

CLIMATE CHANGE AND REGIONAL INEQUALITY: ASSESSING ENVIRONMENTAL VULNERABILITY AND ADAPTATION STRATEGIES IN PAKISTAN

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ABSTRACT

Climate change has emerged as a major challenge to sustainable development, environmental security, and regional equality in Pakistan. The country faces increasing risks from floods, droughts, rising temperatures, irregular rainfall, and water scarcity, which affect regions and communities differently. These environmental challenges intensify existing regional inequalities, particularly between urban and rural areas and among communities with different levels of economic resources and access to public services. This study aims to examine the relationship between climate change and regional inequality in Pakistan, focusing on environmental vulnerability, socioeconomic disparities, and adaptation strategies. The research adopts a qualitative approach based on secondary data collected from academic publications, government reports, climate assessments, and relevant policy documents. It explores how geographical location, income disparities, agricultural dependence, infrastructure, and institutional capacity influence the vulnerability of different regions to climate-related hazards. The study also examines potential adaptation strategies, including climate-resilient agriculture, improved water management, disaster preparedness, sustainable land-use planning, and community-based adaptation initiatives. Existing research indicates that socially and economically disadvantaged communities often face greater difficulties in preparing for and recovering from climate-related disasters because of limited financial resources, inadequate infrastructure, and unequal access to information and institutional support. The study highlights the importance of integrating climate adaptation with regional development planning to reduce environmental risks and promote social and economic equity. It recommends strengthening local institutions, improving access to climate information, increasing investment in vulnerable regions, and ensuring that adaptation policies address the needs of disadvantaged communities

KEYWORDS: Climate Change, Regional Inequality, Environmental Vulnerability, Climate Adaptation, Regional Development, Pakistan.

INTRODUCTION

Climate change has become one of the most significant environmental and developmental challenges of the twenty-first century. Rising global temperatures, changing rainfall patterns, frequent floods, prolonged droughts, and increasing water scarcity are affecting natural ecosystems, human livelihoods, and economic activities worldwide. However, the effects of climate change are not distributed equally across geographical regions or social groups. Some regions possess sufficient financial resources, infrastructure, technology, and institutional support to respond effectively to environmental challenges, while others remain highly vulnerable because of poverty, limited resources, and inadequate adaptation measures. Consequently, climate change is not only an environmental issue but also a major concern for social justice, regional development, and economic equality. Pakistan is particularly vulnerable to the adverse impacts of climate change because of its diverse geographical features, dependence on agriculture, water-related challenges, and socioeconomic conditions. The country includes mountainous regions, agricultural plains, arid and semi-arid areas, coastal zones, and rapidly expanding urban centers. Each geographical region experiences different environmental pressures and possesses different levels of capacity to respond to climate-related hazards. Northern areas face risks associated with glacial melting, changing precipitation patterns, and glacial lake outburst floods. Agricultural regions of Punjab and Sindh experience increasing pressure from extreme temperatures, irregular rainfall, water shortages, and flooding. Meanwhile, coastal communities face threats associated with sea-level rise, coastal erosion, and saltwater intrusion. These geographical differences demonstrate the importance of examining climate change through a regional perspective.

One of the most serious consequences of climate change in Pakistan is its potential to deepen existing regional inequalities. Regional inequality refers to differences in income,

employment opportunities, infrastructure, education, healthcare, public services, and economic development between geographical areas. These differences influence how communities experience and respond to environmental hazards. Regions with stronger infrastructure, better access to public services, and greater financial resources may recover more effectively from climate-related disasters. In contrast, economically disadvantaged communities often experience greater difficulties in protecting their livelihoods, rebuilding damaged infrastructure, and accessing essential resources. Therefore, climate-related hazards can reinforce existing patterns of poverty and uneven development. The devastating floods of 2022 demonstrated the relationship between environmental disasters and socioeconomic vulnerability in Pakistan. The floods affected millions of people, damaged homes and infrastructure, disrupted agricultural production, and created serious challenges for public health and economic recovery. The consequences were particularly severe for communities dependent on agriculture, daily wages, and natural resources. People with limited savings, insecure housing, and restricted access to institutional support often faced greater difficulties recovering from the disaster. Although the intensity of a natural hazard is influenced by environmental conditions, its consequences also depend on social and economic circumstances, land-use practices, infrastructure quality, and disaster preparedness.

Agriculture represents another important dimension of the relationship between climate change and regional inequality. A substantial proportion of rural households in Pakistan depend directly or indirectly on agriculture for their livelihoods. Changes in temperature, rainfall, irrigation water availability, and the frequency of extreme weather events can affect crop yields, livestock production, and household income. Small-scale farmers are often particularly exposed because their capacity to invest in improved irrigation systems, climate-resilient seeds, modern technologies, and crop insurance may be limited. Differences in access to agricultural information, credit facilities, and government assistance can further influence the ability of farmers to adapt to changing environmental conditions. Consequently, climate change may increase economic insecurity and widen the development gap between agricultural communities and regions with more diversified economic opportunities. Urban and rural areas also experience climate-related risks differently. Rural communities may face agricultural losses, water scarcity, soil degradation, and declining livelihood opportunities. Urban areas, on the other hand, may experience extreme heat, urban flooding, inadequate drainage, and pressure on water and energy supplies. Rapid and poorly planned urban expansion can increase environmental risks by reducing green spaces, disturbing natural drainage systems, and encouraging construction in hazard-prone locations. Within cities, low-income communities may be especially vulnerable when they lack adequate housing, reliable water supplies, effective sanitation, and access to cooling facilities. Thus, regional inequality exists not only between provinces or districts but also within individual urban and rural communities.

Environmental vulnerability is shaped by the interaction of physical exposure, socioeconomic sensitivity, and adaptive capacity. Physical exposure concerns the likelihood that people and places will experience climate-related hazards. Socioeconomic sensitivity refers to the extent to which livelihoods, infrastructure, and essential services may be affected by those hazards. Adaptive capacity describes the ability of individuals, communities, and institutions to anticipate risks, respond to environmental changes, and recover from adverse events. In Pakistan, these dimensions vary considerably across geographical regions. Areas with limited transportation networks, inadequate healthcare facilities, weak disaster-management systems, and restricted access to climate information may face greater challenges in responding to climate-related emergencies. Understanding these factors is essential for identifying the regions and populations requiring targeted support. Climate adaptation has therefore become

an important component of sustainable development planning in Pakistan. Adaptation involves adjustments in policies, practices, infrastructure, and livelihood strategies to reduce the harmful consequences of climate change. Important measures include developing climate-resilient agricultural practices, improving irrigation efficiency, protecting water resources, restoring forests, strengthening early-warning systems, improving drainage infrastructure, and promoting disaster preparedness. Community participation and local knowledge can also contribute to effective adaptation because environmental challenges differ across geographical settings. For example, agricultural communities may benefit from improved water management and climate-resilient crops, while flood-prone areas may require stronger embankments, better land-use planning, and accessible emergency services.

However, the effectiveness of adaptation strategies depends on how resources and opportunities are distributed. Adaptation policies that do not consider regional socioeconomic differences may benefit communities with greater financial and institutional capacity while leaving disadvantaged populations behind. Limited funding, weak institutional coordination, insufficient public awareness, and unequal access to technology can restrict the implementation of adaptation measures. For this reason, climate adaptation should not be considered solely a technical or environmental process. It should also be understood as a development and governance challenge that requires attention to fairness, inclusion, and the specific needs of vulnerable regions. From a geographical perspective, examining climate change and regional inequality provides an opportunity to understand how environmental processes interact with spatial patterns of development. Geographic analysis can identify differences in climate exposure, resource availability, population distribution, infrastructure, and socioeconomic vulnerability. It can also help explain why similar environmental hazards may produce different outcomes in different regions. The use of regional comparisons, geographical information systems (GIS), climate data, socioeconomic indicators, and policy analysis can contribute to a more comprehensive understanding of these relationships. Such an approach is valuable for identifying priority areas for investment and developing adaptation policies that reflect local environmental and social conditions.

RESEARCH OBJECTIVE

To examine the impact of climate change on environmental vulnerability across different regions of Pakistan.

RESEARCH QUESTION

How do socioeconomic and geographical inequalities influence the adaptive capacity of vulnerable communities in Pakistan?

LITERATURE REVIEW

Climate change has become a major environmental and socioeconomic challenge in Pakistan, affecting natural resources, agricultural production, public health, livelihoods, and regional development. Recent research highlights that rising temperatures, irregular rainfall, floods, droughts, water scarcity, and extreme weather events have increased the vulnerability of communities across the country. However, the impacts of climate change are not equally distributed among regions because geographical conditions, economic resources, infrastructure, and institutional capacity vary considerably. Adnan et al. (2024) examined climate-related challenges in Pakistan and emphasized that environmental risks must be addressed through sustainable development, improved water management, disaster preparedness, and effective environmental policies. Their research highlights the importance of understanding climate change as both an environmental and a socioeconomic issue. Communities with limited financial resources and inadequate public services often face greater difficulties in preparing for climate-related disasters and recovering from their

consequences. This situation demonstrates that regional inequality plays an important role in determining the severity of climate vulnerability in Pakistan. Regional differences are particularly evident when comparing Pakistan's provinces and geographical areas. Sindh and Balochistan experience serious challenges associated with high temperatures, drought, water scarcity, and agricultural stress. Northern mountainous areas, including Gilgit-Baltistan, face risks associated with glacier melting, glacial lake outburst floods, landslides, and changes in snowfall patterns. Punjab, which is an important agricultural region, experiences changing rainfall patterns, heat stress, irrigation difficulties, and potential reductions in crop productivity. These environmental pressures affect communities differently depending on their location, livelihood, and access to essential resources. For example, farmers in water-scarce districts may experience declining agricultural productivity, while communities living near rivers may face displacement and property damage during severe floods.

Such differences suggest that climate adaptation strategies should be designed according to regional environmental conditions rather than implemented through a single national approach. Nadeem et al. (2024) investigated farmers' perceptions of climate change in vulnerable areas of Punjab, Pakistan. Their research highlighted the interaction between climate exposure, agricultural sensitivity, and farmers' ability to adopt adaptation measures. The study demonstrates that even within one province, farmers may experience different levels of vulnerability because of variations in water availability, agricultural practices, financial resources, and access to information. Farmers with adequate capital can invest in improved seeds, irrigation technologies, and climate-resilient farming methods, whereas economically disadvantaged farmers may struggle to afford these measures. Consequently, environmental vulnerability is closely connected to existing economic inequalities. This relationship indicates that effective climate policy must address both environmental hazards and the unequal distribution of resources needed to respond to them. Climate change intensifies regional inequality because communities differ in their economic stability, access to natural resources, educational opportunities, and institutional support. Environmental disasters can cause substantial damage to housing, agricultural land, infrastructure, and employment, particularly in rural areas where livelihoods depend heavily on climate-sensitive activities. Masud and Khan (2023) examined barriers to implementing climate change adaptation policies in Pakistan and highlighted how implementation difficulties can increase vulnerability and limit effective adaptation.

Their research draws attention to the importance of institutional coordination, adequate resources, and practical policy implementation. Although national climate policies provide a framework for addressing environmental challenges, their effectiveness depends on whether local communities receive appropriate financial, technical, and administrative support. Poorer districts may experience greater difficulties when disaster-management facilities, early-warning systems, and recovery services are inadequate. These challenges suggest that climate adaptation should be treated as an issue of environmental justice, requiring fair access to protection, assistance, and development opportunities. Agriculture provides another important perspective for understanding the relationship between climate change and regional inequality. A substantial proportion of Pakistan's rural population depends on agricultural activities for income, employment, and food security. Increasing temperatures, irregular rainfall, floods, and droughts can reduce crop yields and increase production costs. Saqib et al. (2025) investigated farmers' climate-risk management strategies in Pakistan using information collected from 360 farm households. Their findings showed that farmers sometimes adopt off-farm employment and migration-based diversification to manage climate-related risks. However, these strategies may also create unintended consequences, including farmland loss, labour shortages, and increased production expenses. The research

demonstrates that households' responses to climate change do not always lead to sustainable agricultural development. Farmers who lack financial security may be forced to adopt short-term survival strategies instead of investing in long-term resilience. Therefore, climate adaptation policies should combine agricultural innovation with financial assistance, livelihood diversification, improved climate information, and access to affordable agricultural technologies.

Social inequality further influences the capacity of communities to adapt to environmental change. Khan et al. (2025) explored the effects of climate change and adaptation among vulnerable communities experiencing climate-related food insecurity in Pakistan. Their research considered the experiences of internally displaced people, women, smallholders, landless tenants, daily-wage workers, and community leaders in vulnerable districts. The findings highlight that climate-related pressures interact with existing social and economic disadvantages, making recovery particularly difficult for marginalized groups. Households without secure land ownership or stable employment may have limited opportunities to rebuild their livelihoods after floods, droughts, or other environmental disasters. Women and disadvantaged households may also encounter barriers to accessing financial assistance, agricultural information, and decision-making opportunities. This evidence suggests that adaptation programmes should consider differences in gender, income, employment, and social position. Policies that provide targeted assistance to disadvantaged communities can help reduce the unequal consequences of climate change and strengthen local resilience. Recent literature increasingly emphasizes the importance of locally appropriate and regionally differentiated adaptation strategies. Mobeen et al. (2025) examined climate change perceptions, adaptation practices, and constraints among farmers in irrigated agricultural areas of Punjab and Sindh. Their research found differences in the adaptation strategies used by farmers in the two provinces. Farmers in Punjab more frequently adopted crop and farm management practices, whereas farmers in Sindh placed greater emphasis on irrigation measures. Financial limitations, water scarcity, and soil fertility problems were among the constraints affecting adaptation decisions. These findings demonstrate that environmental vulnerability and adaptation capacity vary even between major agricultural regions within the same country. Therefore, adaptation programmes should be designed around regional needs, local knowledge, available resources, and the environmental conditions affecting each community.

METHDOLOGY

This study adopts a qualitative research methodology to examine the relationship between climate change and regional inequality in Pakistan, with particular attention to environmental vulnerability and adaptation strategies. The research is based on secondary data collected from academic journal articles, research papers, government publications, climate policy documents, and reports published between 2023 and 2026. Relevant literature was identified through Google Scholar using keywords such as climate change in Pakistan, regional inequality, environmental vulnerability, climate adaptation, agricultural vulnerability, and climate resilience. The selected sources were reviewed to understand how climate-related hazards, including floods, droughts, rising temperatures, water scarcity, and irregular rainfall, affect different regions and socioeconomic groups. Particular attention was given to differences in geographical exposure, income, agricultural dependence, infrastructure, access to resources, and institutional support. The collected information was analyzed thematically to identify recurring patterns, regional disparities, adaptation challenges, and policy responses. The study compares the environmental and socioeconomic conditions of Pakistan's provinces and vulnerable communities to understand why some populations experience

greater climate-related risks than others. Ethical research practices were maintained by acknowledging the sources used and ensuring that the analysis was based on documented information. As the study relies on secondary data, its findings are limited by the availability, reliability, and geographical coverage of existing publications. The methodology provides a systematic basis for understanding regional climate vulnerability and identifying equitable adaptation strategies that can strengthen resilience and support sustainable development in Pakistan.

RESEARCH DESIGN

This study adopts a Saqib, S. E., Yaseen, M., Yang, S. H., Ali, S., & Visetnoi, S. (2025). Farmers' adaptation to climate change in Pakistan: Can their climate risk management strategies lead to sustainable agriculture?. *Journal of Environmental Management*, 373, 123447. to examine climate change and regional inequality in Pakistan. The research focuses on environmental vulnerability, socioeconomic disparities, and adaptation strategies across different geographical regions. It uses a qualitative approach based on secondary data obtained from academic journal articles, government reports, climate policy documents, and publications by international organizations. The study compares regional differences in exposure to climate-related hazards, access to resources, and capacity to implement adaptation measures. It also examines how poverty, agricultural dependence, infrastructure, and institutional support influence the vulnerability of local communities. The collected information will be analyzed thematically to identify major patterns, challenges, and differences in climate adaptation. This research design provides a systematic understanding of the relationship between climate change and regional inequality and helps identify policies that can promote environmental resilience, equitable resource distribution, and sustainable regional development in Pakistan.

DATA ANALYSIS

This study analyzes secondary data using a qualitative thematic analysis approach to examine the relationship between climate change and regional inequality in Pakistan. Information collected from academic journal articles, government reports, climate assessments, and policy documents is reviewed and organized according to key themes, including environmental vulnerability, socioeconomic inequality, agricultural dependence, and climate adaptation strategies. The analysis compares the climate-related challenges experienced by different geographical regions of Pakistan, including Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, and Gilgit-Baltistan. It focuses on differences in exposure to floods, droughts, extreme temperatures, water scarcity, and other environmental hazards. Particular attention is given to the role of poverty, infrastructure, access to resources, and institutional support in determining the vulnerability of local communities. The study also examines existing adaptation strategies, such as climate-resilient agriculture, improved water management, early-warning systems, disaster preparedness, and community-based initiatives. These strategies are assessed in terms of their potential to address regional needs and reduce vulnerability. The findings from different sources are compared to identify common patterns, policy gaps, and differences in adaptive capacity.

FINDINGS

The findings of this study indicate that climate change presents different levels of environmental vulnerability across the geographical regions of Pakistan. Floods, droughts, rising temperatures, irregular rainfall, and water scarcity affect communities differently depending on their geographical location, economic conditions, and access to resources. Areas exposed to repeated floods and droughts face significant challenges in protecting livelihoods, infrastructure, and agricultural production. The study also highlights that regional inequality plays an important role in determining the ability of communities to respond to climate-related risks. Low-income households, rural communities, and people dependent on

agriculture are particularly vulnerable because they often have limited financial resources, inadequate infrastructure, and restricted access to modern technology and institutional support. Consequently, climate-related disasters may deepen existing economic and social disparities between regions. Another key finding is that adaptation capacity varies considerably across Pakistan. Communities with better infrastructure, access to information, effective disaster management systems, and stronger institutional support are generally better positioned to prepare for and respond to environmental challenges. In contrast, vulnerable regions may experience difficulties implementing effective adaptation measures because of limited funding, weak coordination, and insufficient access to technical resources. The analysis further suggests that climate adaptation strategies, including climate-resilient agriculture, improved water management, early-warning systems, and community-based disaster preparedness, can help reduce vulnerability. However, their effectiveness depends on whether these measures address the specific geographical and socioeconomic needs of local communities.

CONCLUSION

This study concludes that climate change is a major environmental and socioeconomic challenge that contributes to regional inequality in Pakistan. Floods, droughts, rising temperatures, irregular rainfall, and water scarcity affect different regions in different ways. The severity of these impacts depends not only on geographical conditions but also on poverty, infrastructure, agricultural dependence, access to resources, and institutional capacity. As a result, vulnerable communities often face greater difficulties in protecting their livelihoods and recovering from climate-related disasters. The study highlights that existing regional disparities can increase the negative effects of climate change, particularly for rural households, low-income communities, and people dependent on agriculture. Although adaptation strategies such as climate-resilient farming, efficient water management, early-warning systems, and disaster preparedness can reduce environmental vulnerability, their effectiveness depends on adequate funding, effective implementation, and local participation. Therefore, Pakistan needs an inclusive and region-specific approach to climate adaptation. Government institutions should strengthen climate policies, improve infrastructure in vulnerable areas, promote sustainable resource management, and ensure that disadvantaged communities have fair access to financial and technical support. Cooperation among government agencies, local communities, researchers, and development organizations is also essential for building long-term resilience.

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