentration	Precipitation increase of Approximately 20% Increase in heavy rainfall during the summer monsoon period (Kharif crop growing season)	Mall <i>et al.</i> , 2007
All Pakistan	Prediction or forecasting Increase in mean temperature °C Year 2020	Prediction or forecasting Change in rainfall (%) Year 2020	Lal <i>et al.</i> , 2007

	<p>Kharif season: 0.87 to 1.12 Rabi season: 1.08 to 1.54 Year 2050 Kharif season: 1.81 to 2.37 Rabi season: 2.54 to 3.18 Year 2080 Kharif season: 2.91 to 4.62 Rabi season: 4.14 to 6.31</p>	<p>Kharif season: 1.8 to 5.1 Rabi season: -2.0 to 4.7 Year 2050 Kharif season: 7.2 to 10.5 Rabi season: -9.2 to 3.8 Year 2080 Kharif season: 10.1 to 15.2 Rabi season: -24.8 to -4.5</p>	
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Table 2: Impact of climate change on India

Regions	Temperature	Rainfall	Reference
All India	Increase in 0.4°C/100 years in the mean annual temperature.		Hingane <i>et al.</i> , 1985
All India	Increase in max. Temp. (0.6°C/100 yrs) Min temp trend less. General increase in the diurnal range of temp		Rupa <i>et al.</i> , 2001
Western Himalayas	Winter season, Srinagar, Mussoorie and Mukteswar shows increasing trend (0.5°C/100 year) Monsoon season, Srinagar, which is beyond the monsoon regime, shows significant increasing trend, No increasing or decreasing trend for last 100 years whereas Mussoorie and Dehradun which are at the foothills of Himalaya show decreasing trend	No increasing or decreasing trend for last 100 years	Pant <i>et al.</i> , 1999
Western and Eastern Himalayas		Western Himalayas get more snowfall than the eastern Himalayas during winter. More rainfall in the eastern Himalayas than in the western Himalayas during the monsoon season	Kripalani <i>et al.</i> , 2003
Rajasthan desert		Slight increase in monsoon rainfall; in spite of large inter annual variations	Pant and Hingne 1998

Table 3: Major crops in Pakistan and their production trends

Crops	Regions	Production/mean yield	Trend
Rice	In Punjab, the division of Lahore and Gujranwala	7,005 thousand tonnes in 2014-15 as compared to 6,798 thousand	Increasing

	In Sindh division Sukkar and Larkana District	tonnes in 2013-14 showing an increase of 3.0 percent	
Wheat	Mardan, Peshawar and Bannu Potwar Plateau Southern Punjab Sukkar, Hyderabad, Larkana	25,478 thousand tonnes in 2014-15 as compared to 25,979 thousand tonnes in 2013-14 showing a decrease of 1.9 percent	Decreasing
Maize	Faisalabad, Sargodha, Lahore and Gujranwala In Sindh Hyderabad and Hyderabad	4,695 thousand tonnes in 2014-15, as compared to 4,944 thousand tonnes in 2013-14 showing a decrease of 5.0 percent	Decreasing
Sugarcane	cultivated in canal irrigated areas of Punjab, N.W.F.P and Sindh provinces	62,652 thousand tonnes in 2014-15, as compared to 67,460 thousand tonnes last year, and registered a decrease of 7.1 percent.	Decreasing
Cotton	In Punjab, Bahawalpur, Dera Ghazi Khan, Faisalabad, Sargodha, Lahore and Gujranwala In Sindh Hyderabad and Hyderabad	13,983 thousand bales as compared to 12,769 thousand bales in 2013-14 and registered an increase of 9.5 percent	Increasing

Source: Economic Survey 2014-15

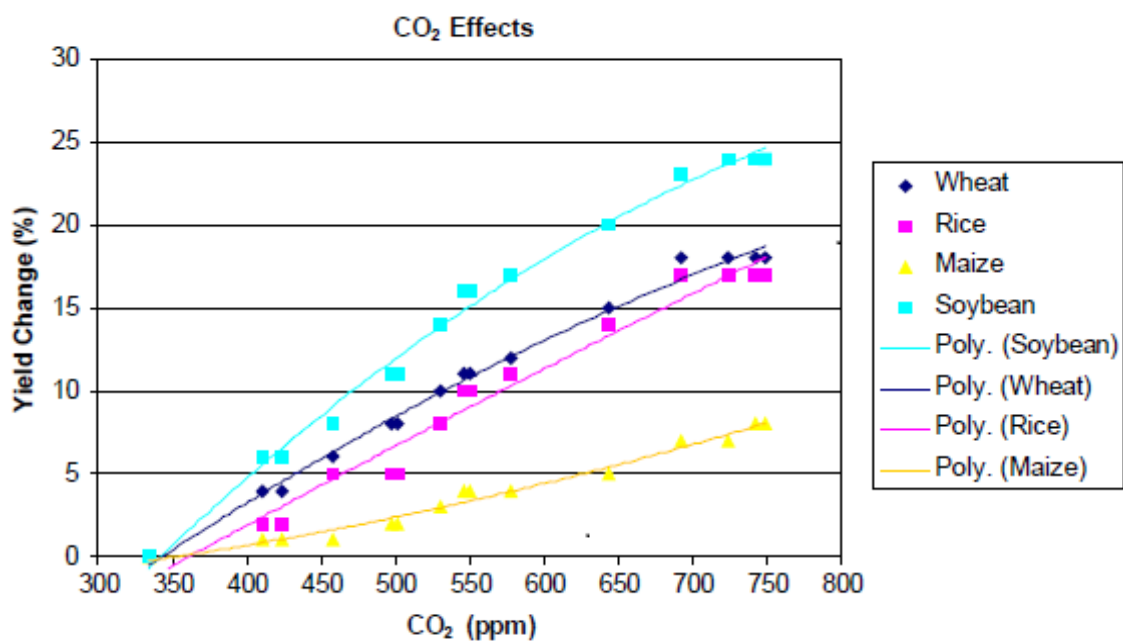


Fig. 4. A global consequences on potential increases in yield exhibited by wheat, rice, maize and soybean under elevated levels of CO₂ (source: GISS analysis, multiple citations)

4. Conclusions

This study is based on systematic review of climate change impact on agriculture sector of Pakistan. Climate change has initial indications like long term decreases in available freshwater from glaciers and contamination of water supplies, reduction in crop yields, increased incidence of heat related illness and death, water born (cholera and diarrhea) and vector borne diseases (malaria, tick borne) malnutrition and poor hygiene from water scarcity, floods and droughts (Cruz *et al.*, 2007). So the adaptation techniques should be taken to mitigate this climate change. One key issue requiring immediate attention in agriculture is the hydrological cycle of Pakistan, especially the availability of water for irrigation will be a key aspect for determining the future impacts of climate change on yields in Pakistan (Ahmad and Schmitz, 2011). It is particularly important that a developing country like Pakistan will be most probably more suitable for adaptation to climate change than mitigation. Awareness for climate change and its adverse effects for the livelihoods of the population has to be raised and existing adaptive measures have to be used to maximum effect, such as in the case of agricultural credits. The government of Pakistan has to establish schemes that can compensate farmers for their losses and yield effects as a consequence of implementing certain adaptive measures. Adaptation can include new cropping patterns, introduction of heat and drought resistant crop varieties, water harvesting, especially in years where weather developments are indicating water shortages from precipitation. Nevertheless, in order to implement adaptation strategies successfully, the respective agencies, such as agricultural extension services will have to be strengthened, their outreach will have to be significantly increased. Similarly, adaptation techniques should be done to eliminate the risk of climate change in livestock and aqua culture production. Forests are declining day by day due to anthropogenic activities so more plantations should be done to overcome this problem as "Go green live green". Plants are important as it reduces the soil erosion activities during flooding and best in waterlogged soil as a remedy. To reduce the CO₂ emissions in agriculture biogas plants should be used instead of diesel-based tube wells as one gallon of diesel emits 22.38 pound of CO₂ (U.S Energy information administration) but by using biogas these emissions should be minimized and climate change will be lesson. A concept of waste bank should be introduced to eliminate the household garbage. 3R's (Reduce, Reuse, Recycle) are also helpful in agriculture for the reduction of greenhouse gas emissions. It not only eliminates the pre harvest losses but also lesson the postharvest losses.

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