



RESEARCH PAPER

Climate Change: Threats to Agricultural Growth Sustainability in Pakistan and Government Policies

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ABSTRACT

This study examines the impact of climate change on Pakistan's agriculture, evaluates government measures, and proposes strategies to ensure sustainability. Pakistan's agricultural sector faces severe threats from rising temperatures, erratic rainfall, and extreme weather events. These changes jeopardize the production of staple crops like rice and wheat, vital for the economy and food security. The research employs qualitative exploratory method to assess climate change risks and government interventions. Climate change significantly reduces crop yields due to altered precipitation patterns and rising temperatures, threatening food security and agricultural sustainability. To address these challenges, the study suggests redistributing public funds, enhancing water storage, promoting community-based natural resource management, and investing in research and development for climate-smart agriculture. Implementing these strategies can improve resilience, safeguard food security, and benefit millions of Pakistanis' health and well-being.

Keywords: Agricultural Sectors, Climate Change, Government Policies, Pakistan, Sustainability

Introduction

Climate change presents a significant threat to the sustainability and expansion of the agricultural sector in Pakistan, where it is a key economic pillar and the primary source of income for a considerable portion of the population. (Nadeem, Yaseen, & Muzaffar, 2023). Pakistan is especially susceptible to the effects of climate change. Such as rising temperature, unpredictable rainfall patterns, and an increase in the frequency of extreme weather events like floods and droughts, because of its varied climate and topography. These modifications have the potential to seriously impair rural economies, imperil food security and alter agricultural output. Over the past few decades, the effects of climate change have been more noticeable. The term "climate change" describes the substantial and protracted change to the earth's climate change over a lengthy period of time. It encompasses global variation in temperature, precipitation, wind patterns and other meteorological factors. Due to its effects on retaining heat in the upper climate, ozone harming chemical emissions (GHS) from the widespread use of non-renewable energy source is most likely the primary source.

Agriculture is critical to human survival and it's likely the human business most vulnerable to climate change. The agriculture sector is Pakistan's single largest economic sector and its lifeline. It employs 42.3% of the labor force, contributes 18.9% of GDP and generates 80% of total export revenues. Pakistan has released the national food security policy in 2018 with one of its goals being to increase agricultural productivity, profitability and climate resilience. Agriculture in Pakistan is heavily influenced by short term climate fluctuation and may be severely damaged by long term climate change. The duration of

agricultural growth cycles is proportional to temperature; hence a rise in temperature will accelerate crop growth and shorten the period between sowing and harvesting. The shortening could reduce crop output and food for cattle. Global warming is also expected to have an impact on the hydrological cycle, promoting adaptation by the agriculture and cattle industries particularly in rain-fed areas.

Pakistan is one of the most prominent regions in terms of climatic variability. Floods and dry spells are the leading causes of monetary and social risks for people, among other typical risks to which people are exposed, and they contribute to an increase in mortality. Rural residents, particularly in non-industrialized countries, are typically powerless to floods due to limited adaptability and resources. Flooding in developing countries is mostly caused by natural and meteorological fluctuations. If the professional recognizable proof of the effects of variability in climatic conditions on cultivating structures isn't finished effectively, it might especially and unfavorably influence food efficiency and its wellness. Furthermore, it may be an impediment to efforts to reduce neediness and promote favorable outcomes. Pakistan is an agrarian nation, where the overall contribution of farming area to GDP is 21.9%, and directly or indirectly employs 45% of the nation's total workforce, comprising approximately 60% of provincial occupants; thus, any unfavorable result of climatic activities could impact their livelihoods.

Literature Review

Climate change is having a significant impact on Pakistan's agricultural industry. The constant rise in temperature, changing in weather pattern and more frequently climate change events are significantly reducing crops yields, affecting food security and posing major danger to life in rural areas. The major threats to agricultural growth by climate change are temperature and precipitation changing, water scarcity, extreme weather events and their impacts on livelihood. Farmers were observed using more groundwater, resulting in a scarcity of water and less fruitful soil. To maintain agricultural sustainability, Pakistan needs to emphasize climate-resilient agricultural methods, increase farmer awareness and capacity, enhance water management, and promote crop diversity. To overcome these threats Pakistan's government adopted strategies like promoting sustainability practices, support financial mechanisms and international collaboration with different international organizations. (Aitzaz, Aatizaz, & Aatzaz, 2024).

Global warming is a constant danger to food security and the agricultural production system. The agricultural industry has significant challenges in achieving sustainable development goals mainly due to the direct and indirect effects of ongoing climate change. Although many businesses are facing the problem of climate change, the impact on agriculture is immense. The policy implementation has also been evaluated, which showed that government involvement is critical for the nation's long-term growth since it ensures severe responsibility for the instruments and regulations previously enacted to create cutting-edge climate policies. As a result, it is critical to reduce or adapt to the effects of climate change since, in order to preserve global survival, confronting this global threat requires a collective global commitment to mitigating its severe repercussions. (Saleem, Anwar, & Nawaz, 2024).

Climate change has massive socio-economic implications that researchers are concerned about. Pakistan's geographical diversity makes it especially vulnerable to climate change. The huge latitudinal area has almost 5000 glaciers in the northern sections that remain frozen and provide water all year. The melting glaciers in northern parts and rains from the Arabian Sea are crucial for water supply, agriculture, and energy generation. Change in the climate causes unpredictable weather, leading to extreme disasters and food shortages in Pakistan. Climate change has had an important effect on Pakistan's food security, including availability, access, use, and stability. Government of Pakistan makes

several policies to minimize the threats of climate change on our agricultural sectors. (Amjad, 2023).

Framework for National Climate Change Policy The establishment of Pakistan's National Climate Change Policy (NCCP) in 2012 was an important step toward addressing the many complicated issues posed by climate change. It covers methods for mitigation and adaptation in all critical areas, such as agriculture, water resources, and energy (Ministry of climate change, 2012).

To attain sustained progress in Pakistan in the face of extreme climatic danger that affects agricultural sectors, the government must make a fundamental policy shift. The government should prioritize incorporating climate change into economic planning and development strategies. To make sure that climate plans are implemented, institutional structures must be strengthened not only within but also across sectors. Furthermore, increased money should be directed toward green technology and renewable energy sources, which reduce environmental damage while creating economic opportunities (Rafique, sheraz, 2024).

Climate change has a substantial impact on agricultural production and advancement, particularly in drought-prone areas where farmers depend heavily on rainfall for their livelihood. For decades, global warming has been one of the most serious dangers to the agricultural industry, which is especially dependent on climatic conditions. Because of significant changes in urbanization, industry, and agricultural systems, climate change has emerged as a critical threat preventing long-term development. Food security, a global issue, is another critical component linked to a country's economy and people's livelihoods. (Khan, Ma, Zhang & Zhang, 2023).

The agriculture sector is Pakistan's backbone, employing 45% of the low-income population. Insufficient management of canal irrigation and livestock, as well as excessive chemical and fertilizer use are negatively impacting human health, the environment, and sustainability. In Pakistan, the challenges to achieving environmental and agricultural sustainability include poor water efficiency, flood irrigation systems, traditional cultivation techniques, excessive and improper use of pesticides and fertilizers, poor drainage of canal irrigation systems, energy crises, and poor governance. To achieve Pakistan Vision 2025, an extensive policy, strong strategy, and good governance at all levels are required to improve productivity and sustainability through efficient use of water and energy, proper pesticide use, land management, and modernization of cultivation techniques (Muzaffar, Fern & Yaseen, 2023; Hassan, Ali, Amir, Ahmed, Khan, & Abbas, 2016; Muzaffar, M., Fern & Yaseen, 2024).

As the agriculture and water sectors are so interrelated, many water resource adaptation strategies also apply to the agriculture sector. In order to improve the agricultural sustainability of national food security, the Pakistani government, has adopted many policies to control the effects of climate change on the physical, chemical, biological, and financial components of agricultural production systems across various agricultural ecological zones can be evaluated using digital simulation models, new varieties of crops, resistance to heat stress, introduce better breeds to reduce the risk on agricultural growth. (Ministry of Climate Change, 2021).

The province's agricultural contribution has decreased from 31% to 20% as a result of climate change's effects, which include crop failure, water scarcity, environmental and soil degradation, inefficient use of agricultural inputs, and decreased crop yield. Punjab uses river basins, canal farming, and, in certain places, hill torrents for agricultural purposes. These methods can all be significantly impacted by the effects of climate change. A significant amount of greenhouse gases (GHG) are released into the atmosphere by the

agriculture sector. Deforestation decreases the soil's capacity to store carbon by making land available for agriculture. (Ministry of Climate Change, 2021).

Agriculture is extremely important to Pakistan. Climate change is a major driver of agricultural productivity around the world. This sector is the most sensitive to climate change. Climate change-related issues such as temperature and rainfall patterns have an impact on this sector's productivity. The current research uses time series data from 1985 to 2018 from the Pakistan Economic Survey, Pakistan's Metrology Department, and the World Bank. The adaptive distributed lag model is used to assess the influence of climate change on agricultural productivity in Pakistan. (Shafiq, Gillani & Shafiq, 2021).

Material and Methods

The study was conducted using a historical descriptive and analytical methodology in order to go forward and reach a conclusion. The qualitative method was applied in this case. The entire set of data used in this study was come from published works in print media, such as books, articles, journals, official reports from organizations, and expert websites. The research evaluate climate change threats to agricultural growth in Pakistan combines comprehensive data collecting with analytical techniques that highlight the multiple effects of climate variability. As governmental policies evolve in response to these issues, there is an urgent need for continued research and adaptation measures to protect food security and increase agricultural output in the face of changing climate.

Results and Discussion

The results indicate a clear influence of climate change on agriculture survival, with rising temperatures and changing patterns of precipitation resulting in a sharp drop in crop yields (up to 20% in some districts). The study examines the profound effects of these transformations, including increased frequency and intensity of extreme weather conditions, polluted land, water scarcity, and altered seasonal patterns. The findings indicate the growing impact of climate change on pest and disease pressure, hence lowering crop resilience (Aitzaz, Aatizaz & Aatzaz. el.at, 2024). These findings underscore the importance of proactive transformation processes, environmentally sound agricultural technologies, and strategic support in mitigating the negative effects of environmental change on food security and agricultural products. The study's findings underscore the principles of a well-planned response to this grave threat. For Pakistan, the combination of climate change and sustainable agriculture presents formidable obstacles. Even though the government is taking steps to address these problems, in order to guarantee food security and economic stability in the face of persistent climate threats, comprehensive strategies that integrate sustainable practices, technological advancements, and strong support networks for vulnerable populations are essential.

Threats to Agricultural Growth Sustainability in Pakistan

Agriculture is essential to Pakistan's economy, employing over 40% of the workforce and providing about 20% of GDP. However, climate change endangers the agricultural sector's future survival and expansion. Due to its location in a geological area where temperatures rise more than the average, Pakistan, a warm country, is particularly vulnerable to barometric shifts. The terrestrial area is mostly dry and semi-arid (around 60% of the region receives less than 250 mm of precipitation annually, and 24% receives between 250 and 500 mm); the Himalayan, Hindu Kush, and Karakoram ice sheets mostly provide the rivers. They are rapidly declining as a result of the hazardous atmospheric degradation; the economy is agrarian and therefore extremely helpless. If preparations are not taken, there is a good likelihood that Pakistan would face increasing risks of rainfall irregularities in the years to come (Amjad, 2023).

It will automatically calculate the amount of precipitation that regularly results in both extensive dry seasons and exceptional floods. The agricultural industry, energy security, flood security, and water security in Pakistan are all significantly impacted by the aforementioned variables. Farming is the main source of income in Pakistan, employing about 45% of the workforce, contributing 21% to GDP, and providing nearly 60% of the nation's export earnings. According to estimates, Pakistan has 18.63 million hectares recently inundated and 23.4 million hectares under development. With 77% of Punjab flooded and smaller amounts in other areas, Pakistan's water system is essential. Some of the major threats include:

Erratic Weather Patterns

Extreme weather occurrences in Pakistan have become more frequent and intense, including heat waves, floods, and droughts. These erratic weather patterns disrupt agricultural seasons, reduce crop yields, and harm infrastructure.

Temperature Increases

By the end of the century, Pakistan's average temperatures are predicted to climb by 3 to 6 degrees Celsius, which is greater than the global average. Crop yields are adversely impacted by this increase, especially in warmer climates where wheat is typically cultivated.

Water Scarcity

Climate change is predicted to worsen the already serious problem of water supply by decreasing the amount of water available for irrigation, which would put food production at even greater risk (Aitaz, et. al, 2024). Climate change contributes to Pakistan's severe water scarcity in agriculture. The primary causes of the country's declining freshwater resources include reduced glacier melt in the Himalayas, erratic rainfall patterns, and unsustainable groundwater extraction supplies from the River Indus.

Crop Yields

Studies suggest that by 2080, rising temperatures could result in a 6–11% decline in wheat yields and a 15–18% decline in basmati rice yields. Furthermore, there may be a 20–30% decline in cattle production, which would impact the price and accessibility of food. Reduced crop yield as a result of inadequate irrigation, crops like wheat, rice and cotton that need frequent watering.

Pests and Diseases

Climate change alters ecosystems, leading to the proliferation of diseases and pests that were previously controlled by natural conditions. Warmer weather and fluctuating humidity are key factors for pests like locusts, which have decimated crops in several parts of Pakistan, particularly in 2020–2021.

Soil Degradation

Changing weather patterns can contribute to soil erosion and degradation, particularly in arid and semi-arid regions. Drought conditions can lower soil fertility, whereas heavy rains and flooding can cause soil loss. This lowers soil production and health, endangering long-term agricultural sustainability. One of the biggest challenges to agricultural sustainability is low soil gradation and salinization brought on by rising temperatures and irregular precipitation (Gillani & shafiq.et.al. 2021). Food security and agricultural production are being significantly impacted by the loss of soil ripeness and efficiency. In Pakistan, environmental change affects the health and ripeness of the soil.

Decreased water-holding capacity, nutrient exhaustion, and soil disintegration are caused by rising temperatures and altered precipitation patterns. This led to increased emissions of ozone-depleting substances, decreased soil carbon sequestration, and decreased crop yields.

Impact on Livestock and Fisheries

Climate change impacts not only grain cultivation but also fisheries and animals. Long-term heat stress affects meat production and lowers dairy farming productivity. Fish populations are also impacted by fisheries issues brought on by rising water salinity and temperatures.

Food Insecurity

A prolonged decline in crop output and the use of the least effective methods are two causes of the costly food scarcity. As a result of this volatility, the most vulnerable residents of the country will have to bear the weight of growing hunger and health problems. Changes in growing seasons, lower harvest yields, and decreased livestock output are some of the ways that climate change significantly affects Pakistan's food security. Because of the reduced food supply, restricted access to nutrient-dense foods, and inflation, this has a major effect on the poor class.

Government Policies and Responses

When the Pakistani government realized how severely climate change was harming agriculture's sustainability, it took a number of actions to address the problem. However, these initiatives have had inconsistent results, and there are still major challenges to be solved. Included in its development goal, the Pakistani government has begun to prioritize adaptation to climate change. The necessity of taking concrete steps to mitigate the impact of climate change on agriculture is becoming increasingly apparent to policymakers (Ministry of Pakistan, 2021).

National Climate Change Policy (2012)

Pakistan established the National Climate Change Policy (NCCP) in 2012 to address the consequences of climate change through adaptation and mitigation strategies. Among the primary objectives are: Promoting climate-resilient farming practices; guaranteeing efficient water resource management and conservation; and introducing drought- and flood-resistant agricultural varieties. Despite the policy's ambitious goals, implementation has been slow due to a lack of funding, coordination, and monitoring systems.

National Water Policy (2018)

After recognizing the consequences of water scarcity, Pakistan enacted the National Water Policy in 2018. Building new dams to improve the amount of water that can be stored is one of its primary goals. Promoting water-saving agriculture technology. Ensuring equitable distribution of water resources. However, there are still challenges with water management, particularly given the ongoing infrastructure issues and the growing demands of the agricultural sector.

Climate Smart Agriculture (CSA) Initiatives

The government has also started to encourage Climate Smart Agriculture (CSA) methods in an attempt to increase resilience to climate change. These include: Using drought-resistant agricultural varieties. Improved irrigation methods, including as drip and sprinkler systems. Farmers can use climate forecasts and early warning systems to get ready

for extreme weather. Notwithstanding the potential of these initiatives, poor awareness, a lack of finance, and restricted access to technology in rural areas are barriers to their widespread adoption.

Sustainable Land Management (SLM) Programs

The government has launched projects focused on Sustainable Land Management (SLM), including afforestation and soil conservation initiatives, to combat desertification and soil erosion in vulnerable regions like Sindh and Baluchistan. The scale of these projects is still inadequate, though, given the enormous areas affected by land degradation.

Disaster Risk Management Framework

Due to its frequent disasters, Pakistan has implemented a Disaster Risk Management Framework to reduce its susceptibility to heat waves, droughts, and floods. This framework consists of: Software systems for disaster response. Provide impacted farmers with cash assistance through compensation plans. Creating mechanisms for early warning of severe weather.

Conclusion

An important and expanding threat to Pakistan's agricultural industry which is the backbone of the country's economy and food security is climate change. Unpredictable weather events like floods, droughts, and extremely high or low temperatures are already having a negative influence on soil health, crop output, and water scarcity. These changes weaken the resilience of rural populations that depend on farming for their livelihoods and threaten the sustainability of important agricultural crops like cotton, rice, and wheat (Saleem, Anwar & Nawaz. et.al. 2024).

The immediate response is that Pakistan's agricultural sustainability is being threatened by climate change. When it comes to rising temperatures, perceptual uncertainty, and exceptional climate occurrences, the nation's farming industry is extremely vulnerable. All of these elements disrupt food security and help to reduce byproducts. An admirable hazard to the cultivation is created by the deteriorating groundwater level and the disrupted rain cycle. The efficiency of the results is further diminished by soil degradation and a growing number of pests. An already vulnerable farming community is further burdened by all of these circumstances.

The Pakistani government has acknowledged the urgency of tackling climate change through a number of policies and initiatives, such as the National Water Policy (2018), the National Climate Change Policy (2012), and programs that support Climate Smart Agriculture (CSA) and Sustainable Land Management (SLM). However, these policies' sluggish adoption, lack of finance, and coordination problems has restricted their impact. Farmers' lack of education and awareness about climate dangers has also made it more difficult to apply adaption strategies.

Pakistani governments face a challenging issue with climate change and agriculture that need immediate attention. Although efforts are being made to implement adaptive techniques and encourage agricultural resilience, their success will depend on sustained political will, adequate funding, and local residents' active involvement. Addressing these issues holistically is critical to sustaining food security and economic stability in the face of rising climate threats.

By implementing this action plan, Pakistan would be able to avoid additional agricultural degradation while also ensuring food security and developing a well-organized system for the population with no damage from climate change. Seriousness in terms of

successful policy initiation and implementation is critical since it will determine the prosperity of future generations.

Recommendations

Pakistan should try to promote climate-resistant crop varieties. The country should try to invest resources in creative work on yield varieties that are resistant to drought, intensity, and pests (Ministry of Pakistan, 2012). This includes hereditarily modified crops as well as traditional rearing methods to increase crop adaptability. Encourage the adoption of environmentally friendly farming practices such as protective culturing, agroforestry, and coordinated both the board to improve soil health and increase crop yields. Furthermore, water conservation methods should be promoted from the grassroots level. Execute profitable water system procedures, such as dribbling and reaping. Advance approaches that aid in the efficient use of groundwater and surface water resources. Advance yield enhancement and intercropping to reduce reliance on a few crops. This can improve flexibility in response to environmental concerns and market volatility. Disseminating educational and vocational practices among farmers is an important step in achieving long-term agricultural development in Pakistan. In addition to governmental regulations, the following suggestions are offered to address the risks posed by climate change to agriculture:

Promoting Climate-Resilient Crop Varieties

Crop yields and productivity are impacted by rising temperatures, droughts, and floods, especially for important crops like cotton, rice, and wheat. Enhance the genetic quality of crops to increase their resistance to climate stress. Funding for agricultural research organizations should be increased by the government in order to create high-yield, climate-resilient cultivars. To obtain access to climate-smart technologies, collaborate with international agricultural research organizations. Put seed distribution programs into action to guarantee farmers have access to improved cultivars.

Water Management and Irrigation Efficiency

Encourage water-saving irrigation methods including sprinkler systems and drip irrigation. Encourage the installation of rainwater collection devices to supplement irrigation, especially in arid regions. Put in place efficient water management techniques, such as real-time weather monitoring systems and soil moisture monitors. The government ought to assist in setting up new irrigation systems and instruct farmers on water management practices. Invest more in water-saving infrastructure, such building reservoirs and restoring wetlands. Reduce waste by enforcing water-use regulations, especially in regions with limited water supplies.

Disaster Preparedness and Early Warning Systems

Create early warning systems to alert farmers about possible weather disasters such as heat waves and floods. Encourage farmers to receive disaster preparedness training so they can make sure they have plans in place for severe weather conditions. The government ought to incorporate agriculture into climate risk management and fortify the country's framework for disaster management. Give farmers insurance policies and financial support to help them recover from climate-related disasters. Establish a national disaster fund to aid in the prompt response and post-disaster recovery of agricultural areas.

Strengthening the Agricultural Extension System

Extend the agricultural extension program to teach farmers water conservation, pest control, and climate-resilient farming techniques. Disseminate climate-related

information and farming recommendations via social media and mobile devices. Funding for agricultural extension services should be increased by the government, and extension staff should receive enough training on climate change adaptation. Provide mobile agricultural advisory services that offer up-to-date market and climate data. Encourage non-governmental groups and agribusinesses to collaborate in educating farmers about climate change.

Promoting Sustainable Agricultural Practices

Encourage integrated pest management (IPM), organic farming, and agricultural ecology to improve soil health and lessen dependency on chemicals. Promote crop diversification to reduce the risk of crop failures brought on by stress from the climate. Farmers who employ ecologically friendly inputs and organic farming methods should get financial incentives or subsidies from the government. Organize training sessions on the benefits of crop variety and sustainable agricultural methods. Enforce regulations to promote environmentally friendly substitutes and reduce the overuse of hazardous substances.

The many threats posed by climate change have placed Pakistan's agricultural economy in a precarious position. By putting in place thorough adaptation plans, making investments in sustainable practices, and enhancing government support networks, Pakistan may endeavor to safeguard its agricultural future in the face of climate change. By creating and sharing accurate weather forecasting and early warning systems, we can help farmers make informed choices and take proactive measures to safeguard their crops from severe weather conditions. Educate and train farmers on environmentally friendly transformation systems and manageable horticultural practices. Strengthen growing administrations to close the knowledge gap between experts and laypeople.

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