The Impact of Climate Change on Agricultural Sector of Pakistan : Challenges and Opportunities

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Abstract- As a consequence of changes in the global climate, the long-term weather patterns typical of a variety of regions around the world are undergoing transitions. "weather" refers to the short-term variations (daily) in a region's temperature, wind, and precipitation. These variations may occur in any combination. Any permutations of these adjustments are possible. Long-term climate changes might potentially have many consequences on agriculture, including the quantity and quality of crops in terms of productivity, growth rates, photosynthesis and transpiration rates, as well as the availability of moisture and other elements. There is a good chance that the effects of climate change will directly impact food production in every region of the planet.

There is a possibility that a rise in the season's average temperature may cause a shorter growth time for several crops, which will ultimately result in a poorer yield. According to the Intergovernmental Panel on Climate Change (IPCC), warming will directly impact agricultural productivity in locations where temperatures are already pretty close to the physiological maximum for many different kinds of crops. Suppose the causes that drive climate change also induce changes in the atmospheric composition. In that case, the impacts those factors have on the physiology of plants might directly influence the amount of food produced as a result of those shifts. It is predicted that these variables will have a substantial effect on food production and may represent a threat to food security due to the severe severity of the consequences that will result from agriculture's contribution to climate change and climate change's negative influence on agriculture. This is because agriculture's contribution to climate change has a negative effect on agriculture. To address these concerns, adopting extra safety procedures in the agricultural sector will be important.

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Index Terms- Climate change, Greenhouse Effect, Greenhouse gases (GHGs), Global Warming Potential (GWP), Intergovernmental Panel on Climate Change (IPCC), parts per million (ppm). The greenhouse effect is a natural process that plays a major part in shaping the Earth's climate. It

produces a relatively warm and hospitable environment near thEarth's surface where humans and other life forms have been able to develop and prosper. However, the increased level of greenhouse gases (GHGs) (carbon dioxide (CO_2), water vapour (H_2O), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) etc.) due to anthropogenic activities have contributed to an overall increase of thEarth's temperature, leading to global warming. The average global surface temperature has increased by 0.74 ^oC since the late 19th Century and is expected to increase by 1.4 ^oC - 5.8 ^oC by 2100 AD with significant regional variations (IPCC, 2007). The atmospheric CO_2 concentration has increased from 280 ppm to 395 ppm, CH_4 concentration increased from 715 ppb to 1882 ppb and N_2O concentration from 227 ppb to 323 ppb between the years 1750 and 2012. The Global Warming Potential (GWP) of these gases, i.e., CO_2, CH_4 and N_2O, are 1, 25 and 310, respectively (Cao, Halpern et al. 2023).

I. INTRODUCTION

A phenomenon regarded as an example of climate change is any significant longterm change in the projected patterns of average weather that occurs over a substantial amount of time in a particular region (or on the whole planet). The subject at hand is the occurrence of unusual changes in weather patterns and the effects of these changes on other parts of the world. It's possible that these changes won't take place for tens, hundreds, or even millions of years. However, rising human activity, like industrialization, urbanization, deforestation, agriculture, and changes in the pattern of land use, all contribute to larger emissions of greenhouse gases, which in turn causes the speed of climate change to accelerate much faster (Cappelli, Conigliani et al. 2023).

This is because greenhouse gases trap heat in the atmosphere and prevent it from escaping. Changes in precipitation patterns and increases in atmospheric CO2 concentrations are expected to occur due to climate change, according to the many forecasts that have been made. There are potentially three main ways in which the Greenhouse Effect will impact agriculture. To begin, it is possible that an increase in the amount of carbon dioxide in the atmosphere would directly influence the growth rate of agricultural plants and weeds. This is because carbon dioxide is a greenhouse gas. Second, the climate changes induced by CO2 might alter the temperature, rainfall, and sunshine levels, all of which can influence the productivity of plants and animals. This could harm the environment. In the end, rising sea levels may cause the disappearance of agriculture in coastal areas due to floods and an increase in groundwater salinity (DeAngelo, Saenz et al. 2023).

Temperature projections in every single climate model show an upward trend. The precipitation pattern has changed due to decreased rainfall in south and southeast Asia. Since the 1970s, we have seen droughts that are not only more severe but also last for a longer period. With time, not only has the amount of land permanently covered with snow reduced in size, but the snow has also become thinner. It is expected to rise to 0.18 to 0.59 meters in the worldwide average sea level by the turn of the Century (Hendrix, Koubi et al., 2023).

Ten countries top the list of those most vulnerable to the effects of climate change, and six of them are located in Asia and the Pacific. Bangladesh comes first, followed by Pakistan, Nepal, the Philippines, Afghanistan, and Myanmar. As a direct and immediate result of the loss of farmland that would occur as a direct and immediate consequence of a rise in sea level of 1.5 meters, it is anticipated that about one-fifth of the population of Bangladesh would need to migrate as a direct and immediate consequence. The landmass that makes up the Maldives

Islands, located in the Indian Ocean, would have one-half of its total area flooded if the ocean level rose by two meters (Kumar, Sahu et al. 2023).

PAKISTANI SCENARIO OF CLIMATE CHANGE

There is a possibility that the warming would be felt more acutely in the northern parts of Pakistan. It is projected that as a consequence of climate change, both the highest and lowest temperatures may become substantially more extreme. There is a possibility that certain areas may get drier, while others are forecast to see an increase in the amount of precipitation. Except for the provinces of Punjab and KPK in the north-west and Sindh in the south, which indicate a little decline on average, it is expected that there will be a 20% rise in the amount of rainfall that occurs during the summer monsoon across all of Pakistan's provinces. There may be a reduction in the number of rainy days (for instance, in the province of Balochistan), but it is projected that there will be an increase in the intensity of the precipitation over most of Pakistan (for instance, in the North East). From a level of 1820 m3/yr in 2001, the gross per capita water availability in Pakistan is anticipated to drop to 1140 m3/yr in the year 2050 (Noto, Cipolla et al. 2023).

The summer temperatures that corals in the Indian Ocean will encounter will soon approach levels greater than the thermal thresholds documented over the last 20 years. This will occur shortly. After the year 2050, yearly coral bleaching will almost become routine. This trend is expected to continue.

The historical statistics on the mean sea level along the coast of Pakistan indicate that throughout this particular length of coastline, there has been a long-term (100-year) rising trend of around 1.0 mm per year in mean sea level. On the other hand, the most recent data suggests that the average elevation of the sea level along the coastline of Pakistan is increasing at a rate of 2.5 millimetres per year (Pande, Kadam et al. 2023).

It is projected that the average sea surface temperature in the region around Pakistan will increase by roughly 1.5–2.0 degrees Celsius by the middle of this Century and by approximately 2.5–3.5 degrees Celsius by the end. A rise in sea level of one meter would result in the relocation of about 7.1 million people in Pakistan, as well as the loss of approximately 5764 square kilometres of land area and 4200 kilometres of roadways. In addition, this increase in sea level would destroy approximately 5764 square kilometres of land area (Pande and Moharir, 2023). It is quite likely that more than half of Pakistan's forests will see a change in forest type. This would have a detrimental impact not only on the biodiversity associated with these forests but also on the dynamics of the climate in the area and the lives of people who depend on forest products. Even within the relatively short period of around 50 years, it would seem that the bulk of the forest biomass in Pakistan is quite vulnerable to the changes in climate that are projected to occur. This is the case even though this period is very short. In addition, it is expected that by 2085, 77% and 68% of Pakistan's wooded grids will have experienced changes in the kind of forests they consist of. This change is projected throughout the country (Pathak, 2023).

CROP RESPONSES TO EXPECTED CLIMATE CHANGE FACTORS

There is a possibility that climate change will result in higher temperatures, different patterns of precipitation, and higher concentrations of CO2 in the atmosphere. These factors may affect yield (quality and quantity), growth rates, photosynthesis and transpiration rates, and moisture availability. These effects may be caused by changes in water use (irrigation) and changes in agricultural inputs such as herbicides, insecticides, and fertilizers, among other things. Several environmental factors, including the frequency and severity of soil drainage (which may result in

nitrogen leaching), soil erosion, the availability of land, and a decline in crop diversification, are all potential factors that might impact agricultural production (Warsame, Sheik-Ali et al. 2023).

According to Cure and Acock (1986) and Allen et al. (1987), a greater CO2 content in the atmosphere would result in a higher net photosynthetic rate. Higher CO2 concentrations may cause plants to lower the size of their stomatal apertures, which are the tiny pores in the leaves through which CO2 and water vapour are exchanged with the environment. This will result in less water being lost via transpiration. In certain agricultural plants, the drop in transpiration might be as high as 30 per cent. Predicting the influence of high CO2 on the responsiveness of stomata is still extremely difficult since stomatal response to CO2 interacts with various environmental (temperature, light intensity) and plant characteristics (e.g. age, hormones). As a result of these interactions, it is difficult to determine how elevated CO2 will affect the responsiveness of stomata. Rice yields will rise by 0.5 t/ha for every 75 ppm increase in CO2 concentration; however, yields will fall by 0.6 t/ha for every 1 °C increase in temperature (Cao, Halpern et al. 2023).

CO2 enrichment has typically demonstrated considerable increases in rice biomass (2540%) and yields (15-39%) at ambient temperature, but those gains tended to be reversed when the temperature was raised simultaneously with increasing CO2, suggesting that the two factors work in opposition to one another. According to research done by Matsui et al. (1997a), yield reductions brought on by concurrent increases in CO2 and temperature are predominantly the result of high temperatures inducing spikelet sterility (Cappelli, Conigliani et al. 2023).

When nighttime temperatures exceed 21 degrees Celsius, an increase in CO2 levels may also directly suppress the maintenance respiration process. Regarding rice, the highest possible temperature is of utmost significance during the blooming stage, which typically lasts around two to three weeks. A loss of yield may result from pollen having its vitality significantly diminished after being subjected to high temperatures for just a few hours. Temperatures over 35 degrees Celsius have been shown to increase spikelet sterility significantly, and rising CO2 levels may further exacerbate this issue, presumably due to decreased transpirational cooling (DeAngelo, Saenz et al. 2023).

The diminished capacity of the pollen grains to expand due to high temperatures is one of the primary mechanisms contributing to the high temperatures-induced floret sterility in rice. This results in inadequate thecae dehiscence. There is significant genotypic heterogeneity concerning the induction of floret sterility by high temperatures. Variations in solar radiation, higher maintenance respiration losses, or differential effects of night vs day temperature on tillering, leafarea expansion, stem elongation, grain filling, and crop phenology have been hypothesized as probable explanations. These factors might have a role in the development of the plant (Hendrix, Koubi et al. 2023). In a study conducted not too long ago in a climate chamber, the researchers Counce et al. found the first indication of probable genotypic variation in tolerance to high nighttime temperatures. Increased CO2 levels and temperature may impact the pace at which crops grow.

Predicted effects of climate change on agriculture over the next 50 years

Climatic element	**Expected changes by 2050's**	**Confidence in prediction**
Effects on agriculture		

	CO2	Increase from 360 ppm to 450 - 600 ppm (2005 levels now at 379 ppm)	Very high	Good for crops: increased photosynthesis; reduced water use
	Sea	Rise by 10 -15 cm Increased in the south and offset in the north by natural subsistence/rebound.	level Very high	Loss of land, coastal erosion, flooding, salinization of groundwater
	Temperature	Rise by 1-2 oC. Winters are warming more than summers. Increased frequency of heat waves	High	Faster, shorter, earlier growing seasons, range moving north and to higher altitudes, heat stress risk, increased Evapotranspiration.
	Precipitation	Seasonal changes by ± 10%	Low	Impacts on drought risk' soil workability, water logging irrigation supply, transpiration
	Storminess	Increased wind speeds, especially in the north. More intense rainfall events.	Very low	Lodging, soil erosion, reduced infiltration of rainfall
	Variability	Increases across most climatic variables. Predictions uncertain	Very low	Changing the risk damaging events (heat waves, frost, droughts, floods) which affect crops and the timing of farm operations

of

Alterations to the soil-floodwater system may affect both the carbon and nitrogen cycles. The patterns of crop residue degradation might change. There is a correlation between an increase in

the temperature of the soil and an increase in the quantity of autotrophic CO2 lost from the soil. Root respiration, root exudates, and fine-root turnover may be responsible for these CO2 losses (Kumar, Sahu et al. 2023).

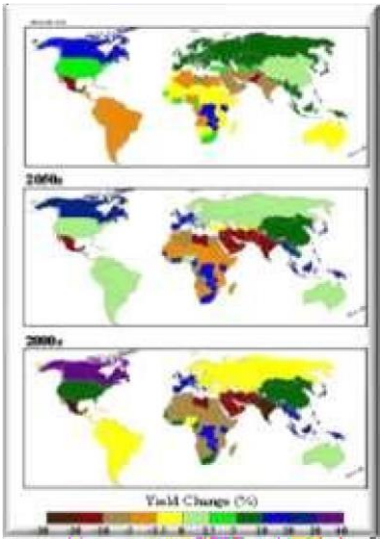
The production of rice will be negatively impacted due to the consequences of climate change, namely due to the Rise in sea level. According to the vast majority of research findings, an increase in temperature of 2–3.5 degrees Celsius would lead to poorer yields of non-irrigated wheat and rice and a loss in farm-level net income ranging from 9–25 per cent. According to the research that Aggarwal and Mall (2002) conducted, an increase in temperature of 2 degrees Celsius resulted in a 15–17% decrease in the grain produced by rice and wheat. It is anticipated that areas that are seeing an increase in the amount of precipitation will also experience an increase in the severity of bacterial and fungal illnesses. If the climate around the cereals were warmer and more humid, the cereals would have a lower yield because they would be more prone to outbreaks of disease and pests (Noto, Cipolla et al. 2023).

IMPACT OF CLIMATE CHANGE ON WORLD'S AGRICULTURE

There is a good chance that the effects of climate change will directly impact food production in every region of the planet. There is a possibility that a rise in the seasonal average temperature could decrease the growth time of several crops, which will ultimately result in a lower overall yield. In locations where temperatures are already very close to the physiological maximum for many plants, the impact of climate change on agricultural productivity will be more direct. The impact of climate change on global agriculture is expected to impact the sector during this Century significantly negatively (Pande, Kadam et al. 2023).

It is projected that by 2080, there will be a decrease of between 3 and 16% in the agricultural output carried out over the whole planet. By 2080, it is expected that emerging countries, many of which now experience average temperatures near or over the limits of crop tolerance, would suffer a loss in agricultural output that varies from 10 to 25 per cent on average. This is because temperatures will have risen to levels closer to or beyond the thresholds of crop tolerance. Rich countries, which often have lower average temperatures, would have a far milder or even more positive impact on average, ranging from an 8% boost in output to a 6% reduction in production. This is because rich nations are more resilient to the effects of climate change. This is because wealthy nations have a greater capacity to withstand the consequences of climate change. The declines experienced by specific rising countries are far more severe. For instance, the number of deaths in Pakistan might fall between 30 and 40 per cent (Pande and Moharir, 2023).

Fig. 1 Results of models showing possible crop yields in the future



The figure shows the results obtained by running the Hadley climate model for 2020, 2050, and 2080 respectively. The maps indicate that an increase in temperature throughout a huge area of Africa would have a detrimental effect on the amount of food that could be produced. Reduced rainfall in Australia will lead to a loss in agricultural yields. However, in certain circumstances, this drop may be compensated for by irrigation to achieve the same results. There will likely be a favourable influence on food production in North America due to increased rainfall and a slight temperature increase. This is worth keeping an eye out for. It is reasonable to assume that the expense of mitigating the impacts of climate change will fall disproportionately on the countries that now have the lowest living standards (Pathak, 2023).

For us to have an accurate understanding of the maps, we need to bear in mind that the results acquired rely on the climatic conditions, the impact that CO2 levels have on the growth of crops, and the changes in socioeconomic situations. Only then will we have an accurate understanding of the maps? For instance, in industrialized nations, low amounts of rainfall may be compensated for by irrigation, but in less developed countries, such technological solutions are not always accessible. This is because irrigation is more difficult to implement (Warsame, SheikAli et al. 2023).

THE REPERCUSSIONS THAT MAN-MADE CLIMATE CHANGE WILL HAVE ON THE AGRICULTURE OF PAKISTAN

Since ancient times, Pakistan's agriculture has depended more on monsoon rains. Any change in the monsoon's normal course significantly negatively affects agriculture. Even a little increase in temperature is impacting agriculture in Pakistan. These changes in the pre-monsoon period will substantially influence the wheat crop in the Indo-Gangetic Plain (a rise of more than 0.5 degrees Celsius in the time slice 2010-2039; IPCC 2007). Rice production losses during severe droughts (about once every five years) average nearly forty per cent of total output and have an estimated value of eight hundred million dollars (Pandey, 2007). In addition, rice production losses during severe droughts occur approximately once every five years (Kumar, Sahu et al., 2023).

AGRICULTURAL PRODUCTIVITY AND FOOD SECURITY

Both immediately and ultimately, the security of our nation's food supply may be jeopardized due to the effects of climate change. Any change in the environmental circumstances, such as temperature and humidity, that govern crop development will directly affect the quantity of food produced. Temperature and humidity are two examples of environmental factors that regulate crop growth. This is because temperature and humidity are two of the most crucial elements in crop growth. The phrase "indirect relationship" refers to catastrophic phenomena such as floods and droughts, which are anticipated to grow more commonly as a direct effect of climate change(Cao, Halpern et al., 2023).

Wheat production in Pakistan will decrease by 0.45 tons per hectare if winter temperatures rise by 0.5 degrees Celsius, according to estimates provided by the Intergovernmental Panel on Climate Change (IPCC), which is less pessimistic than other projections. Rice and wheat are the two most important crops grown in Pakistan, which together make for a significant share of the country's total output of food grains. Any change in rice and wheat production might substantially affect the nation's ability to provide enough food for its citizens. And this is when Pakistan's agriculture industry is already in crisis, with 2,566,000 farmers committing suicide since 1995. Medium-term climate change estimations have estimated that the expected reduction in agricultural yields due to climate change would be between 4.5 and 9 per cent by the year 2039 (Pande, Kadam et al. 2023, Pande and Moharir 2023, Pathak 2023).

The projections conducted over a longer length of time depict a worsening scenario, with agricultural production anticipated to drop by at least 25 per cent by 2099. We must take action to lessen our vulnerability to the adverse consequences of climate change since there are still 27.5% of people in our country who are living below the federal poverty line. The annual amount of food produced in Pakistan has to be increased by 5 million metric tons for the nation to keep up with its growing population and preserve its level of food security. It will be necessary to practice rigorous resource management to reduce the negative consequences of climate change on agriculture. This management will include the management of soil, water, and biodiversity. Suppose Pakistan will effectively reduce the consequences of climate change on agriculture and food production. In that case, it must take action on several levels, including global, regional, national, and local (Pathak 2023, Warsame, Sheik-Ali et al. 2023). **References**

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