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Cropping pattern to cope with climate change scenario in Pakistan

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In modern eras, the environmental disasters become more intense and frequent due to global warming; a devastation caused by climate change in Pakistan might have far-reaching consequences for the whole nation. Droughts and floods threaten crops, food supplies, animals and lands. Also, farm production, market access, and the water table are all negatively affected by them. Poverty-stricken people with little coping mechanisms are more vulnerable to the effects of climate change, increasing their vulnerability to famine. Natural catastrophes may quickly evolve into food and nutrition crises. Disasters will continue to worsen food poverty and hunger, driving migration and forecasting many humanitarian catastrophes. In the previous 30 years, Pakistan has seen rising temperatures and varying rainfall. Further, the weather in Asia is growing increasingly erratic. In Pakistan's beaches and desert plains, less rain means longer drought. Even though climate change is unavoidable, the most significant threats to the crop pattern are integrated approaches like water management, tillage and nutrient management as well as pest management and breeding approaches such as temperature, moisture, salinity, water logging and drainage congestion resistant genotypes. Adaptation and mitigation must be effective to avoid the largest repercussions on agriculture.

Keywords: Climate change; cropping pattern; Agriculture; Drought; Salinity; Disaster management

INTRODUCTION

Climate change

Change in climatic condition, is an indisputable truth that has serious consequences for human life, particularly food production. Climatic variation is the primary aim of food insecurity since it affects agribusiness profitability, stability, and several segments of the nutrition framework, including usage, access and capacity (Sohail et al. 2021). Modifications in environmental circumstances affect farming and the development of adopting methods by affecting trim efficiency. This is also true in affluent nations since technology mitigating climate change harmful effects is either in development, or too costly. This involves the pursuit of varied adaptation techniques to changing climates in many aspects of life. Climate change is a worldwide issue, although emerging and least developed countries are more vulnerable to it (Gondal et al. 2022).

As a developing nation with an agricultural economy, Pakistan may face severe challenges from climate change. Because Pakistan is a developing country with limited technical skills, it may be used to minimize GHG emissions. Pakistan's normal reserve is arable land output, which contributes 21 percent of GDP through agriculture. In Pakistan, the two most significant crop seasons are Rabi and Kharif, which require specific quantities of rainfall and precipitation that, if exceeded or decreased, reduces agricultural production due to droughts and floods (Naheed and Rasul, 2010; Tayyiba et al. 2021).

Weather

Some experts believe that climate change would cause more spectacular climatic occurrences such as heat waves, dry seasons, powerful gusts, and massive deluges. The environment of models has accurately

forecast such atmospheric phenomena as a result of climate aberrations. Because of ebb and flow, models can't account for whether the number of storms on a hotter globe would be essentially greater, but experts also determined that the kind of ocean storms would change in relation to how long their storm season would last.

Temperature

Climate factors can have an impact on agricultural livelihoods in both good and negative ways. So far, climatic factors such as temperature have had a favorable influence on food production in Pakistan. 97 Nonetheless, research indicates that when temperatures rise, climatic factors will have a considerable detrimental influence on agriculture in the nation. Temperatures fluctuate greatly in Pakistan due to its diverse geography. In the southern provinces of Sindh, Balochistan, and Punjab, the average temperature rose beyond 24°C from 1981 to 2015. Researchers say Pakistan has seen an increase in average temperature. Haensler et al. (2013) find that Pakistan's annual average temperature has increased by 0.60°C since the turn of the twentieth era, according to a multi-modeling system16 they developed.

It has increased at a rate of 0.070°C by 0.35°C on average basis since the 1960s, each decade. Sindh and southwest Balochistan, which are both arid regions, have had growth that is higher than usual. According to Sheikh and colleagues (2009), the national average temperature is increasing. The Balochistan plateau is the only part of Pakistan where they don't see a trend of cooling temperatures throughout rainy season. Agriculture will suffer as a consequence of rising temperatures exacerbated by hot and dry periods and water-stressed circumstances, which will lead to poorer yields.

Humidity

The amount of rain that falls each year varies across Pakistan's unlike geography. Northern parts get more rain 1,000 mm/year than the much dry south 200 mm/year. There have been no significant changes in yearly rainfall amounts; nonetheless, there has been considerable variance in seasonality and precipitation patterns have altered somewhat in regions of Sindh and Punjab. Generally in Pakistan, precipitation levels in Punjab have become more prominent for agriculture. However, studies show that extreme precipitation events are becoming more frequent throughout the country, particularly in Sindh and Balochistan in the north. Floods are caused by excessive rain in Punjab, Sindh, sections of KP, and Balochistan (Zahid and Rasul, 2012).

Rainfall

Annual rainfall varies over Pakistan's varied topography. Northern parts get more rain 1,000 mm/year than the much dry south 200 mm/year. There have been no significant variations in total annual rainfall extents; nevertheless, there has been considerable variance in precipitation patterns, and seasonality has moved somewhat in regions of Punjab and Sindh. There have been no significant changes in yearly rainfall amounts; nonetheless, there has been considerable variance in seasonality and precipitation patterns have altered somewhat in regions of Sindh and Punjab. Generally in Pakistan, precipitation levels in Punjab have become more prominent for agriculture.

Floods are caused by excessive rain over brief periods of time in Punjab, Sindh, sections of KP, and Balochistan. Furthermore, while no universal variations in general precipitation levels are anticipated, the frequency of hot existences during night and day is likely to increase dramatically, resulting in a projected drop in rice and wheat yields.

Impact and causes of climate change

Globalization

Globalization has both advantages and downsides; one of the most significant issues linked with the fate-changing globalization is un-favourable environmental change (Cowens, 2009). Most states are attempting to transition their rural economies to industrial ones while keeping environmental considerations in mind (Nasir & Rehman, 2011). The question now is which habits are generating sudden climate shifts. Humans are mostly responsible for the rising CO2-enriched and hotter planet, with little regard for the environmental impact evaluations of industrial and development initiatives (Leichenko et al. 2010). Climate is mostly caused by the emission of heat-trapping gases, particularly carbon dioxide, from cars, industrial activities, power plants, and deforestation.

Flooding

Floods are a significant climatic danger in Pakistan. Flooding has happened on a regular basis in recent years, wreaking havoc. Over 20 million people were hit by'mega' floods in 2010, while severe flooding in Sindh and Balochistan wreaked havoc in 2011 and 2012. 31 Floods were caused by erratic monsoon rainfall in various areas of Punjab in 2014, while other districts of KP were affected by flooding in 2015. Many people in Chitral, KP, lost their lives in the recent flash floods, which also created significant long-term problems for their families' livelihoods.

Drought

Every 16 years, Pakistan is predicted to suffer from a drought. In June 2015, a devastating heat wave in Sindh killed 1,000 people, but it was only one of many. Food insecurity in rural regions has worsened as a result of drought. Extreme heat destroys grasslands, changes agricultural development, jeopardizes cattle herd viability, and produces recurrent water shortages (Gondal et al. 2021).

Global warming

Human migration, depletion of water resources, crop pattern alterations, decreased yields, and food insecurity is only a few of the negative consequences of global warming.

Salinity

Drought is the principal source of elevated soil salinity, which is a severe threat to vegetable production in irrigated croplands. Plant susceptibility to salt stress is manifested by turgor loss, growth reduction, wilting, leaf curling and epinasty, leaf abscission, reduced photosynthesis, respiratory alterations, loss of cellular integrity, tissue necrosis, and perhaps plant death. Onions are vulnerable to salty soils environment, whilst eggplant, pepper, tomato and cucumber, are somewhat sensitive (Lopez et al. 2011; Pena and Huges, 2007).

Increase in CO_2

It has been observed that atmospheric CO_2 (carbon dioxide) levels increased from 280 to 380 ppm. Since 2000, these points ensure gradually increased by 1.9 ppm per year, owing mostly to the use of petroleum derivatives.

Reduction of nutrients

Carbon dioxide is essential for flora proliferation since it is the base of the photosynthetic activity. Carbon dioxide additions that are small but effective result in increased plant growth and improved CO2 uptake. Higher CO2 levels are projected to result in more harvestable goods. In any event, this is mostly dependent on the availability of appropriate water and plant development nutrients. Nutritional levels may be affected by a single disruption to this long-term production, according to some experts. A lack of manure in trim age might have a substantial influence on human well-being, according to experts (Atta-Krah and Sumberg, 1988).

Invasive species of insects

Arthropod diversity will be greatly impacted by large-scale climate change-induced changes in rainfall. As a result of drought and other harsh climatic occurrences, arthropod populations are expected to become less diverse, which might have a ripple effect on other organisms. The most numerous and diverse group of creatures are arthropods (insects, spiders, and mites) (Gregory et al. 2009; Kannan and James, 2009). Climate change may have a significant impact on the abundance of diverse insect species, and those that are unable to cope with the stresses may go extinct in the near future (Thomas et al. 2004). The rate of extinction is currently 100–1000 times greater than it was before, and 45–275 species are disappearing every day. Multiple extinction variables, such as habitat loss and invasive species, complicate attempts to relate extinctions solely to climate change (Jump and Penuelas, 2005).

Migration and competition of insect pests

Climate change is primarily caused by rising temperatures and higher carbon dioxide concentrations in the atmosphere. Because climate change is now seen to be more definite, it is time for researchers to devise management measures to deal with the increased prevalence of pests as due to climate change. Temperature extremes are one of the environmental variables that influence the proliferation of insect pests. Our observations show that there has been a'shift' in the pest status of numerous major species in recent years, however these alterations may not be entirely because of climatic changes. Significant changes in the growth, enlargement, and population dynamics of many insect pests might be expected under the current circumstances. Increased temperature and CO_2 concentrations modify the duration of the insect life cycle, resulting in a varying number of generations every year.

Many studies have found that when CO_2 levels are raised, leaf chewing insects consume more vegetation and have longer larval lifespans. According to published data, certain pests become more harmful, while others may drop. Evaluating the inspiration of climate change on insect is a problematic task that necessitates a deeper knowledge of the interplay of variables. For farmers to develop adaptation strategies, a more essential database on biotic stressors and their interaction with climate change drivers is necessary. While crops are expected to respond to increased CO2 levels with vigorous vegetative growth, other flora are also expected to respond in a similar manner. Weeds have become more profitable and are being forced to invade new dwelling habitats as global climate change accelerates. For example, scientists discovered that the poison ivy actually results in higher quantities of dangerous carbon dioxide in the environment. Herbicides are also less intense in greater carbon dioxide conditions, meaning that larger rates of herbicides will be required to achieve comparable levels of control.

Because climatic conditions have a substantial impact on the growth, reproduction, and survival of insect pests and their natural adversaries, insects are anticipated to be the most affected by climate change (Bale et al. 2002). As a result of their shorter generation times and greater reproduction rates, insects are better equipped to adapt to adverse climatic environment than vertebrates and crop plants. A variety of retorts, including fluctuations in phonological patterning, habitation assortment and development, and regional distribution reduction, are all conceivable. Embryos will develop quicker and adults will emerge sooner than ever before if global warming continues at its present rate. Premature adult appearance as well as an upsurge in flight time has been seen as possible reactions to climate change. Butterflies in Europe have seen their flight time’s increase by 2 to 10 days per 1°C rise in heat or temperature (Stefanescu et al. 2003). Butterfly emergence in Spain and California has increased

by 1 to 7 weeks during the last 15 years (Forister and Shapiro, 2003). Some microlepidoptera species in Europe have also shown varying phenology (Ellis et al. 1997).

Shift in Spatial Boundaries of Crop Potential Areas and change in productivity

Climate change (increased temperatures and less soil moisture) is modifying the duration of the growing season, impacting the amount and quality of biomass, maladies, and involving spatial shifts in possible ranges of agricultural goods. Environmental change affects the value and quantity of harvest production in two ways: a) directly due to temperature fluctuations, reduced water availability or CO_2 fixation, uncommon occurrences, and b) indirectly due to differences in circulation, recurrence or intensity of irritation or infection episodes or the pace, at which flames are spread, weed invasion or soil changes.

Water crisis

Extreme hydrological events are becoming more common in Pakistan, as they are in many other parts of the world, in a variety of forms, including flash floods in steep watercourses in the north. It has been discovered in water availability studies of the Kabul River Basin, a snow melt-fed basin, where there is a sharper peak with a noticeable change in the annual peak flow by a month. A significant finding of this Kabul River Basin study is that larger annual maximum flows occur more often. One other research looked at the glacier-fed Gilgit River Basin and found that rising temperatures cause glaciers to melt faster, resulting in a month earlier but flatter peak in water flow.

Cyclones and tropical storms

The Arabian Sea seldom experiences tropical storms or cyclones. Sindh's coast is at risk if they make it to Pakistan. The monsoon season has a key effect in the occurrence of cyclones between September and October and May and June. When tropical storms make landfall in Pakistan, they are usually weaker and often detour towards India.

Impact of climate change on cropping pattern

Crop management strategies have an impact on the conservation of soil and water resources. A variety of cropping patterns, including monoculture, continuous cropping, crop rotations, and multiple cropping patterns, all play a role in a farmer's crop management strategy. Biophysical and socioeconomic considerations, as well as the farmer's decision-making process, all have a role in the selection of crop patterns. In rain-fed areas, cropping patterns are more varied. Currently, cropping patterns are out of step with the rainfall patterns. In the rain-fed Pothwar area, 80 percent of farmers use summer fallow to stabilize wheat (Razzaq et al. 2002).

Rainfall and soil water content affect crop yields and intensity in rain-fed areas on a year-to-year basis. Wheat yield is low, but it may be increased with careful management of production factors. The capacity of legumes to transfer nitrogen from the atmosphere into organic soil reserves makes them a crucial component of sustainable agriculture systems in the semi-arid tropics. For sustainable agricultural systems, legumes' ability to fix their own nitrogen is a no-brainer. Legumes fix a large amount of the nitrogen that is used by cereals and other grains. With legume cereal cropping sequence, production improvements were highest at Mandra and lowest at Islamabad, according to Asim et al. (2006).

The average advances in straw and grain yields were 2.50 ton/hac at Islamabad and 6.20 ton/hac at Mandra, equating to yield improvements of 0.490 ton/hac at Mandra and 0.030 ton/hac at Islamabad. At four separate locations in Niger and Burkina Faso in West Africa, Rifat and Safdar (2010) performed research on legume and cereal rotation. They found that rotations of legumes and cereals increased harvest yields of cereal grain and total dry matter at all sites. As a result of N use and N efficiency, the effects of rotations may be muddied.

In a study, Asim et al. (2006) found that wheat growth, development, and production were significantly affected when mung bean was followed by fallow rather than a fallow field. Mung bean wheat crop rotation generated net financial benefits of Rs.5820/hectare.

Impact on agriculture

Agriculture is the most important sector of any economy, yet it is constantly harmed by climate change. Terminated time, the possessions of climate change have grown increasingly misleading (Patt et al. 2009). Agriculture, which is the backbone of the Pakistani economy, accounts for 21.4 percent of GDP. Agriculture employs over 45 percent of the country's workforce, with two-thirds of the country's population living in rural regions directly or indirectly dependent on this industry for a living (Govt. of Pakistan, 2013). Irrigated land accounts for 19.62 million hectares of Pakistan's total culturable land, whereas culturable waste accounts for 8.32 million hectares (Bhutta, 1999; Salma et al. 2012).

Changes in Land Use Pattern and coastal agriculture

An increase in global temperature, climatic limits, and CO_2 concentrations would result in adjustments in arrive utilization frameworks due to changes in product development periods.

Table 1: Impact of climate change of different agro-ecological zones of Pakistan

Agro ecological zone	Province	Impact of climate change
Northern dry mountains	GB	Erratic, cool temperatures and torrential rainfall patterns
	KP and FATA	Glacial lake outburst floods (GLOFs) and torrential rains
Western dry mountains	Balochistan	Semi-arid uplands with long cold winters and mild short summers, droughts and flash floods
Sulaiman Piedmont	KP and FATA	Semi-arid highlands, prone to flash drought and floods
	Balochistan and Punjab	Hot arid climate and drought prone
Dry western plateau	Balochistan	Hot summers 38 to 44°C, droughts and cold winters 3 to 6°C
Wet mountains	Punjab and KPK	Floods
	KPK	Both humid and arid climate with 116-235mm rainfall
	AJK	Erratic rainfall

Increasing water logging and salinity in dry areas would be ideal for a ranger service and aquaculture combine with yield-based agricultural frameworks if climate change occurs. As a result of the rush of seawater into the mangroves, Indus delta, fish breeding sites and coastal agriculture have been adversely affected. Climate change is causing this salty water incursion. Crop production is influenced by climate change in a wide range of ways, necessitating measures to combat the danger presented by climate change to agriculture. A wide range of innovative, political authoritative and institutional levels may be used to accomplish efficiency, relief, and adjustment measures (Arakelyan et al. 2017).

Adaptations to climate change w.r.t agriculture

Many prospective agricultural adjustment solutions have been offered, which are techniques or practices that might be used to reduce the usual antagonistic impact. They comprise a broad range of structures (specialist, budgetary, and administrative), sizes (global, local, and neighborhood), and members (governments, agriculturist and companies) (Skinner et al. 2001; Smithers and Smit 1997). Many of them refer to possible, hypothetical, or modification measures, rather than ones that have been implemented. The effects of environmental change frequently influence specific changes, despite the fact that the process of change itself remains hazy (Smit & Skinner, 2002). Despite the considerable influence of climate change, including changeability and extremes, agricultural change does not function and is not created solely in response to these climatic enhancements. Non-climatic forces, such as monetary situations, governmental concerns, nature, society, and innovation, undeniably have a substantial impact on horticulture basic leadership, especially flexible basic leadership (Parry et al. 2004).

A broad range of features of rural generation may be affected by natural changes. Harvest and biological system responses will advance, affecting important agricultural operations, as more major atmospheric inconsistency, altering temperature and precipitation patterns, and other components of global change are introduced. All of these factors have a direct influence on nutrient production or sustenance security, including changes in supplement cycling and soil moisture, as well as changes in nuisance or disease infections (Fuhrer et al. 2003). In the future, agricultural frameworks will be able to take a more active role in addressing abiotic and biotic issues due to these improvements.

All that can be done to mitigate the negative effects of climate change on vegetable production, including productivity, quality, and yield, are effective and efficient procedures. Effective solutions for reducing the consequences of climate change in agriculture include the adoption of heat and salt stress-resistant crops, flood and drought-tolerant soil conservation measures, fertiliser management via fertigation, and plant regulators.

CONCLUSION

It is well recognized that the agriculture ecosystem system has been directly impacted by climate change, posing problems to food security, food production, distribution, and consumption systems. Agriculture methods in South Asia are changing noticeably. Because of its geographical layout, the area is one of the most sensitive to climate change. The climate change trend in South Asia exhibits notable changes and risks in weather patterns, which have a direct influence on the agricultural sector. The Climate Danger Index indicates that the risk of unprecedented climate change shocks is growing. People living in poverty and women are the utmost susceptible to the possessions of typical weather change. To deal with the effects of climate change on agriculture, several adaptation and mitigation methods are required. There is a need for study to address these issues: Investigate the know-how of food production patterns and offer solutions to boost the yield of healthy food even during climate changes. Create a model and, if applicable, reproduce it in other areas. Investigate how subsistence farmers are

adjusting to climate revolution and other socioeconomic issues in order to sustain their livelihoods. To explore whether policy tools address concerns of equality, particularly the well-being of disadvantaged populations. Investigate how individuals contribute to the sustainable management of natural resources and biodiversity in the face of climate change.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors equally contribute to carry out the present study; review and write the manuscript. All authors have read and agreed to the published version of the manuscript.

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