
Socioeconomic Impacts of Climate Change on Rural Livelihoods in Pakistan

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Abstract

Pakistan ranks among the world's most climate-vulnerable nations, with rural communities comprising 65–70% of the population and heavily dependent on climate-sensitive agriculture, livestock, and fisheries bearing the brunt of its impacts. This review synthesizes the multifaceted socioeconomic consequences of climate change across Pakistan's diverse agro-ecological zones, drawing on meteorological trends, disaster records, and livelihood studies from 2018 to 2025.

Rising temperatures (national average increase of 0.57–0.63 °C over the past century, with accelerated warming in the northern highlands), erratic monsoons, glacial melt, and frequent extreme events such as the 2022 floods (affecting 33 million people and causing >USD 30 billion in damages) have destabilized agricultural production, triggered widespread livestock losses, degraded fisheries in the Indus Delta, and intensified water scarcity. These biophysical shocks translate into severe socioeconomic outcomes: declining crop yields (particularly wheat, rice, and cotton), increased rural poverty (projected 3.7–4.0 percentage point rise post-2022 floods), deepening debt traps through informal credit systems, heightened food insecurity, and accelerated climate-induced migration. The impacts are profoundly gendered, with women facing intensified labor burdens, restricted mobility during disasters, and heightened psychosocial stress. Institutional responses, including the National Climate Change Policy and community-based adaptation initiatives, remain hampered by implementation gaps, limited financing, and insufficient integration of local knowledge. The paper concludes that without urgent, scaled-up adaptation measures encompassing climate-smart agriculture, improved water governance, diversified livelihoods, and gender-responsive policies rural livelihoods in Pakistan face existential threats that could undermine national food security and socioeconomic stability in the coming decades.

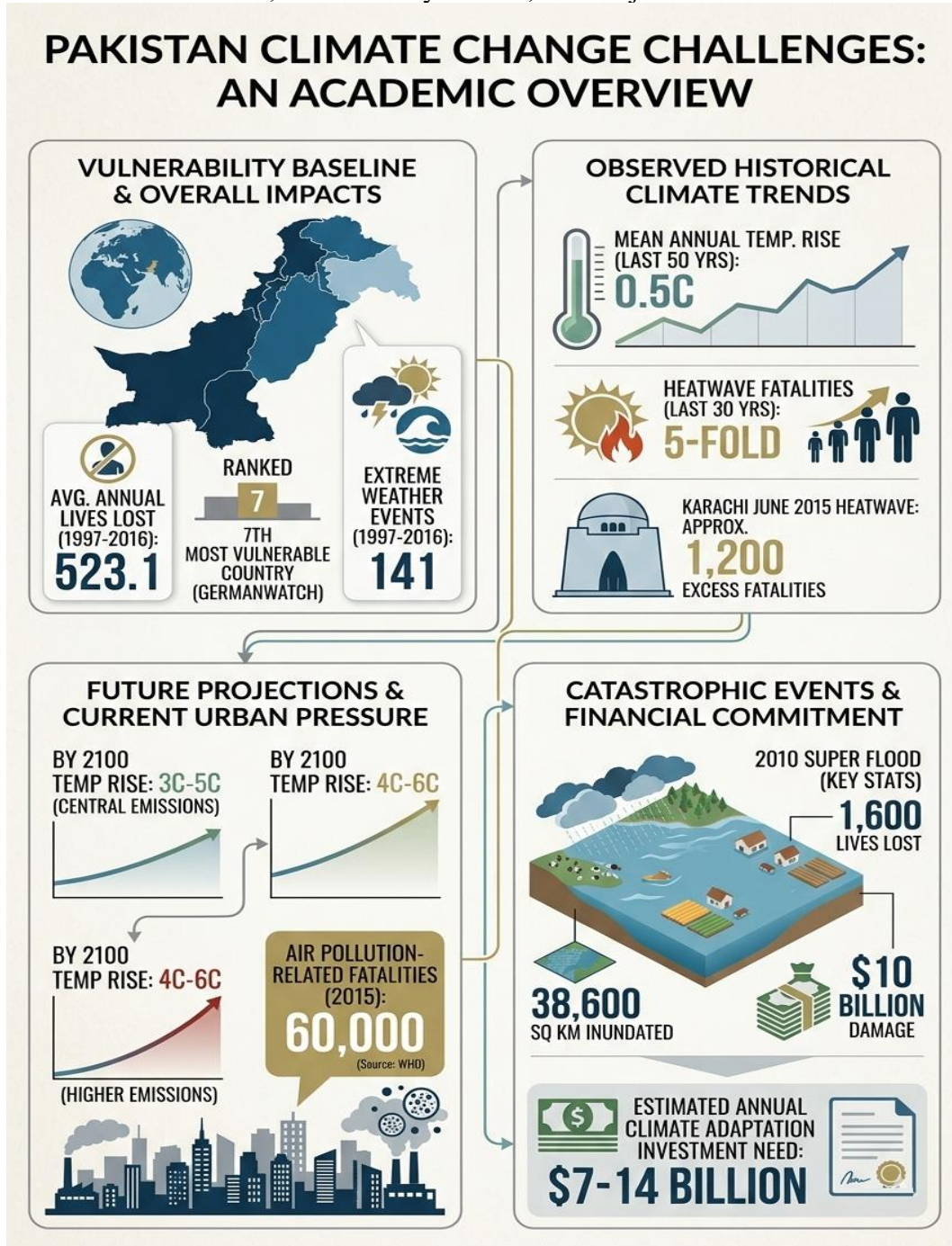
Keywords: Climate Change, Rural Livelihoods, Pakistan, Agricultural Vulnerability, Floods, Water Scarcity, Gender And Climate Change, Livestock Losses, Indus Delta Fisheries, Glacial Lake Outburst Floods (GLOFs), Adaptation Strategies, Socioeconomic Impacts

1. Executive Summary of Climatic Vulnerability

The geographical positioning and socioeconomic architecture of Pakistan render it one of the most susceptible nations to the global climate crisis. Ranked consistently among the top ten countries most affected by extreme

weather events over the last two decades, the nation faces a bifurcated threat of hydrometeorological volatility and systemic economic fragility (Government of Pakistan et al., 2022). Approximately 65 to 70 percent of the population resides in rural areas, where livelihoods are intrinsically tied to agricultural cycles and natural resource availability (Saddique et al., 2022). This heavy dependence on the primary sector creates a direct transmission mechanism through which climatic shocks ranging from record-breaking heatwaves to catastrophic floods cascade into severe socioeconomic disruptions (Maryam et al., 2025)

Figure 1: Historical Climate Trends, Vulnerability Indices, and Projected Thermal Shifts in Pakistan



The national economy, characterized by its reliance on the Indus River system and monsoon patterns, is

currently navigating an era of unprecedented environmental stress (Stratford, 2025). Historical data indicates that Pakistan’s average annual temperature has increased by approximately 0.57 to 0.63 degrees Celsius over the last century, a trend that is accelerating in the current decade (Yousaf et al., 2025). These shifts are not merely statistical artifacts; they represent a fundamental alteration of the thermal and hydrological regimes that sustain the country’s food and water security. The 2022 floods served as a visceral demonstration of this vulnerability, affecting 33 million people and resulting in economic losses exceeding USD 30 billion (The News, 2025). As the nation moves toward the 2025–2030 period, the convergence of population growth projected to reach 247 million by 2025 and diminishing per capita water availability creates an evolving national security challenge (Ishaque et al., 2025).

Table 1: Economic indicators pre- and post-flood status

Economic Indicator	Pre-Flood Status (FY22)	Post-Flood Projection/Impact
Real GDP Growth	5.97%	2.2% Decline (Direct Impact)
Agriculture Sector Growth	4.40%	0.9% Contraction
Per Capita Income	\$1,798	Stagnation/Decline in Real Terms
Current Account Deficit	4.6% of GDP	Widening due to Food/Cotton Imports
National Poverty Rate	21.9% (approx.)	3.7 to 4.0 Percentage Point Increase

2. Climatological Transformations and Regional Heterogeneity

The impacts of climate change in Pakistan are not geographically uniform. The diverse topography spanning from the high-altitude glaciers of the north to the arid plateaus of Balochistan and the alluvial plains of the Indus results in localized climate hotspots with distinct risk profiles (Wells et al., 2023). Analysis of temperature and precipitation trends reveals significant regional variations that continue to shape adaptation requirements in 2025 and 2026 (Jamil, 2025).

2.1. Thermal Trends in the Northern Highlands

Northern Pakistan, encompassing the Greater Himalayas, Karakoram, and Hindu Kush ranges, is experiencing warming at a rate higher than the national average. This region serves as the water tower for the entire country, housing over 7,000 glaciers that feed the Indus River system (The Friday Times, 2025). However, the rapid recession of these glaciers estimated at 40 to 60 meters per decade presents a dual threat: the short-term increase in Glacial Lake Outburst Floods (GLOFs) and the long-term depletion of Base River flows (United Nations Development Programme, 2025).

Over 75 percent of meteorological stations in the Greater Himalayan Region recorded an increase in extreme temperatures during the latter half of the 20th century (Yadav et al., 2021). Future climate models predict that warming in Northern Pakistan will be significantly higher than in the southern plains, with potential increases of 5.0 to 5.8 degrees Celsius by the end of the 21st century (Government of Pakistan, 2021). This thermal acceleration directly influences snowmelt rates, shifting the timing of peak runoff and threatening the stability of traditional mountain agriculture (Qin et al., 2022).

2.2. Hydro-Meteorological Volatility in the Indus Plains

In the central and southern plains of Punjab and Sindh, the primary climatic driver is thermal stress and erratic monsoon behavior. While mean annual temperatures in the plains have shown a relatively modest increase compared to the north, the frequency of extreme heatwaves has escalated (Qureshi et al., 2023). Summer temperatures in these regions regularly exceed 45 to 49 degrees Celsius, causing significant physiological stress to crops like wheat and cotton (Mobeen et al., 2025).

Precipitation patterns in the plains have become increasingly unpredictable. While historical data suggests a

general increase in annual precipitation for central Punjab, southern regions and the desert areas of Sindh are facing a decrease in summer precipitation of up to 60 percent according to some projections (Abbas et al., 2018). This unpredictability disrupts the traditional sowing and harvesting windows, leading to reduced yields and increased susceptibility to pests that thrive in warmer, humid conditions (Shah et al., 2025). The 2022 monsoon exemplified this volatility, where Sindh received more than 700 percent of its average August rainfall, leading to catastrophic riverine and flash flooding (Jan Alam, 2025).

2.3. Aridization of the Balochistan Plateau

Balochistan presents perhaps the most critical scenario of climate-induced scarcity. The province is characterized by high temperature increases rising by 1.17 degrees Celsius on the Balochistan Plateau and a projected decrease in precipitation in south-western areas (Hassan et al., 2025). Rural livelihoods in Balochistan depend heavily on groundwater extraction via tube wells, but the lack of sustainable recharge systems and erratic rainfall have led to a rapid depletion of aquifers (Ashraf et al., 2021).

Table 2: Regional temperature trends and primary hydrological threats

Region	Mean Temp Trend (1951-2000)	Summer Temp Rise (Apr-May)	Primary Hydrological Threat
Greater Himalayas	+0.63 °C	+1.91 °C	Glacial melt, GLOFs
Western Highlands	-0.72 °C	+0.17 °C	Flash floods, landslides
Central/Southern Punjab	+0.11 °C	+0.83 °C	Heatwaves, Monsoon floods
Lower Indus Plain	-0.08 °C	+0.35 °C	Salinity, Sea intrusion
Balochistan Plateau	+1.17 °C	+2.17 °C	Severe drought, Aquifer loss

3. Agricultural Destabilization and Rural Food Security

Agriculture is the primary conduit through which climate change impacts rural livelihoods in Pakistan, contributing roughly 26 percent to the national GDP and employing 39 percent of the labor force (Khan et al., 2020). The sector's extreme vulnerability stems from its dependence on the timing and quantity of river flows and monsoon rains, both of which are increasingly compromised (Mustafa et al., 2021).

3.1. Physiological Impacts on Staple and Cash Crops

The productivity of major crops wheat, rice, cotton, and sugarcane is declining due to thermal stress and water shortages. Wheat, the staple food source, is particularly sensitive to rising temperatures during the grain-filling stage. Studies indicate that temperatures between 40 and 42 degrees Celsius prevent wheat grains from expanding to their maximum size, directly reducing yields (Muitire et al., 2021). Rice production is equally at risk; a 1 degree Celsius increase in mean annual temperature is estimated to result in a 5.8 percent short-term reduction in rice production (Liaqat et al., 2024).

Cotton, Pakistan's most significant cash crop and the lifeblood of the textile industry, has suffered catastrophic losses. In 2024, heatwaves in Punjab and Sindh caused cotton production to plummet, with yields in some districts halving from historical averages (Sabagh et al., 2021). Nationally, cotton production decreased from 2.11 million bales to 1.07 million bales in 2024. The destruction of cotton crops has significant ripple effects on the national economy, as domestic cotton constitutes approximately 50 percent of the textile industry's required input (Zhang et al., 2023).

Table 3: Observed impacts of the 2024 heatwave on major crops

Crop Category	Climate Sensitivity	2024 Observed Impacts	Economic Impact
Wheat (Staple)	Grain-filling heat stress	Area/yield decline in Sindh	Food price inflation
Rice (Export)	Maturity rate changes	Yields dropped 5-50 mounds	Export revenue loss
Cotton (Cash)	Heat stress/pest pressure	Production halved in Punjab	Textile industry shock
Mangoes (Export)	Intense heatwaves	60% yield decline (2022)	Seasonal income loss

3.2. Soil Degradation and Waterlogging Mechanisms

Beyond direct atmospheric impacts, climate change alters soil chemistry and hydrology. Excessive heat accelerates soil moisture evaporation, leading to increased crop water requirements a phenomenon reported by 89 percent of farmers in some surveys (Bhattacharya, 2021). In the lower Indus basin, sea-level rise and reduced freshwater discharge have led to extensive saltwater intrusion, rendering approximately 1.2 million hectares of once-fertile land uncultivable (Jamil, 2025).

The increased frequency of flash floods in arid regions like Balochistan does not necessarily improve water availability. Instead, extreme rainfall often disappears as surface runoff, causing severe soil erosion and failing to recharge underground aquifers (Farooqi et al., 2024). This process of desertification and land degradation forces rural families to abandon traditional farming, contributing to a growing population of climate-induced migrants. In the Swat and Malakand districts, sudden alterations in weather patterns, such as hailstorms and unseasonal rains, result in significant food waste (Yousafzai et al., 2022).

4. The Livestock and Fisheries Economy

For many rural households in Pakistan, livestock acts as a mobile bank and a crucial safety net against crop failure (Faraz et al., 2023). The livestock sector accounts for over 60 percent of agricultural production and more than 11 percent of the national GDP, supporting approximately eight million households. However, this vital resource is increasingly threatened by climate-induced fodder shortages, disease outbreaks, and heat stress (Hussain et al., 2022).

4.1. Livestock Vulnerability and Pastoral Assets

The 2022 floods resulted in the death of over 1.1 million livestock units, a staggering blow to the wealth of rural families. Beyond direct mortality, the surviving animals suffer from reduced productivity; heat stress in cattle and buffaloes leads to lower milk yields and slower growth rates (Okolo, 2023). The loss of livestock is also a primary driver of urban inflation, as meat, eggs, and milk represent a significant portion of the consumer price index (Singh et al., 2025).

In arid regions, prolonged droughts force pastoral communities to sell their animals at distressed prices to survive, depleting their long-term assets and deepening the cycle of poverty (Ishaque et al., 2025). The transition from a water-stressed to a water-scarce status in 2025 is expected to further exacerbate these challenges, as the competition for water between human consumption, agriculture, and livestock intensifies (Golele, 2022).

4.2. Coastal Livelihoods and Marine Ecosystem Decay

The fisheries sector is the primary livelihood source for millions in the coastal districts of Sindh and Balochistan. Pakistan's 1,046-kilometer coastline and the Indus Delta are currently facing existential threats from sea-level rise, ocean acidification, and rising sea temperatures (Ali, 2018).

The Indus Delta has seen its freshwater inflow fall by nearly 80 percent since the 1950s due to upstream projects. This reduction, combined with rising sea levels, has caused significant land erosion and a sharp decline in fish stocks (Baset, 2020). Coastal communities report that it is becoming increasingly difficult to

catch fish, leading to food insecurity and the forced relocation of villages inland. Seawater intrusion has threatened more than 1.2 million acres of land in the Indus River Delta with salinity (Shahzad, 2024).

Mangrove forests, which serve as breeding grounds for marine species and a buffer against cyclones, are under extreme pressure. Although total mangrove cover increased to 250,000 hectares by 2025, these forests remain fragile and are frequently destroyed for development. The loss of these habitats accelerates the collapse of local fisheries (Ilyas, 2025).

5. Socioeconomic Resilience and the Debt-Poverty Trap

The socioeconomic impacts of climate change in Pakistan are deeply intertwined with structural inequalities, particularly land tenure systems and access to credit. For millions of tenant farmers, a single climatic shock can result in a permanent descent into indigence (Ayaz et al., 2023).

5.1. The Informal Credit System and Underplay

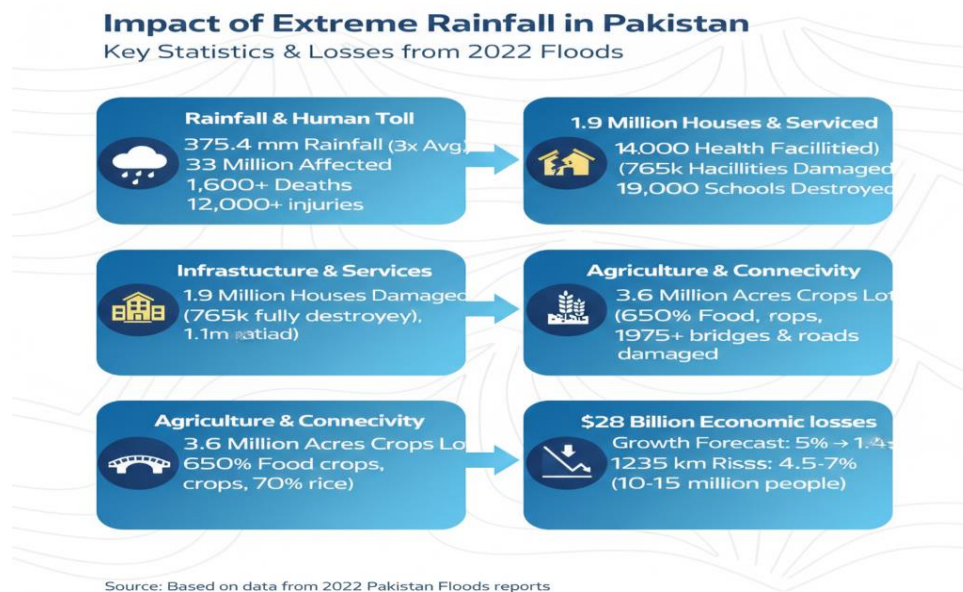
A critical dimension of rural vulnerability is the reliance on informal credit markets. In regions like Swat and Malakand, tenant farmers who suffer crop losses often find themselves unable to meet financial obligations to landlords. In the absence of formal support, these farmers engage in a practice known as underplay or Neta Watta (Siyal et al., 2018).

Under this system, a lender provides goods to the farmer at inflated prices, which the farmer then sells at the market rate to generate immediate cash. This acts as a high-risk financial lifeline that transfers the farmer's future labor and harvest to the lender at a massive discount. It is estimated that 25 to 30 percent of farmers in some northern districts are trapped in such informal debt cycles (Yousafzai et al., 2022).

5.2. Poverty Dynamics and Malnutrition

The national poverty rate in Pakistan is projected to increase by 3.7 to 4.0 percentage points as a result of the 2022 floods, pushing an additional 8.4 to 9.1 million people below the poverty line (Youth Council, 2025). For rural families, this manifests as a reduction in food intake. National reports indicate that 44 percent of children suffer from stunted growth due to malnutrition a crisis exacerbated by climate-induced food shortages (Saxena, 2018).

Figure 2: Multi-Sectoral Impact Analysis of Extreme Hydrometeorological Events: Case Study of the 2022 Monsoon Floods



The feminization of poverty is a notable trend, as women often prioritize the nutritional needs of other family members over their own during times of food scarcity. The loss of household assets, including stored grains and livestock, removes the final buffers against hunger. Out of the 25 poorest districts in Pakistan, 19 were calamity-affected during the 2022 floods (Adil et al., 2025).

Table 4: Estimated flood damages and losses by province

Province	Damages (USD Million)	Losses (USD Million)	Reconstruction Needs (USD Million)
Sindh	9,068	11,376	7,860
Balochistan	2,516	1,625	2,286
Punjab	515	566	746
KP	658	780	935

Data synthesized from (Government of Pakistan et al., 2022).

6. Gendered Vulnerabilities and Social Dimensions

Climate change is not gender-neutral in its impact. In Pakistan’s patriarchal rural societies, women face disproportionate burdens due to restricted mobility and limited access to resources (Zafar et al., 2025).

6.1. Labor Intensification and Resource Scarcity

As water sources dry up or become contaminated, the responsibility of fetching water falls heavily on women and girls. In arid regions, women are now forced to travel much longer distances to find potable water, a task that consumes several hours of their day. This increased workload often prevents girls from attending school (Ali, 2024).

Women make up approximately 49 percent of the rural population involved in farming and livestock rearing. When climate disasters strike, women are often tasked with rebuilding homes despite having no ownership of land or access to formal credit. In Gilgit-Baltistan, male out-migration has further intensified the responsibilities of women, who must manage entire households in high-risk zones (Adil et al., 2025).

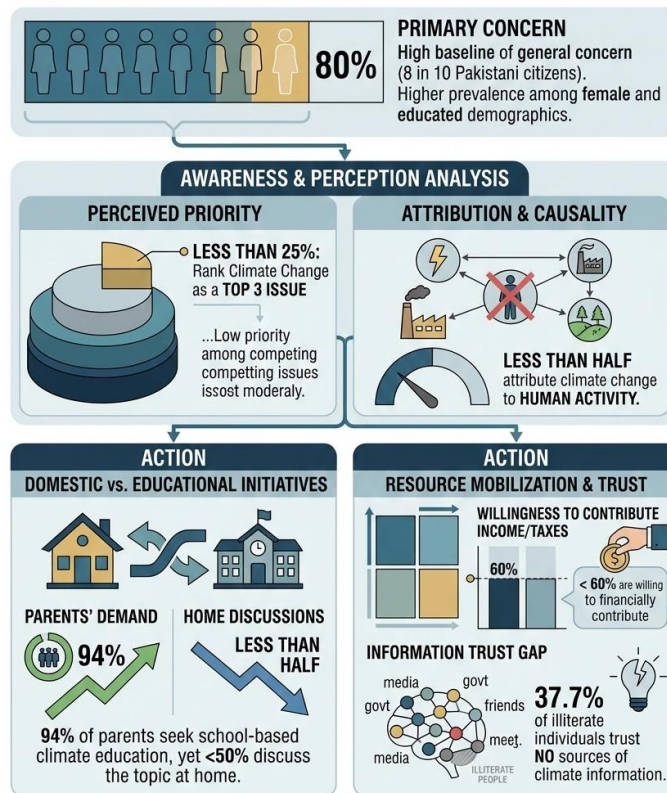
6.2. Psychosocial Burden and the Invisible Wounds

The mental health toll of climate change on rural women is a significant issue. Research following climate-induced disasters found that 72 percent of women reported high levels of stress, while 56 percent suffered from clinical depression. These feelings are rooted in social conditioning that compels them to endure suffering alone (Global South Forum, 2025).

Furthermore, extreme weather events are linked to social practices that further victimize young women. Families facing extreme financial desperation following crop losses sometimes resort to marrying off their daughters young as a desperate coping mechanism (Memon, 2025).

Figure 3: Psychosocial Dimensions and Public Perception Gaps in Climate Change Awareness and Institutional Trust

MAPPING SOCIOECONOMIC DISCONNECTS IN PAKISTANI CLIMATE CONSCIOUSNESS: A SYNTHESIS OF GALLUP-WORLD BANK DATA



6.3. Institutional and Cultural Barriers to Adaptation

Cultural norms significantly hinder women’s ability to respond to climate emergencies. During the 2022 floods, many women were unable to evacuate early because of societal norms regarding mobility and the lack of gender-responsive evacuation methods (Adhikari & Ghimire, 2025). While policies like the Climate Change Gender Action Plan (ccGAP) acknowledge these roles, participation largely remains symbolic (Ullah et al., 2024).

7. Water Governance and the Approaching Scarcity Line

Pakistan’s transition from a water-stressed to a water-scarce nation is a defining feature of the 2024–2026 period. Per capita water availability has declined from 5,600 cubic meters in 1947 to just 930 cubic meters in 2023. This scarcity is exacerbated by aging infrastructure and inefficient management (Idrees et al., 2025).

7.1. Storage Deficits and Inefficient Irrigation

Despite receiving 80 percent of its annual rainfall during the monsoon season, Pakistan has less than 10 percent storage capacity to hold this water. The Indus River system is suffering from increased siltation of major dams, reducing their efficiency. Furthermore, the irrigation system is notoriously inefficient, with almost half of the water lost through seepage (Irfan et al., 2019).

In provinces like Balochistan, the lack of small and medium-sized dams means that rainfall cannot be captured for agricultural use. This forces farmers to rely on expensive tube wells, which accelerates the depletion of groundwater (Afzal, 2021). The probability of meteorological drought is projected to increase, with severe conditions potentially experienced with an annual probability of 25 to 65 percent (Zhao et al., 2020).

7.2. Degradation of Water Quality and Health Implications

In Balochistan, laboratory testing has revealed that most drinking water samples fail to meet the safety standards set by the World Health Organization (WHO) and Pakistan's National Quality Standard (NQS). Contamination from heavy metals, arsenic, and organic pollutants is common (Perveen, 2023).

Rural communities face constant risks of waterborne diseases like malaria and cholera. The 2024 heatwave in southern Pakistan, where temperatures exceeded 49 degrees Celsius, further overwhelmed hospitals and exacerbated food insecurity for over 8.6 million people (The News, 2025).

8. Glacial Lake Outburst Floods and Mountain Livelihoods

Northern Pakistan faces an escalating threat from Glacial Lake Outburst Floods (GLOFs). Rapid glacial melt is causing increased water flow into lakes formed from melting glaciers, creating sudden releases of water (Liaquat et al., 2024).

8.1. The Scale of the GLOF Risk

The northern mountain ranges contain more than 3,000 glacial lakes. Of these, 33 to 36 have been identified as highly prone to hazardous bursting. These events put the lives and livelihoods of over 7.1 million people at high risk, particularly in Gilgit-Baltistan and Khyber Pakhtunkhwa (Baset, 2020).

8.2. Impact on Infrastructure and Agriculture

GLOF events in 2024 and 2025 have demonstrated their destructive capacity. In the Hunza valley, a 2024 GLOF destroyed a bridge connecting village segments and damaged homes. In 2025, a glacier burst in Gulmit swept away agricultural farms and a 45-year-old bridge (Jamil, 2025). For mountain communities, the loss of a bridge or an irrigation channel is catastrophic, as it isolates villages from essential markets. Fruit yields in Gilgit-Baltistan have already declined by as much as 15 percent over the past decade (Shahzad, 2024).

Table 5: GLOF-II project intervention targets and achievements

Project Intervention (GLOF-II)	Target Amount	Achieved Impact (by 2025)
Flood Protection Structures	411 units	39,615 meters constructed
Irrigation Channels	317 schemes	126,246 meters rehabilitated
Early Warning Systems (EWS)	292 systems	174 live EWS providing alerts
Slope Stabilization (Bio-engineering)	760 hectares	Reduced landslide/erosion risk
Community Training (Women)	N/A	5,761 women trained in resilience

Data synthesized from (UNDP, 2025).

9. Institutional Responses and Policy Barriers

Pakistan has developed a policy framework to address climate change, most notably the National Climate Change Policy (NCCP) updated in 2021. This document aims to steer the country toward climate-compatible development (Government of Pakistan, 2021).

9.1. The Policy Implementation Gap

Despite the ambitious goals of the NCCP, implementation remains largely aspirational as of 2025 (Maryam et al., 2025). Several critical barriers prevent these policies from being translated into action:

- Financial Limitations:** Pakistan's climate goals are heavily dependent on international finance (Government of Pakistan, 2021).
- Technical Capacity Deficits:** Provincial departments frequently lack staff trained in climate science or hydrology necessary for flood modeling (Youth Council, 2025).

3. **Exclusion in Environmental Assessments:** A review of 18 Environmental Impact Assessment (EIA) reports for road projects revealed that climate change was almost entirely ignored (Yousaf et al., 2025).

9.2. Community-Based Adaptation and Farmer Resilience

In the absence of robust state support, rural farmers have adopted indigenous strategies. These include adjusting sowing dates, switching to stress-tolerant crop varieties, and diversifying income. Evaluation revealed that planting sunflower crops 21 days earlier could reduce yield losses significantly (Saddique et al., 2022).

In the northern mountains, the GLOF-II project has introduced innovative solutions like ice stupas artificial glaciers designed to store winter meltwater (UNDP, 2025). Furthermore, the installation of early warning systems has begun to build community resilience in vulnerable valleys (Golele, 2022).

10. Synthesis and Strategic Outlook

The socioeconomic impacts of climate change on rural livelihoods in Pakistan represent a systemic threat. The convergence of hydrological instability, agricultural decline, and social inequalities creates a volatile landscape where the most vulnerable pay the highest price (Siyal et al., 2018).

The year 2025 marks a critical juncture. As the nation enters a period of severe water scarcity, the historical approach to resource management is no longer viable. Resilience in the Indus Basin will require the institutionalization of community-based adaptation and the creation of formal credit mechanisms that protect the rural poor (Shahzad, 2024). The implementation of the National Climate Change Policy and the realization of NDC targets are essential prerequisites for national survival in an increasingly hostile climate (Maryam et al., 2025).

Conclusion

Climate change is no longer a distant threat but a present-day reality profoundly reshaping rural livelihoods across Pakistan. From the rapid melting of northern glaciers and escalating GLOF risks to devastating floods in the Indus plains and creeping desertification in Balochistan, climatic stressors are systematically undermining the foundations of rural economies agriculture, livestock, and fisheries upon which the majority of the population depends. These environmental disruptions are magnified by structural vulnerabilities, including heavy reliance on rain-fed and canal irrigation systems, fragmented landholdings, informal credit traps, and deeply entrenched gender inequalities that place disproportionate burdens on women. The cumulative result is a vicious cycle of declining productivity, rising poverty, food insecurity, malnutrition, and distress migration that threatens to reverse decades of development gains. The 2022 floods served as a stark national wake-up call, yet the pattern of recurrent extreme events indicates that such disasters are becoming the new normal rather than exceptions. Effective response requires moving beyond incremental adjustments toward transformative, integrated adaptation. This includes scaling climate-smart agricultural practices, investing in sustainable water storage and governance, strengthening early-warning systems, promoting livelihood diversification, and ensuring meaningful inclusion of rural women and marginalized communities in decision-making. Robust implementation of the National Climate Change Policy, enhanced climate finance, and genuine community-based adaptation supported by scientific research and traditional knowledge offer the only viable pathway to build resilience. The future of rural Pakistan, and by extension the nation's food security and social stability, hinges on decisive action today. Failure to act boldly will not only deepen existing inequalities but also lock millions of rural households into chronic vulnerability, with far-reaching consequences for Pakistan's overall development trajectory in an increasingly hostile climate.

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