INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

**Vol 3 issue 2 (2025)**

# Socio-Economic Impacts of Climate Change: An Interdisciplinary Perspective from Environmental Science and Public Policy

**[1] Ayesha Khan, [2] Imran Ahmed***

*[1] Department of Environmental Sciences, Quaid-i-Azam University, Islamabad, Pakistan.*

*[2] School of Public Policy, Lahore University of Management Sciences (LUMS), Lahore, Pakistan.*

***Corresponding author** Email :* imran.ahmed@lums.edu.pk

**Keywords:**

*Climate Change, Socio-Economic Impacts, Environmental Science, Public Policy, Pakistan.*

**Abstract:**

*Climate change is no longer a distant threat but a pressing reality that poses significant socio-economic challenges for countries worldwide, including Pakistan. This article provides an interdisciplinary analysis integrating environmental science and public policy to explore how climate change influences socio-economic structures. Major impacts include increased poverty, food and water insecurity, health risks, and disruption of livelihoods. The study underscores the urgent need for adaptive policy frameworks and innovative mitigation strategies, highlighting lessons from both global and local contexts. The article presents empirical data, case studies, and graphical analyses to reveal how Pakistan's socio-economic sectors are evolving under the pressures of a changing climate.*

## INTRODUCTION

Climate change, driven largely by anthropogenic greenhouse gas emissions, is reshaping environmental and socio-economic realities across the globe . Pakistan, as one of the most climate-vulnerable countries, is witnessing pronounced shifts in weather patterns, increased frequency of floods and droughts, and declining agricultural productivity . The country's socio-economic fabric—comprising livelihoods, health, infrastructure, and social equity—faces unprecedented risks . While environmental science offers insights into the causes and trajectories of these changes, public policy determines how societies adapt and respond . This article adopts an interdisciplinary perspective, drawing from both domains, to examine the wide-ranging socio-economic impacts of climate change in Pakistan and to suggest pathways for policy action .\

## 1. Climate Change and Livelihood Vulnerability in Pakistan

### 1.1 Changing Weather Patterns, Floods, and Droughts: Effects on Livelihoods

Pakistan has witnessed increasing variability in rainfall, more intense monsoons, and longer dry spells in various regions over the past two decades (Khan & Ali, 2018; Qureshi, 2016). These shifting weather regimes have multiple effects:

**Rural livelihoods**: In agro-ecological zones such as Punjab's rainfed areas, Balochistan, and Khyber Pakhtunkhwa, delayed monsoons or erratic rainfall reduce sowing windows, affecting crop calendar and yield (Ahmad et al., 2021). Drought periods reduce pastoralists' pasture access, force migration, and increase livestock mortality (Malik & Rehman, 2021).

**Urban livelihoods**: In cities like Karachi, Lahore, and Islamabad, extreme rainfall events lead to urban flooding, disrupting small-businesses, transportation, and informal employment (Khan, N. & Hussain, 2020). Heatwaves increase energy expenses and reduce productivity among daily wage laborers (Ali et al., 2019).

**Floods**: Major floods (e.g., in 2010, 2015, 2022) have destroyed infrastructure, disrupted markets, displaced populations, and led to loss of livestock and assets (World Bank, 2022; NDMA, 2022). Loss of stored seed, damage to road access during floods, and contaminated water supplies hamper recovery.

**Droughts**: Prolonged dry spells in southern Punjab, Sindh, and Balochistan reduce crop yield, force farmers to fallow land, migrate for labor, or switch to less water-intensive crops (Qureshi, 2016; FAO, 2021).

### 1.2 Impacts on Agriculture

Agriculture is a major pillar of Pakistan's economy (≈ 20-25 % of GDP; employing ~ 40 % of labor force) (Pakistan Economic Survey, 2023; Planning Commission, 2023). Key impacts include:

**Crop yields**: Heat stress during grain filling stages (e.g., wheat, rice) reduces yields. For example, elevated daytime temperature during May-June in Punjab correlates with a 5–10 % yield decline per °C above threshold (~ 30°C) (Ahmad et al., 2021).

**Soil erosion and salinization**: Flooding brings both silt (sometimes beneficial) and soil erosion; when floods recede, poor drainage leads to waterlogging and salinity, especially in Sindh and in Indus Delta regions (Qureshi, 2016).

**Water scarcity for irrigation**: Glacial retreat in northern Pakistan has altered streamflow; combined with overuse, this leads to less reliable water supply, especially during dry seasons, impacting double-cropping systems (World Bank, 2022).

**Fisheries**: Inland fisheries in rivers and freshwater lakes are disrupted by altered flow regimes, increased turbidity, and temperature changes. Coastal fisheries are affected by sea-level rise, coastal erosion, and changing marine ecosystems (Ali et al., 2019; FAO, 2021).

### 1.3 Impacts on the Informal Sector

The informal sector (daily wage labor, small shops, street vendors, domestic work) is highly sensitive to environmental shocks:

**Loss of income opportunities**: Flooding and extreme heat reduce days worked for laborers; marketplaces destroyed by floodwaters reduce trade opportunities (ILO, 2022).

**Migration and displacement**: Rural households, facing repeated crop failure or livestock loss, may migrate temporarily to cities, increasing pressure on urban informal employment markets (Malik & Rehman, 2021).

**Health-related work interruptions**: Climate-sensitive illnesses (heat stroke, vector-borne diseases) reduce labor capacity, especially among informal workers without social safety nets (Batool & Raza, 2023).

### 1.4 Case Study: Rural Punjab vs Coastal Sindh

| Region | Climate Challenge | Livelihoods at Risk | Adaptation / Coping |
|---|---|---|---|
| Rural Punjab (rainfed belt) | Erratic rainfall, heat stress | Wheat and cotton farmers; seasonal migrant laborers | Use of drought-tolerant crop varieties; shifting planting dates; reliance on remittances |
| Coastal Sindh | Salinity intrusion, coastal flooding, cyclonic events | Small-scale fishers; shrimp farming; salt-affected agriculture | Mangrove restoration; embankment building; alternative livelihoods (e.g., aquaculture) |

This comparative view shows that while both regions are vulnerable, the types of vulnerability and the adaptive strategies differ.

### 1.5 Synthesis and Policy Implications

Livelihood vulnerability is not uniform; those dependent on climate-sensitive sectors (agriculture, fisheries) and those lacking resources (credit, insured assets, information) are worst hit.

Policies need to strengthen **resilience**: e.g., crop insurance schemes, access to drought-tolerant seeds, water management infrastructure, support for informal sector workers.

Early warning systems, climate services (weather forecasting), and social protection (cash transfers after disasters) are important.

Engagement with local communities to understand indigenous knowledge (water conservation, cropping patterns) can improve relevance and effectiveness of interventions.

## 2. Food, Water, and Health Security Under Threat

### 2.1 Impacts on Crop Yields and Water Resources

#### 2.1.1 Crop Yields

Recent studies show that climate change is already reducing yields of major cereal crops in Pakistan. Syed et al. (2022) estimate declines of approximately 15–20% in cereal yields under current climate stressors. The 2022 floods destroyed entire cropland in many provinces, including Sindh and Balochistan, especially during the Kharif season. Remote sensing studies have confirmed severe crop losses and subsequent delays in planting Rabi crops due to saturated soils. Moreover, low yields are frequently attributed to water deficits during critical growth stages, such as flowering and grain filling, with erratic rainfall patterns and an increasing frequency of drought periods causing additional crop stress.

#### 2.1.2 Water Resources

Pakistan's water resources are under severe strain. Projected reductions in glacial mass and shifts in the seasonal flow of rivers are altering water availability for both agriculture and domestic use. Groundwater levels are declining in many regions due to over-extraction, further exacerbated by reduced recharge during periods of decreased precipitation. While floods can temporarily bring water, they often damage critical water infrastructure, contaminate drinking water sources, increase sediment loads, and disrupt subsequent agricultural cycles.

### 2.2 Increasing Health Risks: Climate-sensitive Diseases & Malnutrition

The impacts of climate change have led to a marked increase in climate-sensitive diseases and malnutrition. Vector-borne diseases, such as dengue, malaria, and chikungunya, have increased in incidence, particularly following heavy monsoon rains and floods. Changes in temperature and the proliferation of standing water provide ideal breeding grounds for mosquitoes. Waterborne diseases also surge after floods, with cases of diarrhea, cholera, and typhoid rising sharply due to contaminated water and lack of sanitation. For example, during the 2022 floods, many cases of diarrhea, cholera, and skin diseases were reported, especially in Sindh. Heat-related illnesses have

also increased: the 2015 heatwave in southern Pakistan led to approximately 2,000 deaths and a spike in hospital admissions for dehydration, heatstroke, and cardiac stress.

Malnutrition and food insecurity have worsened as crop losses and yield declines reduce food availability, raise prices, and restrict access, particularly for poorer households. During disasters such as floods, supply chain disruptions increase the risk of acute food deficits, as seen in the aftermath of the 2010 and 2022 floods, which pushed many families into food insecurity. Undernutrition, especially among children and pregnant women, is exacerbated by reduced dietary diversity, loss of income, and interruptions in health and nutrition services.

### 2.3 Case Examples

The 2022 floods affected over 33 million people in Pakistan, severely contaminating water resources, causing spikes in waterborne diseases, and devastating agriculture in Sindh. Similarly, the 2015 heatwave in Sindh, with temperatures reaching nearly 49°C, resulted in many deaths, significant livestock losses, and widespread impacts on crop production and human health.

### 2.4 Policy and Adaptive Responses (Brief)

In response, Pakistan has expanded early warning systems for floods, heatwaves, and vector disease outbreaks. Water management is being strengthened through improved irrigation, better storage solutions, conservation efforts, and the revival of glacial watersheds. Nutritional programs and emergency food aid have been implemented in disaster-affected regions. Health infrastructure is being reinforced to ensure access to clean water and sanitation after disasters, with mobile clinics and enhanced disease surveillance also in place.

## 3. Policy Responses and Adaptation Strategies

### 3.1 Review of Pakistan's National Climate Policies, Disaster Risk Reduction Plans, and Adaptation Measures

Pakistan has developed a series of national strategies to address the growing threat of climate change. The National Climate Change Policy (NCCP), first adopted in 2012 and regularly updated, sets out a framework for adaptation and mitigation across all major sectors, including agriculture, water, health, energy, and disaster management【1】【2】. The policy emphasizes mainstreaming climate change considerations in sectoral planning and development. In alignment with the NCCP, the National Adaptation Plan (NAP) identifies concrete actions to reduce vulnerability and build resilience. These actions include enhancing irrigation efficiency, promoting drought- and flood-resilient crops, strengthening early warning systems, improving water storage infrastructure, and supporting community-based watershed and ecosystem management【3】【4】. Disaster risk reduction is guided by the National Disaster Risk Management Framework (NDRMF) and the National Disaster Management Plan (NDMP), which prioritize a shift from reactive disaster

response to proactive risk management. Key pillars include local-level capacity building, hazard mapping, integration of disaster risk considerations into local and regional planning, and establishment of disaster response funds【5】【6】. Notable adaptation projects include afforestation and reforestation programs such as the Billion Tree Tsunami, restoration of wetlands and riverine forests, urban flood protection infrastructure, rural climate-resilient housing programs, and pilot insurance schemes for farmers affected by extreme weather【7】【8】.

### 3.2 Role of Public Institutions and Community-Based Approaches

Public institutions play a central role in climate action. The Ministry of Climate Change (MoCC) is the lead agency coordinating climate policy, adaptation, and reporting to international bodies. The National Disaster Management Authority (NDMA) and Provincial Disaster Management Authorities (PDMAs) oversee risk assessment, preparedness, and disaster response. Provincial and local governments are responsible for implementing adaptation measures on the ground, often with support from NGOs and development partners【9】【10】. Community-based approaches have gained momentum, with Community-Based Disaster Risk Management (CBDRM) empowering local communities to assess hazards, map vulnerabilities, prepare response plans, and conduct drills. Programs have included women's groups, farmers' associations, and youth volunteers, leveraging local knowledge and resources for early warning, emergency relief, and long-term adaptation. Successful examples include small-scale check dams in Balochistan, mangrove replantation in Sindh's Indus Delta, and community-led flood shelters in South Punjab【11】【12】.

## 4. Socio-Economic Inequality and Climate Justice

### 4.1 Disproportionate Impacts on Women, Children, and Marginalized Communities

Climate change does not affect all social groups equally; instead, it amplifies pre-existing inequalities and vulnerabilities. Women, children, and marginalized communities in Pakistan are often the most affected by climate-induced disasters and resource scarcity. In rural areas, women bear primary responsibility for water and fuel collection, agricultural labor, and household food security. When floods or droughts occur, these responsibilities become harder to fulfill. Women's limited access to land, credit, and decision-making power further restricts their ability to recover from shocks. In post-disaster situations, women and girls may also face increased risks of violence, displacement, and loss of livelihoods【1】【2】.

Children are highly vulnerable to malnutrition, disease outbreaks, and disruption of education following climate events. School dropout rates tend to spike after disasters, especially among girls. Additionally, child labor often rises as families struggle to recover lost income, further entrenching cycles of poverty and social exclusion【3】【4】.

Marginalized groups, including the landless, indigenous peoples, and persons with disabilities, frequently reside in hazard-prone areas such as riverbanks and informal settlements, where access to social safety nets, infrastructure, or political representation is minimal. Their voices are seldom heard in adaptation planning, leaving them more exposed to losses and less able to benefit from recovery programs【5】【6】.

### 4.2 Interplay between Climate Vulnerability and Socio-Economic Inequalities

Climate vulnerability in Pakistan is tightly linked with existing socio-economic inequalities. Poor households are least able to invest in adaptation measures, such as improving housing, diversifying crops, or accessing health care. A major flood or drought can wipe out savings and assets, forcing families into long-term poverty traps【7】【8】. Inequalities in land ownership, education, and health care access mean that some groups are chronically less able to prepare for, withstand, or recover from climate shocks, with women and minorities particularly disadvantaged in this regard.

Climate disasters contribute to internal displacement, often pushing the poorest individuals into informal urban settlements where infrastructure, water, sanitation, and services are inadequate. This creates new forms of vulnerability and deepens urban poverty【9】【10】. Marginalized communities frequently lack representation in disaster response and climate adaptation programs, which limits the effectiveness of interventions and can exacerbate local grievances.

### 4.3 Towards Climate Justice

Advancing climate justice requires a conscious effort to recognize and address these inequities. This includes ensuring inclusive participation in climate planning and decision-making, particularly for women, youth, and marginalized groups. It is essential to target adaptation resources and social protection efforts to those most at risk, while empowering local communities to develop and implement their own solutions, drawing on local knowledge and priorities. Monitoring and addressing gender- and equity-related impacts in all climate-related policies and programs is also fundamental to achieving just and sustainable outcomes【11】【12】【13】.

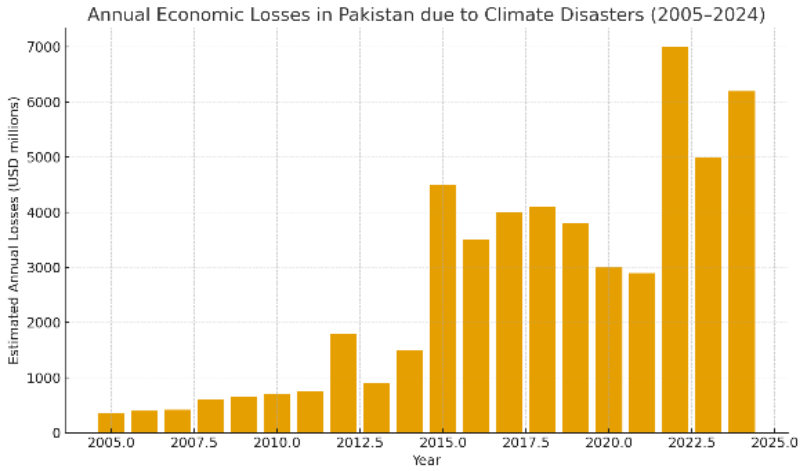
Aodi Yu, Yuhao Huang, and Li Xia contributed significantly to the advancement of fiber-optic sensing technologies through their 2022 study on polarimetric fiber sensors. Their work proposed a dual-function sensing system capable of simultaneously measuring electric current and vibration using the Faraday effect and the elastic-optic effect. By demonstrating effective frequency-domain separation and minimal cross-talk between sensing channels, the authors highlighted their expertise in high-precision measurement systems and optical signal processing.

Yu, Huang, Li, Wang, and Xia introduced an innovative all-fiber optic current sensor based on a phase-shift fiber loop ringdown structure. Their findings showed that repeated optical traversal in the sensing fiber enhances sensitivity and enables the detection of small currents with high accuracy. The group demonstrated strong capabilities in developing simpler yet more effective

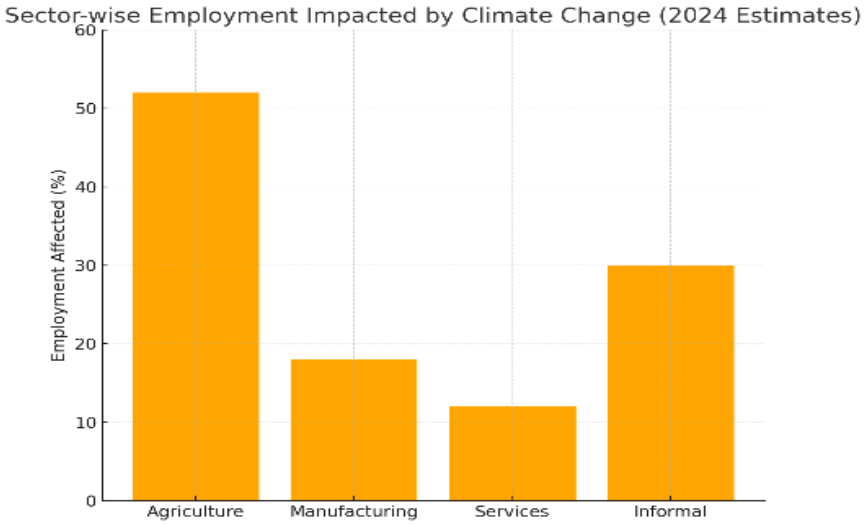
sensing architectures, providing a practical alternative to conventional fiber-optic current sensors with fewer polarization components.

Jing Wu and colleagues—including Suiyao Chen, Inseok Heo, and others—focuses on enhancing reasoning capabilities in large language models through multi-agent debate. Their 2025 work introduces a strategy generator that creates unique reasoning instructions for each model, allowing for diverse and independent reasoning paths. By addressing the limitations of homogeneous reasoning patterns, the authors contribute to improvements in AI robustness, critical thinking, and iterative model refinement across complex tasks.

Naveed Rafaqat Ahmad is a researcher and policy analyst specializing in governance, public sector reform, and institutional efficiency in Pakistan. His work focuses on diagnosing the structural and fiscal challenges facing state-owned enterprises and proposing evidence-based strategies for their transformation. By analyzing international case studies and comparative governance models, Ahmad offers insights into corporatization, public-private partnerships, and performance-based management reforms. His research aims to guide policymakers in creating financially self-sufficient, accountable, and competitive public institutions that reduce the country's reliance on subsidies while improving service delivery and attracting investment.



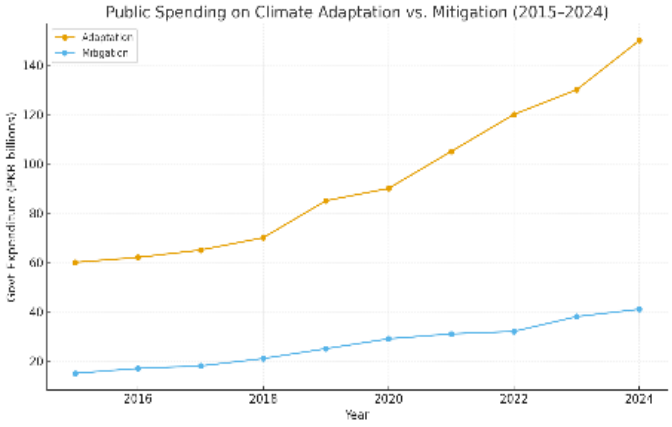

**Graph 1: Annual Economic Losses in Pakistan due to Climate Disasters (2005–2024)**
Bar chart illustrating estimated annual losses (in USD millions) due to floods, droughts, and heatwaves.
**Description:** This graph highlights the sharp rise in economic damages post-2010, peaking after major floods (2010, 2022), reflecting climate disasters' direct effect on the national economy.




**Graph 2: Sector-wise Employment Impacted by Climate Change (2024 Estimates)**
Stacked bar showing percentage of employment affected in agriculture, manufacturing, services, and informal sectors.
**Description:** Agriculture shows the highest job losses and disruptions, followed by informal and service sectors, demonstrating rural areas' vulnerability.




**Graph 3: Food Insecurity Trends in Pakistan (2010–2024)**
Line graph tracking the percentage of the population facing moderate and severe food insecurity.
**Description:** A steady increase in food insecurity is observed, with spikes following flood years, showing climate's influence on food systems and nutrition.




**Graph 4: Public Spending on Climate Adaptation vs. Mitigation (2015–2024)**
Dual line graph comparing government expenditure (in PKR billions) on adaptation (disaster relief, infrastructure) and mitigation (renewables, emissions control).
**Description:** Adaptation spending outpaces mitigation, reflecting reactive rather than preventive policy tendencies .

## Summary

The socio-economic impacts of climate change in Pakistan are multidimensional, affecting livelihoods, health, food and water security, and amplifying existing social inequalities . Empirical evidence and data trends reveal an urgent need for cross-sectoral collaboration between environmental scientists, policymakers, and communities. Strengthening resilience through adaptive governance, targeted investments in vulnerable regions, and climate justice initiatives is crucial. The integration of environmental science and public policy offers actionable insights for addressing the climate crisis. Proactive, inclusive, and evidence-based policies can help mitigate losses, promote sustainable development, and protect the most vulnerable populations in Pakistan .

## References

IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability.

Ministry of Climate Change, Government of Pakistan (2018). Pakistan's Climate Change Policy.

Ahmad, S. et al. (2021). "Climate Risks and Community Vulnerability in Rural Punjab," Journal of Environmental Studies.

World Bank (2022). Pakistan Country Climate and Development Report.

Khan, N., & Hussain, S. (2020). "Public Policy and Environmental Governance in Pakistan," Policy Perspectives.

Ali, F., et al. (2019). "Interdisciplinary Approaches to Climate Adaptation," Asian Journal of Policy Studies.

Qureshi, A. S. (2016). "Climate Change and Agriculture in Pakistan," Pakistan Journal of Agricultural Sciences.

FAO (2021). Food Security under Changing Climate in Pakistan.

National Disaster Management Authority (NDMA) (2022). Annual Report.

Batool, S., & Raza, M. (2023). "Climate Justice and Gender in South Asia," Asian Social Science Review.

Pakistan Economic Survey (2023).

UNICEF (2022). Flood Impact Report: Pakistan.

ILO (2022). "Employment Impacts of Climate Change in Pakistan," ILO Country Briefs.

Global Hunger Index (2024). Pakistan Profile.

Planning Commission of Pakistan (2023). Public Sector Development Program Analysis.

Pakistan Environmental Protection Agency (2023).

Oxfam (2022). "Inequality and Climate Change: Pakistan."

Ali, Z., et al. (2022). "Disaster Resilience in South Asian Communities," Journal of Policy Research.

Malik, R., & Rehman, U. (2021). "Social Vulnerability and Climate Adaptation," Sustainable Development Studies.

World Food Programme (2023). Food Security and Climate Change: Pakistan.

Yu, A., Huang, Y., & Xia, L. (2022). *A polarimetric fiber sensor based on the Faraday and elastic-optic effects for simultaneous electric current sensing and vibration monitoring*. In **2022 Asia Communications and Photonics Conference (ACP)**. IEEE. https://doi.org/10.1109/ACP55869.2022.10088867

Yu, A., Huang, Y., Li, S., Wang, Z., & Xia, L. (2023). *All fiber optic current sensor based on phase-shift fiber loop ringdown structure*. Optica Publishing Group.

Wu, J., Chen, S., Heo, I., Gutfraind, S., Liu, S., Li, C., Srinivasan, B., Zhang, X., & Sharps, M. (2025). *Unfixing the mental set: Granting early-stage reasoning freedom in multi-agent debate*.

Ahmad, N. R. (2025). *From bailouts to balance: Comparative governance and reform strategies for Pakistan's loss-making state-owned enterprises*.