IMPACT ASSESSMENT OF CLIMATIC RISKS ON CROPS

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1. INTRODUCTION

Climate change describes a change in the average conditions such as temperature, wind and rainfall in a region over a long period of time (Sofoluwe, Tijani and Baruwa, 2011). The Earth is surrounded by the glass wall which is also called greenhouse ceiling emitting in the result of human induced activities in the form of gases such as carbon dioxide and carbon monoxide (Ifeanyi-obi, Etuk and Jike-wai, 2012). The ozone layer around Earth's atmosphere is a thin part that absorbs almost all of the sun's harmful ultraviolet radiation. As a result of increased greenhouse gases emissions in the atmosphere this ozone layer is rapidly growing thicker, resulting in a rapid climate change. Over the past 100 years, the earth's average surface temperature has risen by around 0.74^0C (Ariyani, Putuhena, and Wira, 2020). Some scientists argue that global temperature will continue to rise (which depends on future greenhouse gases emissions), but shifts will be so drastic if the temperature increase is high it will be difficult to cope with it. Further cases and frequent extreme weather events including floods and hurricanes will likely to occur and sea levels will continue to increase (Linnenluecke, Griffiths and winn, 2012). The inter-governmental panel on climate change (IPCC) stated that human activities are the main cause of the changes seen in the climate. Human-induced changes in the climate are due to three major ways; burning of fossil fuels, deforestation, and growing world population (Reynolds *et al.,* 2010).

The Intergovernmental Panel on Climate Change (IPCC), in its third assessment report published in 2001, ascertained that the developing world would be hardest hit, with agricultural productivity declines in most tropical and subtropical regions due to reduced water availability and new or changed incidence of insect pests (IPCC, 2001).In Africa and Latin America, many rain-fed crops are near their maximum temperature tolerance, so their yields are likely to fall sharply for even small climate changes. Decreases in agricultural productivity of up to 30% in the 21st century have been projected (Edame *et al.,* 2011). Marine life and the fishing industry will also be severely affected in some places. In Asia, agricultural crop yield is expected to decline by 5-30% by 2050s due to rising temperature in the Himalayas and this decline in agricultural yield could lead to food insecurity that can become a serious future problem for human beings (IPCC, 2007).

2. OVERVIEW OF CLIMATE CHANGE:

Before the end of the 20th century climate change had become a serious threat to worldwide human and animal life. In response to emerging regarding climate change, the Intergovernmental Panel for Climate Change (IPCC) was inaugurated in1988 to distinguish the factors that cause long term or short-term changes in the climate system and aimed to make possible the provision of most up-to-date, scientific, technical, socio-economic, comprehensive information about climate change (Parry *et al*., 2001). The extended periods of change that lasted

for decades or millions of years in weather conditions could include uneven patterns of rainfall, unpredictable patterns of temperature variation, rise in sea levels, greenhouse gasses emission, relative humidity, windstorms, and the nature of the season. IPCC pronounced climate change as the change that follows the natural phenomena and human activities (anthropogenic factors) over long periods of time in a climate system.

In Asia, climate change became an established fact significantly affecting societies and economic growth pillars of the nations. Most of the Asian countries are suffering from food insecurity and low economic growth because they have low capacity of adaptation to climate change. The average agricultural yields continue to decline in developing Asian countries due to the variability in temperature and precipitation patterns and several climates induced diseases recorded due to global warming. IPCC already indicated that at the end of the 21st century the global average temperature possibly will be increased by 1.4 C to 5.8 C (Figure 1), and this terrific increase in temperature has tremendous effects on atmosphere, biosphere, hydrosphere, lithosphere, and ecosystem. Pakistan is one of the top ten countries most affected from the negative effects of the climate change (SDPI, 2018).

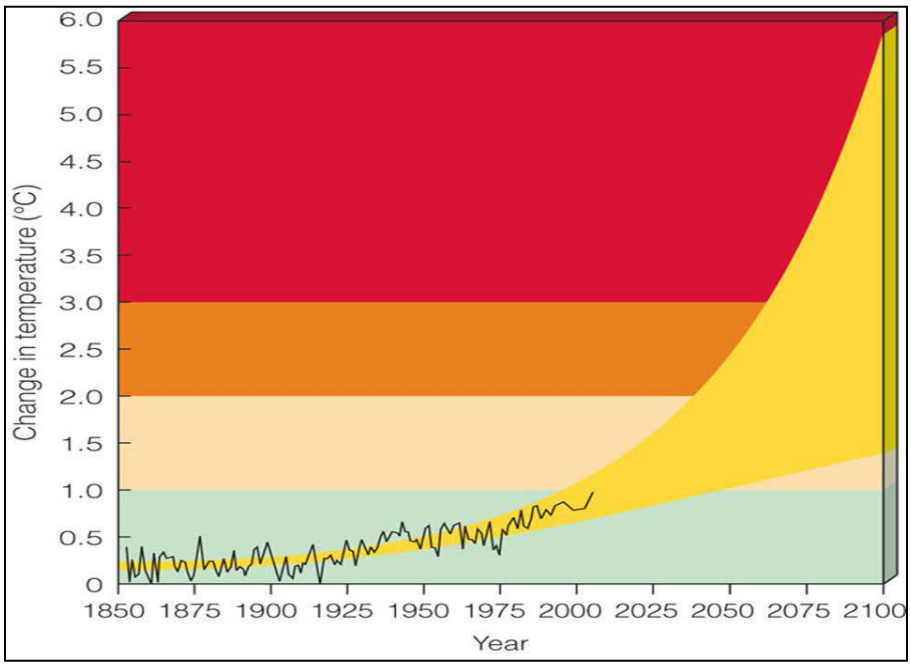


Figure 1: Global average temperature changes since 1850 to 2100 Year.

3. DRIVING FORCES OF CLIMATE CHANGE:

The greenhouse gases (GHGs) emission is surprisingly at the highest concentration over the last eighty years (Figure 3). These gases hold the potential to create extreme events in temperature and rainfall fluctuations, heat waves, floods, droughts, water scarcity, and glacier melting. The earth's climate system over millions of years has been changing from "icehouse" or

cold climate to warm climate or "warm house" with the change in the glacial and interglacial period to the general disappearance of glaciers in Northern hemisphere (Augustin *et al.*, 2004). Heavy rainfall is also measured in South and North America and Northern Europe and in North and Central Asia as well.

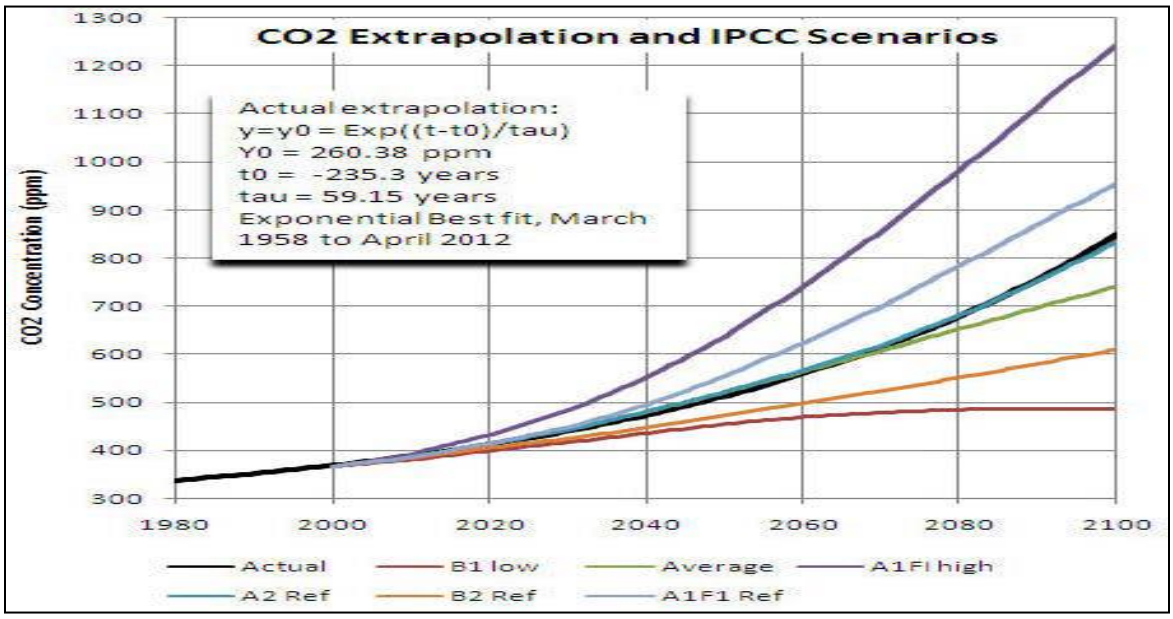


Figure 3: CO2 concentrations; IPCC scenarios vs. Actual extrapolations.

The earth climate system together with GHGs concentration in the atmosphere is undulating due to the extent of severe human activities like deforestation, land use, intensive agricultural practices and most important fossil fuels burning which was associated with the industrial revolution (Figure 4). The history of geology indicates that past changes in climate are due to philosophical modifications in the earth system and life expectancy. Human advancements on reforming global climate system combine with short-term and long-term variations in weather patterns (Crutzen, 2006). IPCC reports also that the human-tempted aspects remained mostly answerable for the amazing upturns of surface air temperature around the globe along with severer influences on the agro-ecological system. The development of the industrial system or the industrial revolution since 1750 was perceived to be the main driver of change to the global climate system by increasing the GHGs concentration in the atmosphere. In addition to that widespread use of fossil fuel had begun since 1750 with the advent of industrial revolution. Moreover, many other human activities such as deforestation, agriculture, livestock and urbanization affecting the atmospheric part of the carbon cycle (Shepherd, 2011).

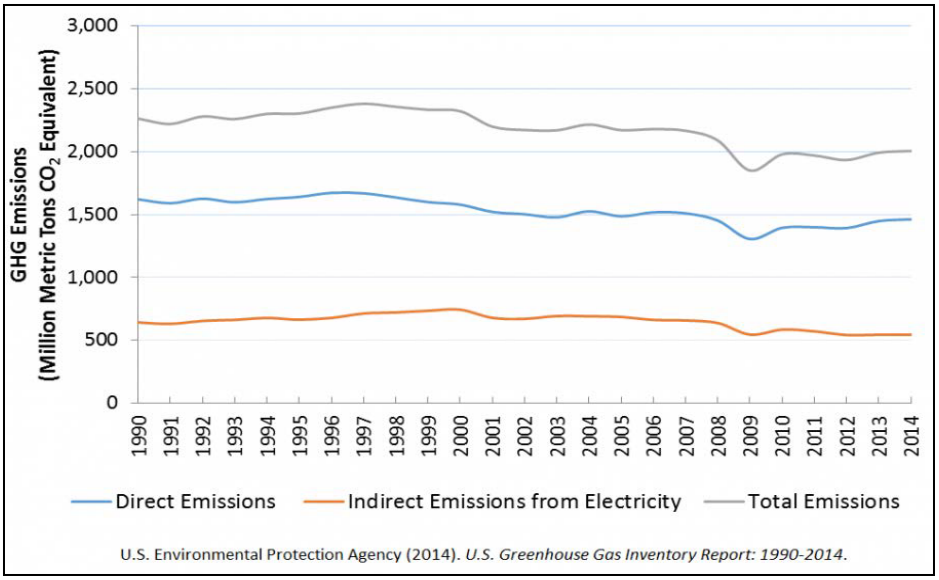


Figure 4: Annual greenhouse gases emission concentration (ppm) by industrial sectors.

The mean temperature of the atmosphere is estimated to increase 2°C to 4°C until the last half of the 21st century due to an increase in CO_2 concentration beyond the pre-industrial era (Figure 5). This global statistical figure may differ from region to region as high latitudinal regions are subjected to the largest increases in mean temperature while tropical and subtropical areas will experience smaller increases in mean temperature (Christensen *et al.*, 2007). The intensity of temperature is regulated by an active hydrological cycle (Meehl *et al.*, 2007). It means upturns and downturns in temperature ultimately cause change in overall rainfall amounts. As temperature fluctuations vary from region to region, seasonal precipitation rates also differ, and the same effects and changes or fluctuations could be measured locally. The temperature and rainfall fluctuations may not be well thought out as parameters of changing climate, but floods and drought conditions, storms, cyclones, land loss, biodiversity loss, water and food scarcity are also known as parameters of changes in the earth's climate system (Parry *et al.*, 2007).

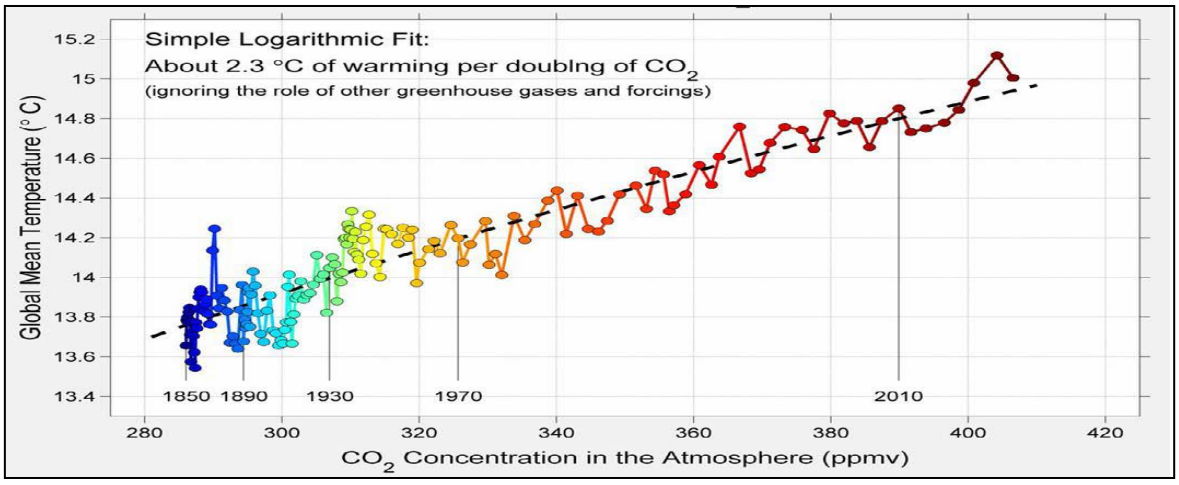


Figure 5: Effect of CO2 concentration in atmosphere on global average atmospheric temperature.

Urbanization continues to expand to provide lodging for a massive density of population, thereby causing/ forcing the transformation of cultivatable agricultural lands into the housing and or city development (McCarthy *et al.*, 2010). These urban areas also contribute to the maximum heat expansion into the atmosphere due to burning of fossil fuels and excessive usage of motor engines/machinery causing global warming. The continuous increase in human population creates a difficulty in meeting the goals of food security, affecting the GHGs concentration in atmosphere from undue scorching of fuel (Khan, 2012). The urban areas, urbanization and energy sectors are also responsible for almost 75% of greenhouse gases emission (Figure 6) which has been acknowledged as the anthropogenic agents of climate change (Komeily and Srinvasan, 2015). Humans have been influencing the climate system since they appeared on the earth. The industrial revolution propelled the concentration of carbon emissions, methane emissions, and large amounts of nitrous oxides. The excessive extent of these greenhouse gases struck the solar radiation and eventually warmed the earth (Figure 6).

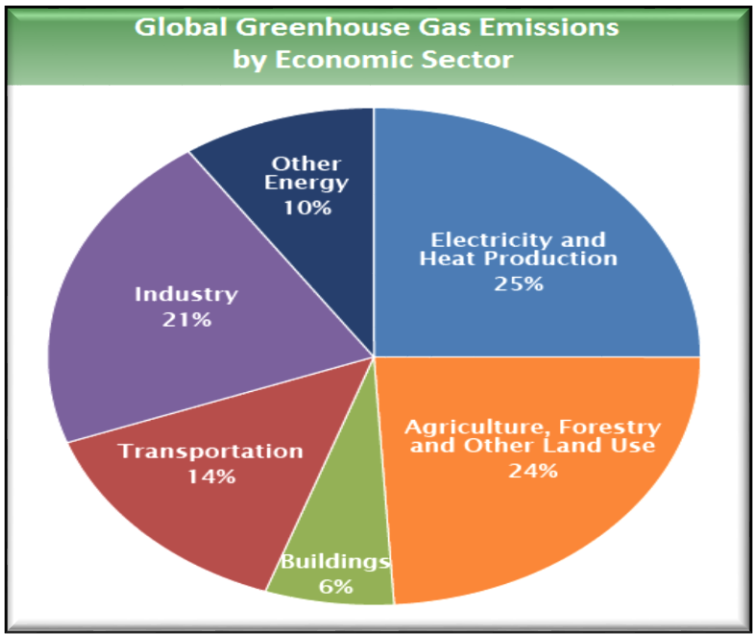


Figure 6: Global greenhouse gases emissions by different sectors.

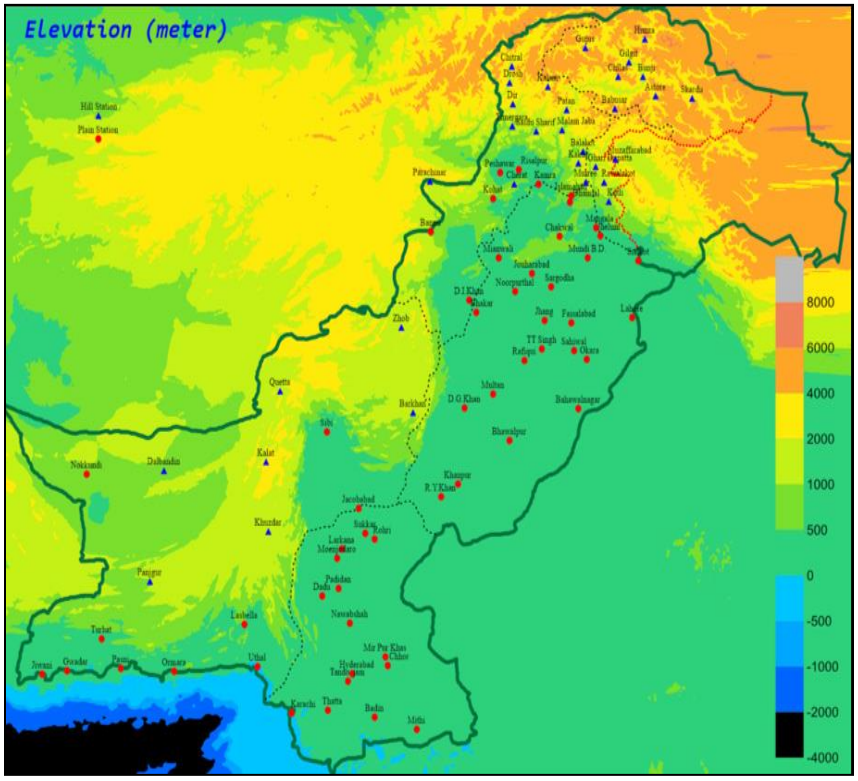
4. CLIMATE CHANGE PROFILE OF PAKISTAN:

Pakistan is situated in one of the most vulnerable spots in the world in relation to susceptibility to climate change. The country though a very minor contributor to the overall Green House Gas emissions, is susceptible to severe climate change effects. The expected increases in temperatures due to global warming and the geographical location already places the country in heat surplus zone of earth.

Scientists believe that climate change might take away or alter monsoon from the Indo - Pak Sub Continent. Coupled with dry erratic and intensive rains, late monsoons, dry winters, and prolonged dry spells, Pakistan will witness severe weather conditions including disasters such as floods and droughts. According to the independent international assessments, e.g. German Watch, a Germany based NGO; Pakistan is ranked among the top countries of the world most vulnerable to climate change. The back to back floods of 2010, 2011, 2012, 2013 and 2014, worst drought during 1999-2003, two cyclones in one month in Karachi/Gawder Coast in 2008 and increased incidences of landslides, GLOFs (Glacier Lake Outburst Floods) in the northern areas of Pakistan bear testimony to the ugly face of climate change.

Pakistan is exposed to a variety of natural disasters such as floods, cyclones, earthquakes, landslides and droughts. Rapid population growth, uncontrolled development and un-managed expansion of infrastructure are the most common factors that result in more people being vulnerable to natural hazards than ever before (Cardona *et al.* 2003). The burden of natural disasters in Pakistan can be underlined by the fact that they have been responsible for the deaths of 6037 people in the period from 1993 to 2002, with a further 8.9 million people also affected (World Disasters Report, 2003). More than 80000 people died and 3.5 million lost their homes in a single event: the earthquake of 8 October 2005. A consistent major problem for Pakistan's authorities is that natural hazards occur more or less regularly at all scales. Furthermore, disaster management in Pakistan, particularly with regard to natural hazards, focuses mainly on rescue and relief processes. There is a dearth of information and little understanding of the processes involved in hazard identification, risk assessment and management, and the relationship between people's livelihoods and disaster preparedness (WCDR, 2005). Disaster management policy in Pakistan does not make adequate use of recent developments in scientific methodologies, methods and tools for cost-effective and sustainable interventions.

There is great diversity in temperature and precipitation across Pakistan (World Commission on Dams, 2000). The climate varies from arid to semiarid. Rainfall, which has great economic value for the country, shows large temporal as well as spatial variability. The annual rainfall pattern exhibits bimodal distribution, with almost half occurring during the monsoon season (July to September). The major amount of monsoon season rainfall occurs in the northern part of the country, in Azad Jammu and Kashmir (AJK), adjoining sub-mountainous areas of Punjab, and in eastern Khyber Pakhtunkhwa (KP). Some effect of the monsoon is also felt in the southeastern parts of the country, but western parts of Baluchistan province remain unaffected and dry. A secondary rainfall peak occurs in winter (January to March) through the western disturbances system (Figure 7). The amount of rainfall received during this winter peak is about half of the monsoon rainfall, and it comprises the major proportion of rainfall in the northern and western parts of the southern half of the country. In the intervening periods, i.e., from April to May and October to December, there is almost no rain in the south of the country and relatively less elsewhere.



Source: Developed at the Climate Data Processing Centre (CDPC), Pakistan Meteorological Department (PMD), Karachi, using data from the Global Land One-kilometer Base Elevation Project, National Geophysical Data Center (NGDC), National Oceanic and Atmospheric Administration (NOAA) Satellite and Information Service.

Figure 7 Elevation map of Pakistan showing weather observing stations

5. IMPACTS OF CLIMATE CHANGE ON AGRICULTURE: REVIEW OF LITERATURE

In recent times agriculture has faced many problems, particularly climate change. Climate change has emerged as a global problem, especially for developing regions of the world including Pakistan, which is highly vulnerable to the consequences of climate change and issues like limited resources and lack of technological advancements (Ali *et al.*, 2017). According to the Intergovernmental Panel for Climate Change (IPCC, 2007) report, developing countries are more vulnerable to severe consequences of climate change as compared to developed countries.

Agricultural products are affected by the fluctuation in climate, such as precipitation rates, temperature variation, humidity rates, floods, droughts, cyclones and wind speed. Pakistan has a warm climate, and that is why it is susceptible to the consequences of climate change. The quality of agricultural crops and production yields are influenced by the climate variations including temperature and precipitation rate changes, water availability, type and method of land use, changes in dates of planting, maturity and harvesting (Shakoor *et al.*, 2011). Climate change

also impacts human and animal health, water depletion and pollution, biodiversity loss, and forests, and these impacts are noticeable. The climate fluctuations require abundant knowledge, experience and skills to predict because it is difficult to predict the climate fluctuations and their impacts. The climate variable increases the risk for farmers' and for the country's economic status.

Agriculture activities and production are highly sensitive and are threatened by the variables of climate change (Ghazala and Mahmood, 2009). Kaiser and Drennen 1993 explained that the consequences of climate change are not limited to the production of crops; it also severely degrades the supply and demand balance, profit margin, and values of agricultural production. Pakistan is counted in the list of those 28 countries those are more vulnerable to the effects of climate change. Increases in temperature could hinder the maturity of crops that adversely affects crop yield. It also has a negative impact on pollination process, fruit ripening, nutrient deficiency, increases in evapo- transpiration, moisture in soil and others. The insignificant increase in sensational temperature dampens down the productivity of the crops (Schlenker and Roberts, 2006). The variation in temperature patterns affected the agricultural crop production and plant phonology over the previous two decades and ultimately caused the food insecurity or hunger conditions, particularly in least developed areas (Tao *et al.,* 2006). The lack of irrigation water causes the death of plants, leading to the famine and food insecurity conditions, and floods obviously cause the destruction of cultivable lands, agricultural standing crops and other economic losses.

The irreversible loss to water bodies, production of agriculture and livestock sectors, and cultivatable lands are imposed by the extensive fluctuations in the climate system (Fischer *et al*., 2005). The water accessibility or availability affects the growth and growing seasons and is critical in determining the positive impacts of climate change on agriculture due to precipitation and dimensions of growing periods. Agronomic and livestock production are in danger because of variations in the rate and patterns of rainfall (Smith *et al.,* 2000). Maize production in Bulgaria is reduced from 5% to 10% because of a decrease in growing periods of maize crop due to the consequences of the changing climate (Alexander and Hoogenboom, 2000).

The productivity of wheat, rice, maize and other cereal and cash crops is being affected by several climatic variations including an unexpected increase in temperature, stress of water and/or water scarcity, and other scenarios of climate change. Wheat production in arid, semi-arid, and sub-humid regions exhibit downward slope due to extended rate and patterns of temperature (Sultana *et al.,* 2009). Overflow and water logging complications have the potential to influence maize crop productivity with the estimated value of above 18% of the total production in South and Southeast Asian belts and an annual estimate of loss of nearly 30% to the total production (Zaidi *et al.,* 2010).

The agricultural production of tropical and subtropical regions in developing countries are subject to the higher vulnerability towards the impacts of climate change as compared the temperate region's crop production (Mendelsohn, 2008). Climate change threats are more surprising in developing nations and especially in South Asia which results in the loss of almost 30% of the production of cash and cereal crops. During the 21st Century production loss will increase about 50% (UNFCC, 2007) if necessary actions and policies are not implemented. The food insecurity measures will increase because of the expansion of human population and the decreased crop production due to adverse effects of changing climate. South Africa is currently confronting severe droughts because of less rainfall and high temperature which significantly reduce agricultural and livestock production, and ultimately lack of water causes food insecurity, water scarcity and aridity (Masipa, 2017).

5.1 WHEAT CROP IN CHANGING CLIMATE

Wheat *(Triticum aestivum L.)* is a significant cereal crop used as a staple food worldwide (Khan et al., 2000).There is a continuous need to obtain higher yield to feed the growing population of the world as it is a staple food for more than 35% of the world population (Khakwani *et al*., 2012). In Pakistan wheat is staple food crop which is sown in winter season, preferably in November. During the 2018-19 wheat was cultivated in 9052 thousand hectare area with production of 25.750 million tons and per hectare wheat yield was 2845 kg/hectare (Pak Eco. Survey, 2018-19). Per head consumption of wheat in Pakistan is about 124 kg/Month which makes the importance of this food crop. Therefore this crop is very important in terms of economy of the country.

5.2 Impact of climatic factors on Wheat crop:

5.2.1 Temperature increase and Wheat crop:

Increase in temperature has significant as well as negative impact on the wheat crop especially in districts of Punjab Province. (Ali *et al.*, 2017, Ahmad *et al.*, 2015). Due to temperature stress, the wheat crop season has prolonged and plant flowering time disturbed thus influenced negatively on crop production and yield (Arshad *et al*., 2017). In Punjab districts, sowing and emergence dates were delayed whereas the maturity dates were advanced with temperature increase(Ahmad *et al*., 2019).

5.2.2. Change in Rainfall Pattern and Wheat crop:

Wheat crop require sufficient amount of rainfall during its growth period and research indicates that adequate amount of rainfall during wheat growing season increase yield by 275.77 kg/h (Ashfaq *et al.*, 2011). Fluctuations in the rainfall schedule at the time of wheat harvesting results in dispersal of immature seeds from the pedicel. From the past decade, the rainfall pattern irregularity causes farmers to sow the wheat seeds late in the season i.e. in mid-December and it

can possibly be delayed further if soil moisture level is not adequate till mid of November (Gul *et al.*, 2012). Statistics shows that Production of wheat crop has reduced from 25.979 million tonnes to 25.478 million tonnes during the timeframe of 2013-14 to 2014-15 because of erratic rainfall (Ali *et al*., 2017).

5.2.3. Floods and its impact on Wheat Crop:

Pakistan faced disastrous flood events in the years of 2010 and 2011 as a result of heavy monsoon rainfall and it affects all four provinces especially KPK province. It affected three million people in the country and took approximately 450 lives and destroyed crop on thousands of hectares of land (Blunden *et al*., 2011). Wheat crop show a slight improvement regarding production of 3.7% in 2010-11 (Economic Survey of Pakistan 2010-11). The reason behind this is soil brought by floods is rich in alluvium and many nutrients that increase wheat production. Also, after the flood the government emphasized much on the staple crop production and distributed seeds and chemical fertilizers free of cost to the farmers. Farmers who had some land area left feasible for farming put all their efforts in growing wheat crop thus results in higher 2010-11 crop production (Lamond, 2008, Trærup, 2010, Bukhari and Rizvi, 2017).

5.2.4 Drought effect on Wheat Crop:

Water stress or drought have a significant impact on the wheat crop as it reduces the flag leaf area to 14% and peduncle length to 36%. At post anthesis, the reduction in yield reaches 98% thus results in complete loss of crop. Wheat crop can tolerate water stress up to pre anthesis stage but after anthesis, drought causes severe damage (Kazmi *et al.*, 2003). Physiological traits of wheat are severely affected under water stress conditions which eventually reduce yield. However, maximum tolerance to drought is observed in Tatara, Ghaznavi-98, ZAS-08 and ZAS-42 and is recommended for cultivation in arid areas of country (Ali *et al.*, 2013).

5.2.5. Accelerated Crop Pest and Diseases attack on Wheat Crop:

Pests along with pathogens and weeds are responsible for yield reduction in major crops of about 25-40% (Myers *et al*., 2017,Flood, 2010). Due to phenomena of climate change, the pest growth, virulence, spread and reproduction is favorably increased (Bajwa *et al*., 2020) because of shorter winter spell. The warmer temperature is causing the aphid *(Diuraphis noxia)* to grow both in size as well as number thus damaging the wheat and other cereal crops severely from the past few years(Arshad *et al*., 2019). Studies reveal that changing the sowing time of wheat crop disturb the phonological harmony of aphids with its host and thus damage it at different stages (Chander *et al.*, 2016). An infestation of Pink stem borer (*Sesamia inferens*) and shoot fly (*Atherigona soccata*) has observed in the fields of wheat crop in the recent years which were not the regular pests of the crop (Ranjith *et al*., 2018).

6. Mitigation Strategies for wheat sowing:

Some mitigation strategies have been adapted to overcome the above mentioned issues i.e. sowing of some early maturing verities. In irrigated Punjab it has been recommended to sow Punjab 2011, Galaxy 2013, Fareed 2008 which are reported as early maturing verities and sowing of recommended seed varities i.e. Akber 2019, Ghazi 2019, Bhakkar Star, Fakhar-e-Bakkher, Anaj 2017, Zincol 2016, Gold 2016, Johar 2016 and Borlag 2016.

In arid areas of Punjab it has been recommended to sow Fateh Jhung 2016, Dharabi 2011.To avoid the late sowing in Rice–Cotton system, introduction of Zero Till Drill and Happy Seeders helped in timely sowing of wheat crop.

6.1. Mitigation Strategy for insect Pest Management

Aphids locally known as “taila” in Pakistan became the regular habit of wheat crop and it attacks at the stage of grain formation so it is recommended to mix the cropping pattern that is to sow at least 4 lines of Sarsoon canola crop in between the wheat crop. As canola attracts the lady bird beetles and one lady bird beetle eats 800 aphids in a day so it is recommended not to use any chemical spray for aphid’s control

6.1.1 Water Shortage and Wheat Crop:

Pakistan ranks 3rd amongst countries facing water shortages, according to an International Monetary Fund (IMF) report. An important reason behind this is the excessive use of water without any mechanism to save it. There is a dire need to divide water into parts the way developed countries have mechanized their system. One part should be of clean water, which should be utilized for drinking and cooking, while the other part should be used for polluted or dirty water, which should be used for household needs.

As Climate change is effecting agricultural sector in different ways i.e. less rainfalls and irregular rainfalls patterns along with wind showers limiting the Crops yields especially the main staple Wheat and Rice Crops.

6.2.2 Raised-Bed Technology as mitigation strategy water scarcity:

Pakistan is facing water scarcity problem. Underground water table is going down & down on yearly basis. Keeping in view this major problem agricultural scientists in the country has come up with an innovative technique of Raised-

Bed Plantation. As About 40% of irrigation water is wasted in the field during its application due to conventional methods of irrigation such as flat basins or inappropriate size of the furrows resulting into loss of previous water, nutrients, energy resulting into overall low water productivity. This precious irrigation water can be saved and crop yield can be increased by growing crops on the raised beds using a bed planter. The Gap between the two beds also helps the crop to strengthen Crop stem and during the heavy wind showers the Gap allows the wind to pass on and protects the crop form wind lodging and grain losses.

6.3. Climate Smart Agricultural Machinery in Wheat Farming System:

6.3.1 Zero till drill:

In this management system, wheat is planted immediately following the rice harvest without tilling the land. Only shallow channels sufficiently deep for seed germination are utilized, minimizing soil disturbance and maximizing soil carbon storage. Minimum tillage practices have been reported to reduce GHG emissions through decreased use of fossil fuels in field preparation and by increasing carbon sequestration in soil. In Punjab and Sindh provinces, no-till rice-wheat systems are increasingly being adopted.

The zero-tillage technology is widely maintained as an integrated approach that can tackle the problem of wheat yield stagnation in the rice-wheat zone by improving planting time, reducing weed infestation, and enhancing fertilizer and water use efficiency (Malik and Singh ,1995), Hobbs, et al. (1997, 2002).

6.3.2 Bed /furrow Plantation

As Pakistan is facing this practice saves approximately 30% irrigation water. Less reduced chances of plant submergence due to excessive rain or over-irrigation. This technique is more suitable for saline soil or sodic soil because of less crusting of soil around plant. It is adaptable for various crops without changing basic design / layout of farm. This technique also increased fertilizer use efficiency due to local application. (Latif *et al*., 2015).

6.3.3. Fertilizer band placement drill for wheat:

In Pakistan, phosphate fertilizer in wheat is conventionally applied by broadcast method before sowing crop. This is a wasteful method of fertilizer application as only 15-25% of the applied phosphate is utilized by wheat crop. The seed-cum-fertilizer drills

currently used in Pakistan place fertilizer either too far from the seed or in direct contact with it. In the former case, fertilizer use efficiency is hampered and in the latter situation, relatively high rate of ammoniated phosphate fertilizer (like DAP) affects the seed germination and crop yield (Ahmed et al., 2004).

6.3.4. Wheat straw chopper-cum-blower

Combine harvesters are gaining popularity in Pakistan for timely harvesting of wheat. These harvesters are concerned with the grains only and leave high stubbles and machine ejected straw in the field. Due to non-availability of proper technology, farmers generally burn this left over straw to clear their fields for subsequent crop. This phenomenon has given rise to three major issues:

- Environmental pollution associated with fire hazards at farm level
- Burning of rich soil organic matter
- Loss of valuable commodity i.e. finely chopped wheat straw (bhoosa) which is common cattle feed and has good market potential.

Therefore, this machine can provide bhoosa to feed their cattle throughout the year and earn a reasonable amount of money through its sale was highly demanded by the farmer (zafar et al., 2002).

- **Wheat Cutter and Binder**

In Pakistan rainfall shifting of rainfall patterns i.e. in the month of April since last 2-3 years at the time of wheat harvest causing delay in wheat harvesting and farmers have to wait until crop dries results in grain sheading. The introduction of wheat cutter and binder make it easy. Cutting and binding simultaneously, efficiently reducing the heavy manual work and working time also solves the problem of labor unavailability.

7. SUGARCANE CROP IN CHANGING CLIMATE

The climate of Pakistan leads to significant inter annual variability in the frequency of many extreme weather types, such as sub-tropical cyclones and associated storm surge, floods and droughts. Sugar- cane is mostly irrigated and partially rain-fed, climate variability has a major impact not only on sugar production but also on the national economy. Therefore, it is essential to understand the impact of major changes in climate patterns that affect sugar-cane and sugar yield. Sugar-cane industries worldwide are exposed to climate -

related uncertainties across an integrated chain of industry sectors, including cane cultivation, harvesting, transport, milling, marketing and shipping.

Sugarcane is cash crop of Pakistan and makes contribute in 0.6% in total GDP. During 2017–2018, sugarcane crop cultivated on 1132 thousand hectares as compared 1141 thousand hectares previous year, with production of 65,475 thousand tons. Decline in area is due to shifted sugarcane area to other crops. Sugarcane mostly propagated by placing cutting and whole stalks in furrows. After each harvest, ratoons mostly grows from stubble and it is possible to harvest 20 successful ratoon crop from a single plantation but environmental related factor such as pathogen infection, low winter temperature, weed competition, stalk borer injury and water deficit condition reduce the production one season to next .Climate related and weather events such as temperature, precipitation and atmospheric CO_2 are the key factor for sugarcane production in the world.

7.1 Temperature increase and sugarcane production

Sugarcane is a C4 species; increase in temperature in the range of 8–34°C increases the carbon dioxide assimilation and improve cane growth during winter but low temperature limit the photosynthesis and leaf growth rate Low temperature below 15°C limited the cultivation of sugarcane but temperature increase under changing climatic condition during low temperature period improve the sugarcane yield. High temperature likely reduces the incidence and severity of frost and extending the growth during winter months, frost known to poor quality in sugarcane. However high temperature has negative effect on sprouting and emergence of sugarcane and ultimate low plant population. Temperature above 32°C result in increased number of nodes, short internodes, higher stalk fiber and lower sucrose. High night temperature usually more number of flowering and flowering in sugarcane ceases the growth of internodes and leaves ultimately reduce the sucrose and cane yield. Increase in temperature under changing climatic conditions also alter the daily evaporation, may cause water stress and more frequent irrigation cycle will be done to meet the demand of evaporation and crop. Frequent irrigation result in over irrigation and create water logging and salinity problem which can reduce the sugarcane yield. Temperature changes also affect the ripening of sugarcane. During winter, low temperature is very important for natural ripening. Under changing climate, elevated temperature reduces the ripening and quality of sugarcane.

7.2. Floods and its impact on Sugarcane Crop:

During the current season 2010-11 most of the Sugar Mills of the Sindh started crushing late October-2010 and up to 31st December, 2010 Crushed 2,165,625 metric tons of sugarcane as against 2,691,769 metric tons crushed in the same period last year. The sugar produced was 167,159 metric tons as against 224,626 metric tons last year and same situation in other provinces. A major issue pertains to sugarcane crushed is more or less the same but production of sugar decreased due to reduction in the recovery percentage. During the current period recovery percentage was 7.72 as against 8.34 % last year. The main cause of reduction in the recovery rate was the excess water due to devastating flood in the country and rain. As a result excessive water was absorbed by the sugarcane crop which reduced the sugar contents in the cane and increased in the weight of the same. This result in dual loss to the mills in the shape of more payments to the growers and less recovery

7.3. Drought stress and Sugarcane crop:

Environmental stress reduces the crop productivity and plant growth and drought is the major abiotic stress, affecting crop productivity. Sugarcane crop is highly sensitive to water deficit and water deficit reduce the crop productivity up to 60%. Under water deficit conditions, sugarcane providing a key impetus to develop bio-technological strategies. Under drought conditions, plant adopt various tolerant strategies such as modulation of growth, changes in life cycle, evolution of stress perception for rapid expression of stress tolerance and balance allocation of resources for stress adaptation and growth. Molecular Breeding and biotechnology techniques are helpful tools to enhance crop productivity under water deficit conditions. Termite and nematodes is expected to increase under warm and dry conditions.

7.4. Change in Rainfall Pattern and Sugarcane crop:

Extreme changes in rainfall have impact on sucrose yield and frequent drought has negative effect on sugarcane as crop requires more water. Water stress also alters the photosynthesis, respiration and stomatal conductance For mitigate the drought conditions, farmer likely to more irrigate and increased the salinity problem and risen the water table. Reduce precipitation during harvesting period is likely to increase harvesting efficiency. Nitrogen is the most limiting factor for sugarcane production Increased precipitation also reduces the quality of cane by inadequate “dry off” period. Changing in precipitation also has prevalence of weeds, diseases and insect pest.

7.5. Accelerated Crop Pest and Diseases attack on Sugarcane Crop:

The more extreme weather events due to climate change have caused more overwintering pests (weeds and insects), more disease pathogens, and more input costs for reducing these risks to maintain a certain level of sugarcane production. A change in temperature under climate change conditions will have effects on some weeds, insects and diseases of sugarcane. Smut disease (caused by Sporisorium scitamineum) is likely to increase under high temperature conditions. But Sanguinodiscus the different diseases of sugarcane, such as Ustilagoscitaminea (Smut), Sugarcane mosaic virus (SCMV) and Xanthomonasalbilineans (leaf scaled disease) and told that all these diseases are systemic and only changed by direct human interference. leaf scaled disease in sugarcane may spread by severe storms.

Extreme weather events have caused more disease pathogen and overwintering pest and also increased the input cost for control them. Sugarcane leaf and orange rust are bid challenges for sugarcane production. Reduced rainfall will also reduce the growth of crops and pasture and decrease canopy covers which favour the weed infestation. Moderate drought can increase the population of many herbivorous arthropods and cause the injury in crop drought also enhanced host plant suitability for herbivores arthropods.

Climate Smart Agricultural Machinery in Sugarcane Farming System:

Mechanized Sugarcane Planter:

The planting and harvesting stages in sugarcane production cycle require huge labor involvement, which indeed makes sugarcane production highly unproductive leading to escalated costs and delays profits for growers. Mechanized sugarcane planting and harvesting enables:

- Better germination
- Protects crop from Climate Changes
- Fast operations
- Improved efficiency
- Less dependence on labor
- Minimized costs
- The process of Mechanized Sugarcane Planting

The 5 in 1 John Deere Twin Row Sugarcane Planter does the following jobs, simultaneously:

1. Ridging
2. Seed cutting
3. Uniform Seed laying

4. Fertilizer application
5. Soil covering

It can plant around 1 acre of sugarcane in an hour and with a single planter. With a compact design. Two people can easily sit on top of the planter with the task of giving seed input to the planter. While the operators give seed input to the planter, the machine performs the above mentioned 5 jobs simultaneously, which in manual planting requires multiple labor personnel. Giving time and cost savings to the farmer, followed by excellent germination.

Mechanized Sugarcane Harvesters

In sugarcane production cycle, the planting & harvesting phases require the highest labor involvement, which in fact makes the sugarcane production highly inefficient leading to increased costs and delays for the growers. Mechanized Sugarcane Harvester production enables:

- Increased efficiency
- Faster operations
- Less dependency on labor
- Reduced costs

Sugarcane harvesters provide optimal harvesting solution. Coupled with the right planting geometry and field layout, this machinery can offer the following advantages:

- Faster & uniform harvesting
- Improved yield of next ratoon
- More number of ratoons
- Higher sucrose recovery
- Minimum cane loss in field

8. RICE CROP IN CHANGING CLIMATE

Pakistan is one of the largest rice producing countries, having annual production of more than 5 million tons, In the year 2019, Pakistan produced 7.5 million tons of rice and ranked 10th in largest rice producing countries. In the year 2016/17, Pakistan produced 6.7 million tonnes, of which around 4 million were exported, mainly to neighboring countries, the Middle East and Africa. Pakistan mostly exports rice to the countries like Saudi Arabia, Afghanistan, Iran and United Arab Emirates (UAE). Rice is the second most important food item used in the eating habits and same as it supplies 21 percent of entire world's human per capita energy and 15 percent of per capita protein (Ghulam *et al.*, 2012). It absolute food requirements all the way of our country with earning source of foreign exchange from its trade export on the other hand rice provides value added products or raw substance for manufacturing paper, mattresses, starch, etc. grain with its husk used as fodder for livestock.

8.1 Impact of climatic factors on Rice crop:

The rice production is expected to be influenced by unseen future changes associated with climate change/global warming, temperature, CO2 and change in rainfall pattern. It was revealed by a comprehensive simulation research that the climate change since 1960s decreased yield of rice by 12.4%, but with largest contribution coming from lowering radiation.

8.2 Temperature and Rice crop:

Previous studies show the fact that the climate change causing increase in temperature and simultaneously cause adverse impact on rice crop and ultimately decrease the crop productivity and its quality. At the end of this century, rice crop is expected to encounter15-20% reduction due to climate change which is twice of the impact on wheat crop (Iqbal *et al.*, 2009). Increase in temperature in rise was found important for rice production in initially stage, however when temperature increases beyond certain level, the increase became destructive towards its production. Similarly, Mahmood *et al.* (2012) evaluated the effects of increasing temperature and suggested that increase in temperature by 1.5 - 3 C will enhance the production. Peng *et al.* (2004) observed close relation amongst rice yield and average minimum temperature. Rice production is exhausted by 10% when minimum temperature is increased by 1 C.

Pakistan is observing the temperature fluctuations in day and night during September. On day time you will find temperature above 30 degrees centigrade in evening/night temperature falls down to 25_20 degrees resulting in stress to Rice Crop and because of this Climate change causes problem in filling of grains.

8.3 Change in Rainfall Pattern and Rice crop:

In Pakistan rice is transplanted in May-June and harvested in October-November; hence its success is mainly dependent upon monsoonal (July-September) behavior. When rice is in grain stage more water/ irrigation can cause damage and mostly this is time of monsoon rains. The heads get heavy, lodge due to associated winds and submerge into water for several days. The floods of 2010 affected 20 % of the land area and the overall production loss of sugar cane, paddy and cotton were estimated at 13.3 million tons. Two million ha of standing crops were either lost or damaged. Mahmood *et al.* (2012) showed that an increase in rainfall by 5% and

15% during September-October could have a negative impact on rice productivity. However, a decrease in rainfall during the period is positively associated with rice yield.

8.4 Floods and its impact on Rice Crop:

According to National Disaster Management (NDMA) during 2010 and 2014 flooding in Pakistan, around 1 million acres of standing rice crop were destroyed. Extensive damages were reported in Jhang, Muzzafargarh, Multan and Sargodha Districts. Loss of standing crops not only affected the income bases of farmers, but also impacted overall production. SUPARCO estimates indicated around a 217,000 ton reduction in rice production.

8.5 Drought effect on Rice Crop:

The challenge of drought is even greater for crops such as rice when compared with other crops such as maize and wheat, as it has relatively higher water needs (Todaka *et al.*, 2015). Rice is sensitive to deficit in soil water content because rice cultivars have been historically grown under flood irrigation conditions where the soil matric potential is zero. About 3,000 to 5,000 L of water is required to produce 1 kg of rice seed, with less than half of that amount needed to produce 1 kg of seed in other crops such as maize or wheat (Bouman *et al.* 2002).

8.6 Accelerated Crop Pest attack on Rice Crop:

Because of climate change frequent attack of different diseases were found in rice crop since 2008 in all over Pakistan.

8.6.1 Blight or Brown Spot

Symptoms: This disease has been recorded all over Pakistan because of difference in day and night temperature in Rice crop zones. Initially small dots or circular eye shaped or oval spots appear light in color on leaves. These spots coalesce and result in linear spots brown in color. Later on withering and yellowing of leaves occur. Seed setting also affected and causes sterility, shriveling and show rotting and poor germination.

Perpetuation: Diseased seeds, plant debris and soils help the fungus to survive, while fluctuating temperature and irrigation water help to the fungus for transmitting from diseased to healthy plants.

Control:

1. Use of resistant varieties or disease free seed in healthy soils,
2. Sanitation and crop rotation,

3. Hot water seed treatment at 54 oC for 10 minutes or with seed dressing fungicides,
4. Collection and destruction of stubble and spraying with copper fungicides at right time and
5. Application of suitable foliar fungicides may help to minimize further dissemination of the disease

8.6.2 Bunt of Rice

Symptoms: This disease also called black or kernel smut is generally distributed wherever rice is grown. Diseased grains are filled with black powder, which can be detected by breaking them. Only a few grains may be affected wholly or partially in an ear. If not severely infected, seeds may germinate but seedlings are stunted.

Control:

1. Cultivation of resistant varieties,
2. Use of healthy seed,
3. Sowing early maturing varieties,
4. Avoid high rates of nitrogen fertilizer,
5. Avoid winnowing and threshing of diseased crop in field,
6. Treat the seed with suitable chemicals easily available in the market and
7. Collect and burn diseased ear heads.

8.7 Rice Leaf Folder

The scientific or technical name of rice leaf folder belongs to family Pyralidae and order Lepidoptera. This insect found favorable temperature for its growth because of climate change from last decade and attacks on rice crop all around Pakistan.

Damage

- Leaf margins are folded and folded capsules and eat tissues by scarping. Paddy turns white, discolors and folded. Paddy is seems as malnourished and poor looking

Control

- Remove shade plant to provide strong sunlight. Apply nitrogen fertilizers as required.
- Use insecticides if the moth population is high to control larvae.

Water Scarcity and Rice Crop

Rice Crop is known as water crop as it grown in standing water. As reported in research Globally 1200 liter of water has been recommended to produce 1 Kg of Rice but in Pakistan it is calculated as approx. 5000 liters of water has been wasted to produce 1 Kg of Rice. and Pakistan is already facing water scarcity issues (Zaheer. A, 2017).

Pakistan is an agro based economy with Rice as a major cash crop in the country. Pakistan is the 11th largest rice produce in the world. Pakistan's exports make up 8% of world's total rice trade. Rice is cultivated on 2.5 million hectares of Land in Pakistan. Approximately 80 percent of the wheat crop in Punjab is grown after harvesting rice. In Pakistan an over whelming majority of farmers burn rice residue after harvesting rice crop in order to prepare the land for wheat crop.

Burning Rice Residue:

The farming community in Pakistan is burning rice residue from decades. Crop straw burning is a traditional way of cleaning the land to prepare for the next crop. Farmers burn rice residue also because majority of farmers believe that it has a beneficial effect on crop yields. Some farmers also believe that it helps them and save time for timely sowing of Wheat Crop. Farmers also say that to burn paddy straw is of no cost & if we manage as Agriculture Extension officers guide it costs more.

Smog because of burning of Crop Residue:

In recent years, this common farming practice has emerged as a major concern for multiple environmental reasons. Every winter in Punjab Pakistan is occupied by the smog, 16% contribution in smog because of burning of Rice residue is the main cause of air pollution. Punjab Pakistan is experiencing Smog from last half decade. Pakistan's second-largest city is choking on smog, driven in part by smoke from bricks kiln and steel mills, burning of rice stubble and garbage, growing numbers of vehicles on the road and large-scale losses of trees as the expanding city

makes way for new roads and buildings. Government of Punjab imposes ban on the burning of crop residue, solid municipal waste, plastic and leather items for a period of three months across the province under Section 144 (6) CrPC, 1898 from last 3-4 years but implementations are still not possible because of geographical spread of farmers.

A growing major concern regarding residue burning emerges from its effects on air pollution and climate change. Incomplete combustion of biomass such as agriculture residues generates black carbon which is the second largest contributor to global warming after carbon dioxide. Black carbon absorbs radiation and warms the atmosphere at regional and global scales. Increased concentration of black carbon and other pollutants, observed in the high Himalayas, is expected to enhance glacier melting. Black carbon emissions and other types of aerosols have also given rise to atmospheric brown clouds (ABCs) in Asia (Nakajima, 2009). The aerosols in ABCs decrease the amount of sunlight reaching the earth's surface by 10% to 15% and enhance atmospheric solar heating by as much as 50% (UNEP. RRC.AP. 2012). One estimate attributes 30% to 50% of the human contributions to global warming to black carbon, methane and ozone (Ramanathan *et al*. 2009). In general, atmospheric brown clouds and their interactions with greenhouse gases can significantly affect climate, hydrological cycle, glacier melting, agricultural and human health.

Effects of Burning Crop Residue on Soil:

A study estimates that crop residue burning released 149.24 million tonnes of carbon dioxide (CO2), over 9 million tonnes of carbon monoxide (CO), 0.25 million tonnes of oxides of sulphur (SOX), 1.28 million tonnes of particulate matter and 0.07 million tonnes of black carbon. These directly contribute to environmental pollution, and are also responsible for melting of Himalayan glaciers. The heat from burning paddy straw penetrates 1 centimeter into the soil, elevating the temperature to 33.8 to 42.2 degree Celsius. This kills the bacterial and fungal populations critical for a fertile soil.

Burning of crop residue causes damage to other micro-organisms present in the upper layer of the soil as well as its organic quality. Due to the loss of 'friendly' pests, the wrath of 'enemy' pests has increased and as a result, crops are more prone to disease. The solubility capacity of the upper layers of soil has also been reduced.

According to a report, one tonne stubble burning leads to a loss of 5.5 kilogram nitrogen, 2.3 kg phosphorus, 25 kg potassium and more than 1 kg of sulfur — all soil nutrients, besides organic carbon. However, suggests that burning straw after harvesting rice can have negative effects on soil quality in the short and long run, reduces soil cropping intensity and resulting land degradation.

Health impacts because of Smog:

Smog posing a serious health risks especially in children's like cough, bad cold, chest pain a study reveals that 84.5 per cent people were suffering from health problem due to increased incidence of smog. It found that 76.8 per cent people reported irritation in eyes, 44.8 per cent reported irritation in nose, and 45.5 per cent reported irritation in throat. Cough or increase in cough was reported by 41.6 per cent people and 18.0 per cent reported wheezing.

Solutions to the burning problem:

One of the main solution is to aware the farmers regarding the issues of burning crop residue. There is dire need to strengthen the agricultural extension services in the country and to transfer the new technology, knowledge and skills to the farming community/ for capacity building of farmers via using Modern Agricultural Extension Techniques and methodologies such as use of ICT's for dissemination of improved agriculture technology, Farmers meetings, Farmer Field Schools (FFS), Agricultural workshops, Field Days, Exhibitions, Seminars, trainings etc.

Farmers can also manage crop residues effectively by employing agricultural machines like:

- Happy Seeder(used for sowing of crop in standing stubble) help in sowing of wheat crop in high residue of rice
- Rotavator (used for land preparation and incorporation of crop stubble in the soil)
- Zero till seed drill (used for land preparations directly sowing of seeds in the previous crop stubble)
- Baler (used for collection of straw and making bales of the paddy stubble)
- Paddy Straw Chopper (cutting of paddy stubble for easily mixing with the soil)
- Reaper Binder (used for harvesting paddy stubble and making into bundles)

This new machine "Pak Seeder" drills wheat in heavy rice residue just after combine harvesting without land preparation and burning of residue. Its operational cost is Rs. 1,200-1,500 per acre as compared with traditional method that cost Rs. 6000-7000 per acre also yield increased from 10-12 monds per acre.

8.8. Climate Smart Agricultural Machinery in Rice Farming System:

Direct Seeding of Rice Technology:

Rice nursery transplantation is the conventionally used method of rice growing countries of Asia especially in Pakistan. But is no more cost effective because of water scarcity unavailability of labor and high cost of production. Transplanting technique has to be replaced with a resource efficient economical and productive method of sowing has to be replaced with are source efficient, economical and productive method of sowing without compromising the yield and net production to ensure the food security in future. Direct Seeded Rice (DSR) in place of the traditional transplanted rice is a way to reduce labor charges for nursery raising, puddling and transplanting. DSR is sown directly into the moist soil like wheat, corn or cotton and does not need continuous submergence so it reduces overall water requirement.

Advantages of DSR:

- Labor saving up to 75%
- Water saving up to 30%
- Early maturity of crop
- Timely sowing of wheat crop
- Saving of machinery operations (needed for puddling)
- Avoids compaction of soil due to puddling
- Good precursor of zero tillage technology

Mechanical transplanting of rice:

Mechanical transplanting of rice is the process of transplanting young rice seedlings, which have been grown in a mat nursery, using a self-propelled rice transplanter. In conventional manual transplanting practice, 8-12 labours are required to transplant one acre. However, if a self-propelled rice transplanter is used, three people can transplant up to four acres in a day.

Advantages of mechanical transplanting

- Uniform spacing and optimum plant density (26-28 hills/m with 2-3 seedling per hill)
- Less transplanting shock, early seedling vigor and uniform crop stand
- Lower stress, drudgery and health risks for farm labourers
- Better employment opportunities for rural youth through the development of custom service business Addresses the problem of labor and water scarcity
- Increases farmers' net income

9. COTTON CROP IN CHANGING CLIMATE

Pakistan's economy depends heavily on cotton crop which significantly contributes by providing raw material to the textile industry, such as cotton lint as an export item. It accounts for 7.0% of value added in agriculture and 1.5% of GDP (GoP,2013).Pakistan has fourth position among cotton producers after China, India and USA and 3rd position among cotton consumers in the world ranking (GoP, 2013).

Climate change is the major factor blamed for Pakistan’s steep drop in cotton production. Cotton crop all over Pakistan has been effected by climate in two ways i.e. Extensive and unexpected rainfall and heat waves. Cotton production dropped by 28 per cent drop during 2015-16 caused by erratic weather and pest outbreaks. Heavy rainfall, high temperatures and major pest outbreaks have taken a heavy toll on Pakistan’s cotton growing districts of Punjab and Sindh province.

9.1 Temperature and cotton crop:

Climate change is leading to a rise in average temperatures, changes in the water cycle and precipitation patterns, and to an increase of some extreme weather events. Although the cotton crop is more resilient to a higher temperature, rising the temperature above the threshold level of 32 °C can distort cotton growth and development (ITC 2011). The higher temperature would trend to shed buds and fruits at the early stage of development.

9.2 Change in Rainfall Pattern and Cotton crop:

Cotton is produced in rainfed or irrigated systems, whereat irrigation generally serves to reduce the impacts of rainfall deficits and thus reduces annual yield variability. However, the actual amount of water applied to fields is unknown and determined by water availability, water management systems and economic rationale. The extent to which rainfall deficits are compensated by irrigation is thus not only a question of equipment for irrigation (Portmann et al., 2010)

9.3 Floods and its impact on Cotton Crop:

Most of the cotton production in Punjab and Sindh is cultivated along the River Indus, which is also a major source of floods. Analysis of various episodes of floods experienced in the last two decades reveals excessive damages to the cotton crop. Almost 21% of the cotton cultivated was destroyed during the 2010 flood (ADB and World Bank, 2010). Losses worth Rs. 11 billion to the farming community were also reported from the 2012 floods (SUPARCO and FAO, 2012).

9.4 Drought effect on cotton Crop:

Drought has been seen to reduce leaf water potential (LWP) in cotton plants. This reflects the reduced water retention of the plant, signifying a loss of this essential substance in times of drought, which negatively impacts several vital plant processes. Whole-plant-based measurements do not always accurately reflect the effect of drought on cotton because of its indeterminate growth habits. During cotton boll development in time of drought cotton crop yield reduces and fiber qualities on different fruiting branches become very low.

9.5. Accelerated Crop Pest attack on Cotton Crop

Weather factors played a role in population dynamics of sucking pest insects. Whitefly and Jassid populations are usually positively correlated with the temperature while negatively with relative humidity. The rainfall has a positive effect on the whitefly and negative effect on the Jassid population build-up (Ashfaq *et al.,* 2010). More moisture and humid conditions in cotton crop due to un-predictable rain fall Pink Boll Worm became a regular habit of Cotton crop. Keeping in view, the existing situation of outbreaks of piercing sucking insects on BT. cotton, there is a need to develop an effective and sound pest- management program, that is well suited to the ecological conditions, particularly the weather factors, which play a key role in the multiplication and distribution of pest insects.

10. RECOMMENDATIONS

- Climate change is the biggest threat to the agricultural sector across globe and is causing the food insecurity. There is dire need to learn the climate changes and adopt mitigation strategies.
- There is a need to design and develop a policy framework for implementing the adaptation and mitigation options so that farming community can be saved from the adverse impacts of climate change.
- There is a dire need that the Department of Agriculture must arrange effective pieces of training for Agriculture Extension staff focusing on Climate Change effects on crops and mitigation strategies so that the staff will be in a better condition for the diffusion of mitigation strategies to the farming community.

- Farmers should be trained about effective irrigation techniques, water harvesting techniques and agronomic practices to save water
- The government should maintain easy access to early warning systems regarding weather forecasts.
- Agricultural Extension staff should arrange training for the capacity building of farmers to overcome the climatic change issues.

11. ROLE OF ZTBL:

ZTBL has established its Green Banking Unit (GBU) for implementation of Green Banking Guidelines of State Bank of Pakistan (SBP) for taking care of Climate Change Issues. ZTBL has also developed its Green Banking Policy.

11.1 Green Awareness Campaign

ZTBL Green Banking Unit has launched its Green Awareness Campaigns. GBU has arranged Clean and Green Pakistan Field day in Sargodha in collaboration with Farmers Training Department. Nearly 120 farmers/clients were the beneficiaries of Green Awareness Campaigns. The main objective of the campaigns was to create awareness among the farming community/clients about **Climate Change and its impact on Agriculture** especially Citrus, and Wheat major staple crop of Pakistan.

11.2. Green Advisory Services

In light of the Green Banking Guidelines of State Bank of Pakistan (SBP). ZTBL, Planning and Research Department, Green Banking Unit ZTBL has published broachers, booklets, leaflets and Research Study for Green Advisory Services of clients and employees

- **Climate Smart Agriculture in Pakistan (Research Study)**
- **Climate Change, Water Scarcity and Effective Irrigation Techniques**
- **Changing Weather patterns and Pakistan's Agriculture**
- **Green Banking (a brief summary) leaflet**
- **Global warming, Climate Change and Role of Green Banking**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clients, subsidiaries and general public are target groups.
Role Of ZTBL In Green Banking Activities
Keeping in view State Banks of Pakistan Guidelines for Green Banking, ZTBL has established its Green Banking Unit in order to implement the Green Culture in the organization and also developed the Green Banking Policy for ZTBL.
The silent features for the Green Banking Policy are as under:
1. The Bank would establish risk management procedures to identify, assess, mitigate and monitor environmental risks arising from operations.
2. The Bank would allocate funding resources for green business facilitation having direct or indirect impact on improving the carbon foot print and be more resource efficient.
3. The Bank would setup its branches and offices in such a way that its operations use minimum energy and other resources leading to own impact reduction having minimum impact on the environment.
Developed By
Green Banking Team
M. Fakhar Imam Green Operation Officer
Fahim Haider Green Banking Unit
Faisal Shehzad Green Leison Officer
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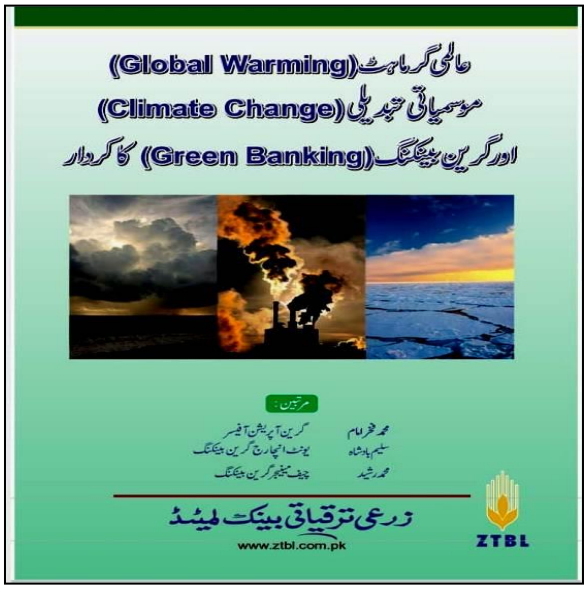
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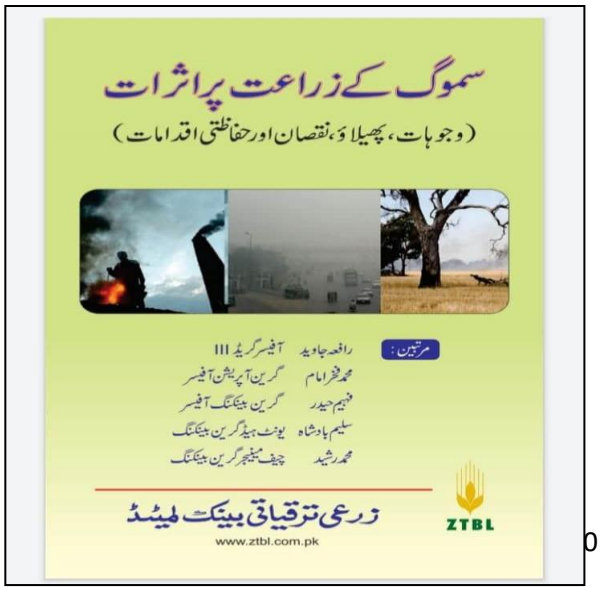
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11.3. Green Capacity Building Programme

ZTBL Green Banking Unit in collaboration with Training and Development Division (T&DD) established annual plan for internal capacity building of its officials on green banking. Up till November 2020, 40 secessions of Green Banking Trainings have been conducted and1084 employees were the beneficiaries. The main objective of the workshop is to build the capacity of the employees and make them aware about the concepts of Green Banking, Climate Change, Green Banking Guidelines of State Bank of Pakistan, Green Banking policy of ZTBL and Climate Smart Agriculture. Trainings have been imparted among ZTBL Employees including MCOs, Managers, Head Office Officials, Zonal Manager Operations, Audit officers, Tellers & Deputy Managers.

11.5. Clean & Green Pakistan (Tree Plantation Campaign)

In light of the vision of PM of Pakistan "Plant 4 Pakistan" ZTBL has join the hands with the mission of PM clean & green Pakistan, "Plant 4 Pakistan Campaign. A Target of 160000 Trees for five years has been allocated to all ZTBL Zones/Branches through Green Banking Unit, ZTBL H.O Islamabad however, up to November, 2020, 104,335 trees has been planted in different areas of Pakistan.

Tree plantation campaign is a continuous activity of Green Banking Unit and the targets will be assigned to ZTBL Zones/Branches in every planting season.

11.6 Green Banking Products:

Section 4.2 (4) of Green Banking Guidelines of State Bank of Pakistan (SBP) says "The Agricultural clients may be financed for farming techniques based on lesser use of chemical fertilizers & pesticides, efficient water usage, drought resistant and water resistant crops etc." In pursuant to this Green Banking Unit (P &RD) has developed/suggested six Green Banking Products and approved by the competent authority. The detail of Green Banking Products as under:

a) Raised Bed Planter
b) Direct Seeding of Rice (DSR)
c) Drip Irrigation powered by Solar Panel

d) Pak Seeder/Happy Seeder
e) Solar Dryer for Agriculture Products
f) Sesbania (Jantar Crop)
g)

Salient Features of these Green Banking Products are as under:

1. Raised Bed Planter:

Raised Bed Planter is Climate Smart Agriculture technology/machinery that helps in conservation of water resources and prevents the crop from harsh weather/climate effects such as wind lodging, and helpful in increasing the crops, vegetables and fruit yield.

Salient Features of the Bed Planter:

- Bed and furrows sizes can be adjusted for individual crop.
- Seed and fertilizer rates can be adjusted as per requirement.
- Bed planter can be operated by a common tractor operator.

Benefits of Raised Bed Plantation on Crops:

- Water saving from 30-50%.
- Improved water distribution and efficiency, fertilizer use efficiency,
- Reduced weed infestation and lodging of standing crop
- Easy crop harvesting.
- Yield increase up to 20-25%.

2. Direct Seeding of Rice (DSR):

The Green product "Direct seeding of Rice" (DSR) technology refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery.

Salient Features of the DSR:

- Labour required for nursery raising, uprooting and transplanting of seedlings are saved to the extent of about 40 %
- Saving of water (up to 50%) as nursery raising and puddling are eliminated
- Early maturity (7-10 days) helps in timely sowing of next crop.
- Energy saving (up to 60% of diesel) because of elimination of field preparation for nursery raising, puddling and reduced water application for irrigation.
- Reduction in Green House Gases emissions.

3. Drip Irrigation powered by Solar Panel:

Solar powered drip irrigation system is found suitable for point to point application of irrigation for orchards and high-value crops.

Salient Features of Solar Powered Drip Irrigation System:

- **Water Efficiency:** A drip irrigation system will provide water with less runoff or evaporation.
- **Root Zone:** Plants need water at their roots, and drip irrigation enables to provide water at the root zone.
- **Conserves Earth's Resources:** Drip irrigation system powered with solar panel helps in conservation of natural resources such as "Soil" from Soil Erosion and save water up-to 80- 90%.
- **Reduction of Pests & Weeds:** A drip irrigation system directs the water at the root zone of plants and effectively reduces insect pests, weeds and harmful fungal growth.
- **Reduction in Carbon Emissions:** Solar Powered Drip Irrigation System reduced input cost, and reduced energy requirements and cut down the carbon emissions.

4. Pak Seeder/Happy Seeder:

1. Happy Seeder is a tractor-mounted machine that cuts and lifts rice straw, sows wheat into the soil, and deposits the straw over the sown area as mulch.
2. Happy Seeder/Pak Seeder machine drills wheat in heavy rice residue just after harvesting of rice is over without land preparation and burning of rice residue.
3. Happy Seeder/Pak seeder machines can reduce air pollution, smog and greenhouse gas emissions.

5. Solar Dryer for Agriculture Products:

1. Solar energy can be utilized very effectively in drying agriculture commodities using solar dryers.
2. Good quality products can be obtained at much less cost due to savings in cost of electricity or other heating fuels that would have been used otherwise for the same purpose.
3. Solar dryer helps in reduction of carbon emissions.

Salient Features of Solar Dryer for Agriculture Products:

The major advantages of solar dryer of fruits and vegetables are given below:

- Drying didn't affect the main nutritional value of fruits.
- Dried fruits and vegetables have a longer shelf-life under proper storage conditions.
- Transportation, handling and storage costs are substantially lowered.
- The most economical and disposable form of packaging.

6. Sesbania (Jantar Crop)

Jantar crop is a Green Baking Product as it is used as a green manure crop restores soil fertility, fixing nitrogen in the soil and improves soil organic matter. Researchers recommending Jantar crop in all climates sensitive areas of the country.

Salient Features of Jantar Crop:

- Jantar crop helps reclaim degraded land and make it productive again. It not only improves physical properties but also helps in meeting nitrogen requirement of succeeding crop.
- Jantar crop is also a drought tolerant crop and can be suggested in the countries like Pakistan facing water scarcity issues
- Jantar crop improves the organic matter in the soil therefore less use of chemical fertilizers are required for the next crop and research also reported that less number of weeds in next crop so very limited or no herbicides' spray are used.
- Jantar is a research-based action together for producing salt tolerant fodder which benefits the land to improve productivity and lessen salinity.

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