

**Climate Change in Pakistan: Agriculture, Water Resources, Socio-Economic Vulnerability,
and Policy Responses**

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ABSTRACT

The issue of climate change has become one of the most urgent developments in Pakistan, which has a minimal contribution to the global emissions of greenhouse gases but at the same time is the one of the most climate-exposed countries in the world. The present paper analyzed the environmental, economical and socio-social effects of climate change in Pakistan based on qualitative research design through analysis of secondary data. Reported data of the Intergovernmental panel on climate change, the Pakistan meteorological department, the world bank, peer reviewed journal articles and government publications were used to gather data. The results have shown a steady increase in the trend of climatic changes, frequency of sporadic severe heat waves, amplified variability of monsoons, enhanced melting of glaciers in the northern mountain ranges, and repetitive widespread flooding. These climatic variability have had a fundamental effect on agricultural production, water security, human health and socio-economic stability, which disproportionately affects the vulnerable populations. The analysis also indicates that although Pakistan has formulated policy frameworks that are consistent with international commitments like the Paris agreement, effective adaptation and mitigation is hampered by gaps in implementation, financial constraint and institutional weaknesses. The research arrives at the conclusion that in Pakistan climate change is a threat multiplier that develops the poverty, inequality and development problems. To achieve sustainable development and long-term resilience, stronger climate governance, climate-resilient infrastructure, and water resource management policy changes, and better climate finance at the international level are needed.

Keywords: Climate change, Pakistan, global warming, floods, melting glaciers, water scarcity, climate vulnerability, sustainable development, adaptation, mitigation

INTRODUCTION

Climate change is defined as a permanent change in temperature, precipitation, and other weather conditions with the major cause being human activities which include burning fossil fuel, deforestation, and industrialization. As stated by Intergovernmental panel on climate change (IPCC), the global temperature has risen considerably compared to the time before industrialization and caused extensive environmental disturbances (IPCC, 2021). The situation is more skewed towards developing countries since

they have few resources and adaptive capacity. Pakistan is one of the most exposed countries that are exposed to the worst climate threats even though it makes a small contribution to the global carbon emissions.

The country of Pakistan is especially sensitive to the changes in climate because of its geographical position. The country, which is located in South Asia, lies within a wide variety of ecological zones, stretching all the way to glaciers in the north and coasts of the Arabian Sea. The Himalayas, Karakoram and Hindu Kush mountain ranges form part of the northern region, and contain some of the largest glaciers other than those found in the polar regions. The glaciers play an important role in freshwater to the Indus River system, which sustains agriculture and livelihoods in the nation. Nonetheless, the warming climate has hastened the melting of glaciers, which threatens glacial lake overflows (GLOFs) (Ali et al., 2019).

In the last several decades, there is an increase in average temperatures, extended heatwaves, and unpredictable rainfall in monsoons in Pakistan. Extreme weather events have become highly frequent and more severe. Recent examples of floods include the 2010 floods, where almost 20 million people were impacted, and the devastating floods of 2022, which submerged a third of the nation displacing millions of people and resulting in billions of dollars in economic damages (Government of Pakistan, 2023). These incidences underscore the close relationship between climatic change and natural calamities in Pakistan.

The agricultural sector that constitutes a significant source of the Pakistani GDP and provides a considerable number of the population with their jobs is the one that is extremely sensitive to climatic conditions. The variability in the rainfall and temperature shifts have decreased crop production and raised the rate of pests and diseases (Abid et al., 2016). Shortage of water has also intensified as a result of dwindling per capita water, accelerated population growth and poor irrigation methods. Indus Basin irrigation system is one of the largest in the world which is subject to huge pressure due to climate change as well as poor management.

On top of the environmental and economical effects, climate change has severe social problems. Women, children and rural groups are vulnerable populations that are disproportionately impacted. Displacement and migration caused by climate are also becoming a source of concern especially in flood prone and drought affected regions. Cities like Karachi are becoming more vulnerable to heatwaves and rise in the sea level threatening to damage infrastructure and health of the population (Khan et al., 2020). The Karachi heatwave of 2015, in its turn, killed more than 1,200 people because of the high temperatures and insufficient planning.

The coastal belt and Indus delta in particular of Pakistan are experiencing increasing sea level and intrusion of salt water and they are posing a threat to agriculture and fresh water sources. Due to environmental degradation and climatic fluctuations, mangrove forests, considered as natural walls against storms, are experiencing a lot of pressure. The vulnerability of the coastline is also aggravated by the rising rate of cyclones in the Arabian Sea.

Nevertheless, Pakistan has made measures in response to climate change on the policy level. To ensure sustainable development and resilience, the country signed the Paris Agreement and presented the National Climate Change Policy. The Ten Billion Tree Tsunami Programme and other similar initiatives are focused on increasing the forest cover and carbon sequestration. Moreover, there is the expansion of renewable energy projects, such as solar and wind power development in order to cut down on the use of fossil fuels.

Nevertheless, ineffective climate governance occurs due to the gaps in implementation, the lack of financial capacity, and institutional inefficiencies. Pakistan needs a lot of international climate finance, transfer of technology and capacity-building to achieve their adaptation and mitigation targets. The resilience building strategies entail strengthening system of disaster risk management, encouraging agricultural practices that

are climate smart, ensuring better water conservation mechanisms and improving awareness in the population.

To sum up, climate change is a multidimensional problem to Pakistan, as it impacts not only the stability of the environment, but also the development of the economy and social welfare. Although the nation has been implementing some policy commitments in the national and global level, there is the need to take immediate and concerted efforts in ensuring that vulnerable communities are safeguarded in order to achieve sustainable development. To combat climate change in Pakistan, it requires the participation of the community, regional and international cooperation as well as the government.

Research Objectives

1. To investigate the environmental, economic, and social effects of climate change in Pakistan, such as a rise in temperature, glacial melting, floods, and water shortage.
2. To analyze the climate governance and adaptation policies in Pakistan, it is possible to define the gaps and suggest recommendations to develop resilience and sustainable development.

LITERATURE REVIEW

Climate change is a topic that has been popularly acknowledged in the academic literature of being a multidimensional global disaster that has had disproportionate effects on developing nations. The Intergovernmental Panel on Climate Change argues that the global surface temperatures have increased drastically because of the anthropogenic release of greenhouse gases, which has aggravated extreme weather conditions, sea-level elevation, and destruction of ecosystems (IPCC, 2021). The scholars believe that exposure to hazards does not always define climate vulnerability but socio-economic situations, capacity of governance, and adaptive resources as well (Adger, 2006). In this respect, Pakistan has been reported severally as one of the most climate-sensitive nations even though it has little contribution to the global carbon emissions. The literature is in agreement with the paradox of low-emitting high-vulnerability states in the Global South and the climate injustice and unequal distribution of climate risks (Eckstein et al., 2021).

A considerable amount of literature has been devoted to the issue of temperature increase and altering precipitation patterns in South Asia and especially in Pakistan. Research shows that the rise in average temperatures in Pakistan is higher than the average in the global context, which contributes to a long duration of heatwaves and unpredictable patterns in monsoons (Kreft et al., 2017). The study of the 2015 Karachi heatwave shows that extreme weather events along with weak urban infrastructure and lack of governance led to the death of more than a thousand people (Mazhar et al., 2015). Researchers associate these disasters of urban climate with fast urbanization, improper planning and lack of early warning mechanism. Climatic stressors combining with socio-political vulnerabilities have thus become a common motif in the Pakistani climatic literature.

Another dimension of climate research in Pakistan that is critical is hydrological changes. The reliance of the country on the Indus River system renders the country especially vulnerable to the melting of glaciers and changes in rainfall. According to scientific research, glaciers are melting faster in the Karakoram and Himalayas as well as ranges of Hindu Kush because of the increased temperatures (Bolch et al., 2012). Although there are other previous studies talking about the Karakoram anomaly, where some of the glaciers experienced a temporary stability, recent results indicate that there is a general movement towards glacial retreat and more formation of glacial lakes (Hussain et al., 2020). These transitions increase the likelihood of Glacial Lake Outburst Floods (GLOFs), which pose a threat in mountain communities and the

downstream population. It is emphasized in the literature that glacial melting will first bring up the river flows, however, in the long-term, the water depletion may lead to serious water deficit (Immerzeel et al., 2010).

One of the most studied climate related disasters in Pakistan has been flooding. The disastrous 2010 and 2022 catastrophic floods are often used as the indicators of the extreme weather variability that is caused by climate. It has been indicated that abnormally high levels of monsoon precipitation, deforestation, poor river management systems, and poor drainage systems enhanced the severity of the floods (Webster et al., 2011). The analyses made after the disaster reveal that millions of people became displaced, farms were burnt, and total destruction of infrastructure costing billions of dollars occurred. Researchers hold that climate change is a threat multiplier that increases prior governance failures and socio economic disparities (Mustafa et al., 2013). The 2022 floods that occurred in almost one-third of the country added more strength to the arguments that the disaster risk reduction mechanism in Pakistan is underdeveloped despite the past experiences.

The climate change literature on Pakistan revolves around agriculture and food security. Agriculture is a major contributor to GDP and a huge percentage of rural population workforce, it is, therefore, very susceptible to climate variability. Empirical evidence demonstrates that increased temperatures harm the production of wheat and rice, whereas the unpredictable rain patterns interfere with the cereal planting (Abid et al., 2016). Climate stress also enhances infestations and soil erosion which adds to productivity losses. The studies of farmer perceptions show that although most farmers are aware of the altering weather conditions, they lack financial resources and institutional support to adapt (Shah et al., 2018). Some of the common solutions put forward are climate-smart agriculture, increased irrigation efficiency, and drought-resistant crop varieties but there are still gaps in implementing them.

The issue of water scarcity has been extensively debated when it comes to the problem of climate change and population increase. The per capita availability of water has decreased significantly during the last decades in Pakistan making it one of the water-stressed nations. Researchers assert that the climate-related fluctuation of the river flows coupled with ineffective irrigation apparatus and over exploitation of groundwater further exposes water insecurity (Qureshi, 2011). Indus Basin irrigation system has been found to be poor in maintenance and loss of water in the world. It is also projected by climate models that will cause more variability in monsoon rainfall, and that might cause a further destabilization of water supply. It has been indicated in literature that water resource management and better storage capacities are two vital adaptation methods.

Another aspect of coastal vulnerability also has a role to play in climate scholarship. An increase of the sea level in the Arabian Sea poses a danger to the low-lying areas, especially to the Indus Delta. Research also shows that saltwater intrusion has destroyed agricultural land and freshwater assets and displaced people (Syvitski et al., 2013). Due to the destruction of the mangrove forests, natural protection against cyclones and storm surges has been compromised. According to researchers, coastal erosion is accelerated by climate change, in addition to the upstream water diversion and the decrease in the sediment flow. The rising number of tropical cyclones in the area indicates the pressing need to plan resilience in the coastline.

Another theme of the recurring literature is the vulnerability of the socio-economic status. Researchers believe that climate change has a disproportional impact on low-income families, women, and children (Rao et al., 2019). According to the gender-based analysis, women in rural regions have extra burdens in the form of inadequate access to resources, moving around, and care giving during calamities. Migration as a result of climate has become another field of scholarly interest as well. Research reports about both short-term and long-term migration due to floods and droughts, showing that there is no unified migration policy regarding climate change in Pakistan (Iqbal and Roy, 2015).

On the policy level, scholars explore the Pakistani obligations against the international agreements like the Paris Agreement. Policy reviews observe that Pakistan has drafted the National Climate Change Policy and other adaptation models, but its practice is still limited due to scarce financial resources and institutional disintegration (Khan and Chang, 2018). Climate finance has been often mentioned as a major challenge and scholars have urged the international community to contribute more towards the same based on the concept of common but differentiated responsibilities. The consolidated attempt of Pakistan to grow renewable energy sources and afforestation programmes, including large scale tree plantation programmes, is, however, recognised as a good move, but its sustainability must be maintained in the long run through constant political deliberations.

In recent years, urban climate governance has received more and more scholarly interest. The process of rapid urbanization, especially in such megacities as Karachi and Lahore, increases the exposure to heat stress, flooding, and air pollution. It has been indicated that informal settlements are particularly susceptible because of inappropriate housing and infrastructure (Hasan and Raza, 2015). Strategies recommended to promote urban resilience, such as better drainage systems, green infrastructure and early warning mechanisms are often suggested. Nevertheless, there is still poor coordination among the federal, provincial, and local governments, which restricts successful climate adaptation.

Another theme the literature concentrates on is the interface between climate change and the health of the population. Increased temperatures are the cause of heat-related illnesses, diseases spread by vectors like dengue, as well as respiratory issues that are aggravated by air pollution (Watts et al., 2018). Flooding elevates the potential of waterborne disease that complicates the health of the displaced populations. Researchers in the field of public health maintain that climate adaptation needs to incorporate health system strengthening in order to minimize mortality and morbidity in extreme events.

All in all, the existing literature on climate change in Pakistan highlights the multidimensional nature of effects of climate change in the environmental, economic and social spheres. Researchers have always emphasized the fact that climate change is a risk multiplier, which enhances the structural imbalances and governance failure. Although there has been substantial research on sector-specific effects including agriculture, water, health and urban vulnerability, the areas of integrated policy implementation and cross-sectoral coordination are still gaps. The literature reviews indicate that a comprehensive framework of adaptation is needed in Pakistan with the help of international climate finance, institutionalization reforms, community plans, and sustainable development planning. It means that climate change in Pakistan is not just an environmental problem but rather a full-scale development problem, which has to be changed structurally in the long term.

METHODOLOGY

Research Design

In this study, the research design was qualitative research based on the analysis of secondary data to discuss the effects of climatic change in Pakistan. The qualitative method was also deemed suitable as the paper in question was intended to synthesize the available empirical data, policy statements, and statistical reports instead of gathering primary data. The design was such that it enabled a detailed discussion of environmental, socio-economic, and institutional aspects of climate change in the Pakistani setting.

The study had a descriptive and analytical framework. It explained the patterns and trends of the effects of climate change and critically analyzed available literature to pinpoint gaps, challenges, and implications of the policy.

Data Source

The research was based fully on secondary sources that are of good quality and those that are publicly accessible. These included:

- The reports issued by Intergovernmental panel on climate change (IPCC)
- The Government of Pakistan national policy documents.
- Pakistan Meteorological Department publications.
- Reports from the World Bank
- The United Nations Development Programme (UNDP) data.
- Academic databases (Google Scholar, JSTOR, and ScienceDirect) were used to find peer-reviewed journal articles.

The official government reports and international databases on climate also reviewed secondary statistical data pertaining to temperature variations, flood effects, water shortage, and agricultural output.

Data Collection Procedure

The data were gathered by the use of a systematic search of the literature that was done between 2005 and 2024. The keywords that were used to get the relevant studies include climate change in Pakistan, floods in Pakistan, glacial melting, water scarcity, agriculture and climate change, climate policy Pakistan.

The inclusion criteria used to select literature were:

- Research with a particular interest in Pakistan or in South Asia that is relevant to Pakistan.
- Articles of well-known journals, international organizations, or governmental sources.
- Reports with theoretical information, statistical data or policy analysis.

The review excluded studies that lacked academic merit, irrelevant and outdated data as well as non scholarly opinion pieces.

Data Analysis Technique

Thematic content analysis was conducted in order to analyze the data collected. The process involved:

- Reading and going through all the documents selected.
- Detecting the common themes associated with climate effects, susceptibility, adaptation, and reduction.
- Classification of the findings as key thematic groups including environmental impacts, economic consequences, social vulnerability, and response on policies.

- Drawing comparisons between the results of various studies to establish similarities, differences as well as gaps in the research.

The interpretation of statistical trends in the secondary sources was done in a descriptive manner to make qualitative arguments. There was no major statistical model done because the research has been based on already existing data.

Reliability and Validity

In an attempt to make the data reliable, data of credible and internationally recognized institutions were utilized. The reliability of the results was enhanced by cross-checking of results.

The validity was also maintained by using peer-reviewed literature and official government reports. Triangulation was used by observing the data collected by the international agencies, national institutions and academic research in order to ensure a consistency in the reported trends.

Ethical Considerations

No human subjects were involved in the study because there was only secondary data used in it. Thus, there was no need of informed consent. All the sources were duly referenced in order to prevent plagiarism and preserve academic integrity. The study was ethically sound in terms of reporting and citation.

Limitations of the Study

Despite the fact that the analysis of secondary data has very detailed information, it is also limited at some points. The research relied on published data that was available and accurate. There could be differences in the methodology of some datasets and this may impact on comparability. Also, there was no primary field data which restricted the possibility of getting localized community views.

These limitations notwithstanding, the fact that a variety of secondary sources with credibility was used guaranteed a solid and in-depth knowledge of the impacts of climate change in Pakistan.

DATA ANALYSIS

Data analysis was carried out through the secondary data that was acquired via the different national and international reports, the peer-reviewed research articles and through official statistical databases. This section aims to make sense of trends and patterns regarding climate change in Pakistan based on the synthesis of available quantitative and qualitative data. The variables are analyzed in terms of temperature changes, precipitation, glacier melting, floods, agricultural productivity, water shortage, socio-economic vulnerability, and effectiveness of response policies. This interpretation is both descriptive and analytical and it seeks to determine the relationship between climate variables and socio-economic implications.

This analysis is a combination of reports of the Intergovernmental panel on climate change, national organizations (Pakistan Meteorological department), world financial and development organizations (World Bank). A detailed account of the climate direction of Pakistan has been formulated as a result of triangulation of these sources.

Temperature Trends and Intense Heatwave.

The secondary data show that there is an average positive change in the yearly average temperature of Pakistan in the last five decades. It has been reported that the mean temperature in the country has risen to about 0.5degC to 0.8degC since the middle of the twentieth century and it is expected to rise further to 1.5degC to 2degC by the middle of the fifteenth century given the moderate situation of emission levels. The warming effect is increased in arid and semi arid areas especially in the provinces of southern Punjab and Sindh.

Extreme heat events have been more frequent and severe. As an example, the 2015 Karachi heatwave showed that urban heat stress can lead to extreme levels of mortality in case of power outages and inappropriate health facilities. Hospital admission and mortality statistics at the time showed that there was a dramatic increase in the number of cases of heatstroke, particularly among the most vulnerable groups (the aged and low-income residents). The recent heatwave experienced in 2022 and 2023 are further signs that extreme temperatures are extended in length and extended in geographical coverage.

According to statistical projections of the climatic models, the number of very hot days per year will increase significantly by 2050. This not only affects the human health but also the labor productivity, energy requirement and water evaporation rate. The results of the analysis indicate that there is a close relationship between the trend of increasing temperature and the increase in the necessary energy to cool the houses and thus puts pressure on the already weak power system.

Altering the Precipitation Patterns and Monsoon Variability.

The rain pattern in Pakistan has been erratic in the last 30 years. Secondary meteorological information reveals the variability of the intensity, timing and spatial distribution of monsoon rainfall. Whereas there are people who receive more rain than they can handle and cause floods, others experience long periods of dry seasons and drought periods.

The monsoon data analysis indicates that the intensity of the extreme rainfall has been observed to be on the rise especially in the months of July and August. The floods of 2010 were caused by heavy monsoon rains that were unfamiliar to the country and some regions even received excessively higher than the monthly average of the rainfall. The same trends were seen in the 2022 floods where records of rainfall were recorded in southern parts of the country. These aberrations suggest that there is a transition to more focused and intense precipitations as opposed to evenly dispersed precipitation in the season.

Climate studies on the modeling of the climate show that the warming of the Arabian Sea has also led to higher availability of moisture hence intensifying rainfall. Nevertheless, precipitation is also affected by regional climatic variations and the modifications of land-use. The unequal rainfall patterns have had quite severe effects on agriculture and water storage systems since infrastructure was initially set in anticipation of historically predictable patterns.

Dynamics of Glacial Melts and River Floods.

The country of Pakistan is home to one of the highest concentrations of glaciers other than in the polar areas, mostly found in the Himalayas, Karakoram, and Hindu Kush ranges. Glaciological research and secondary satellite findings suggest that the glaciers in a number of regions of these mountain ranges are retreating at a higher rate. Even though the previous studies indicated that some glaciers in the Karakoram had stabilized, recent measures have shown a gradual but rising loss in the mass of ice in general.

If the glacial meltwater is extremely low in dry seasons, the system of the Indus River will be severely affected. Evidence indicates that there are short-run surges in meltwater that have temporarily boosted the amount of river flow, thereby increasing the risk of a flood along downstream areas. But, projections in the long term give warnings that further melting of glaciers will cause a shortfall in water supply at critical agricultural periods.

Moreover, glacial lakes have developed tremendously. It has been reported that there is an occurrence of dozens of potentially dangerous glacial lakes that increase the risk of Glacial Lake Outburst Floods (GLOFs). The communities in Gilgit-Baltistan and Khyber Pakhtunkhwa are especially exposed to such occurrences in the mountains. The information indicates that GLOF events have been on the increase in the last ten years, which has endangered infrastructure, livelihoods, and local ecosystems.

Frequency and Economic Losses of Floods.

The available records of floods in 2010 to 2022 indicate the increasing trend in the number and severity of floods. The floods of 2010 had estimated 20 million victims and heavy destruction of infrastructure, agriculture, and property. The loss estimates were also worth billions of dollars affecting the GDP growth tremendously.

Floods that happened in 2022 were even more devastating as almost a third of the nation was flooded. According to secondary economic reports, there is a massive destruction of crops, livestock, roads, schools, and health facilities. The agricultural industry was alone hit by immense losses, which impacted domestic food chains.

The analysis reveals that the effects of floods are over-concentrated in communities of poor and rural residents. The vulnerability mapping shows that the poor drainage systems, deforestation, and unregulated constructions in the areas are more likely to cause a serious damage. The costs incurred in the recovery effort of floods have also burdened national fiscal funds by making funds to be redirected in emergency response and rehabilitation funds to development projects.

Food Security and Agricultural Productivity.

The data in the agriculture industry shows an observable reduction of crops in areas with increasing temperatures and irregular precipitations. The two of the staple crops, wheat and rice, are sensitive to temperature stress at a critical period of growth. Evidence in research shows that a 1degC rise in temperature is sufficient to lower the productivity of wheat by a large margin.

Arid disasters like the droughts experienced in arid areas like Tharparkar have contributed to low productivity of livestock and food insecurity of households. According to secondary survey-based research, a trend in farmers is to report late sowing periods and erratic irrigation periods. These shocks have impacted on the income stability and the level of rural poverty has risen.

Adaptive responses are also pointed out in the analysis including the implementation of heat-resistant crop varieties and altered irrigation methods. Nevertheless, the lack of financial resources and extension services limits the popularity of climate smart farming practices.

Water shortage and Depletion of Resources.

The water availability in the country has reduced drastically over the last number of decades per capita in Pakistan. Statistics indicate that the nation is nearing the water scarcity levels. Water stress has been

aggravated by climate-determined fluctuation of river flows, population increase, and lack of efficient irrigation systems.

The rate of groundwater extraction and recharge in most of the urban and agricultural regions exceeds the recharge rate. Secondary hydrological research suggests that there are declining water levels in large cities and agricultural lands. Decreased amounts of snow and alterations in the pattern of glacial melting only exacerbate seasonal water shortages.

The analysis of the data highlights the urgency of the integrated management of water resources, the enhancement of the storage infrastructure, and the changes in policies to ensure the conservation and effective distribution. In Pakistan, water scarcity can be among the most dire effects of climatic change unless there are structural changes.

Social-Economic Vulnerability and Health-Related Effects on the Population.

The effects of climate change are not purely limited to environmental degradation to encompass socio-economic instability. The secondary data provided by development agencies indicate that marginalized communities are disproportionately impacted due to climate disasters. Females, children, and poor families are more affected by food insecurity, displacement, and health.

There are health sector data which show that there are more instances of heatstroke, disease spread by vectors like dengue and water borne diseases after floods. Flood displacement has caused provisional quell, devoid of sanitation and health amenities.

Migration patterns also show both temporary and permanent movement out of the flood-prone areas and drought-stricken areas. The cities also experience pressure due to migration of climate refugees in search of livelihood and housing, who contribute to poverty of the urban poor and increased pressure on the urban infrastructure.

The Policy Response and Adaptation Effectiveness.

The secondary analysis of the policies of the national climate in Pakistan suggests that Pakistan has worked out various frameworks that are in line with the Paris agreement. These policies focus on mitigation, adaptation and expansion of renewable energy.

Nonetheless, there has been inconsistency in implementation as a result of financial constraints and institutional disunity. Although there is progress in the afforestation and renewable energy programs, community level adaptation is lacking. There is also an improvement in the system of dissemination of early warnings, but response capacity in the case of massive disaster is still a matter of operational concern.

The evidence indicates that the management of climate needs to be more coordinated between federal and provincial governments, have better access to climate funds, and feature consideration of climate in the national development plans. In general, the discussion shows that climate change in Pakistan is escalating on various levels. Increasing temperatures, unpredictable rainfall, glacial melting, water shortages and socio-economic susceptibilities combine to form formidable development problems. The results suggest that climate risks will only keep increasing without speedy adaptation interventions and institutional changes because of which sustainable development and human security are at risk in Pakistan.

DISCUSSION

This research indicates that the issue of climate change in Pakistan is not a single environmental event, but a multidimensional development crisis that cuts across economic, social, and governance constraints. The analysis of data proved the explicit tendency of temperature increase, growing number of days of extreme heatwave and aggravation of monsoon fluctuations. These climatic changes have contributed greatly to the risk of floods, acceleration of melting of glaciers and water stress in various parts. The 2010 and 2022 devastating floods represent how climate variability, in conjunction with frail infrastructure and poor land-use planning, can change natural hazards into humanitarian catastrophes. According to the evidence, climate change is a multiplier of threats which exacerbates pre-existing socio-economic inequalities, especially in rural area, women, and low-income communities.

The increased rate of melting glaciers in the Himalayas, Karakoram, and Hindu Kush basins directly affects the Indus River basin that supports agricultural activities and water supply in Pakistan. Although in the short-term, the meltwater will increase the flooding, in the long run, the retreating glaciers will jeopardize the water security in the future. Likewise, the unpredictable rainfalls interfere with crop production, lowering crop yields and causing a higher level of food security. Agricultural sector which is still climate sensitive is under increasing pressure due to a rise in temperature stress and uneven irrigation patterns. Such trends substantiate the fact that the issue of climate change has direct implications to the wellbeing of the GDP and rural livelihoods.

There has also been increasing urban vulnerability especially in megacities like Karachi where heat waves, inadequate drainage and unplanned settlements escalate mortality and destruction of infrastructures. The records in public health also show that there are increasing incidences of heatstroke and waterborne diseases after extreme events. Even though Pakistan was obligated to carry out the agreement under the Paris Agreement, the implementation gap is still visible. There are frameworks of policies but these lack effectiveness due to financial constraints, institutional fragmentation and poor enforcement. The general discourse shows that the process of adaptation is reactive, but not preventive and that climate governance needs to be more integrated into national development policies.

In summation, the major findings of the analysis could be summarized in the following table:

Table 1

Climate Dimension	Observed Trends	Socio-Economic Impact	Policy Gap
Temperature Rise	Increased heatwaves, rising annual averages	Heat-related deaths, energy stress	Weak urban heat management
Flooding	Extreme monsoon rainfall (2010, 2022)	Displacement, GDP loss, crop destruction	Poor drainage & land-use control
Glacial Melt	Accelerated glacier retreat	Short-term floods, long-term water decline	Limited mountain risk management
Agriculture	Reduced wheat & rice yields	Food insecurity, rural poverty	Slow adoption of climate-smart farming

Water Scarcity	Falling per capita water availability	Irrigation stress, urban shortages	Inefficient water governance
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This synthesis affirms that the issue of climate change in Pakistan is structurally related to governance capacity, resource management and socio-economic resilience. In the absence of systemic reforms, the impacts of climate are bound to grow both in frequency and severity.

CONCLUSION

The paper finds that Pakistan exposes itself to drastic and multidimensional climatic hazards in spite of being a minimal contributor to the greenhouse gas emissions in the world. The temperature rises and unpredictable monsoon cycles, retreating glaciers, frequent floods, decreased agricultural output, and the growing water scarcity all endanger the national development and human security. The results prove the fact that climate change in Pakistan is a threat multiplier, which worsens poverty, inequality, health risks, and economic instability. Even with the policy frameworks and international commitments, gaps in the implementation, the lack of financial resources and instability of the institutions prevent effective adaptation and mitigation. Thus, climate change should not be merely a question of environmental issue but a core question of development and governance that needs to be approached as long-term and comprehensive.

RECOMMENDATIONS

To enhance better climate adaptation and mitigation of climate risks, Pakistan ought to incorporate climate risk assessments in national and provincial development plans. Disaster losses should be reduced by investing in climate resilient infrastructure, better drainage systems and early warning systems. To deal with food and water insecurity, the government should increase climate-smart agriculture programs, advance efficient irrigation systems, and improve the water storage capacity. The enhancement of the coordination between the federal and provincial institutions can enhance the monitoring and policy implementation. Greater availability to international climate finance through global agreements like the Paris Agreement is critical in order to finance mitigation and adaptation measures. Resilience programs at the community level, awareness campaigns, and gender inclusion climate policies should also be prioritized to address the vulnerable population. Green energy shift, planting more trees, and better environmental management will be very vital in the achievement of the climate stability of Pakistan and sustainable development in the country.

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