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IMPACT OF THE 2025 PAKISTAN FLOODS ON AGRICULTURE, PUBLIC HEALTH, AND ECOSYSTEMS: CHALLENGES AND MITIGATION STRATEGIES

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Abstract

The 2025 monsoon floods in Pakistan represent one of the most severe climate-induced disasters in the country's history, causing unprecedented devastation across agriculture, ecosystems, and public health. This review article examines the multifaceted impacts of the floods, highlighting massive agricultural losses, outbreaks of waterborne and vector-borne diseases, and severe disruption to ecosystems. Data from NDMA, FAO, WHO, and WWF indicate that over 12 million people were affected, with significant destruction of crops, health infrastructure, and biodiversity. Challenges such as climate change, weak disaster management systems, and inadequate urban planning have amplified vulnerabilities. Mitigation strategies discussed include climate-resilient agriculture, improved early warning systems, health preparedness, ecosystem restoration, and policy reforms. This study underscores the urgent need for integrated approaches to disaster resilience and climate adaptation in Pakistan.

INTRODUCTION

The 2025 floods in Pakistan have emerged as one of the most severe climate-driven disasters in the country's recent history. Beginning in late June, heavy pre-monsoon and monsoon rainfall, rapid glacial melt in the Hindu Kush-Himalaya region, and sudden cloudbursts in mountainous zones triggered widespread flash flooding, hill torrents, and riverine inundation. According to NDMA Situation Reports, by early September 2025 over 799 fatalities had been confirmed, more than a thousand injured,

and tens of thousands relocated (NDMA, 2025; OCHA, 2025).

By some estimates, over 12 million people across Punjab, Sindh, Khyber Pakhtunkhwa (KP), Gilgit-Baltistan (GB), and Azad Jammu & Kashmir have been directly or indirectly affected, including loss of homes, agricultural livelihoods, infrastructure, and essential services. This flood season is notable not only for its scale and destruction but also for the compounding effect of repeated climate stressors – including prior floods (2022), heatwave-induced glacial melt, and rising baseline vulnerability.

Pakistan's vulnerability to climate extremes is well documented. According to Germanwatch's Climate Risk Index, Pakistan ranked among the top countries most affected by extreme weather events (storms, floods, heat waves) in the period up to 2019 and more recently was considered the most vulnerable country in 2022 owing to the catastrophic floods and heatwave that year. The Climate Risk Index 2025 also places Pakistan first among the countries most impacted in 2022 in terms of human and economic losses (˜US$30 billion) and widespread displacement.

Pakistan's climate vulnerability is further underlined by its ranking in the ND-GAIN Index (ADB), which highlights the country's limited readiness and high exposure to climate risk. The repeated pattern of floods (notably 2010, 2012, 2022) and mounting evidence of intensifying glacial melt due to warming implies that these are not isolated incidents but part of a pattern of escalating climate stress.

Pakistan's geography—a combination of high mountain catchments, limited forest cover, extensive irrigated plains, and densely populated flood-prone zones—makes it particularly susceptible to compound climate hazards. The 2025 floods therefore serve as a stark reminder of the converging risks: climate change exposures (heavier rainfall, glacier melt, cloudburst intensity), socio-economic vulnerabilities (poverty, weak infrastructure, insufficient warning systems), and governance challenges (land-use planning, disaster risk reduction readiness). The scale of displacement, loss of crops and livestock, disruption of health services, and damage to ecosystems underscores the urgent need for robust and integrated adaptation and mitigation strategies (FAO, 2025; WHO, 2025; WWF Pakistan, 2025).

Impact on Agriculture

The 2025 Pakistan floods caused widespread devastation to the country's agricultural sector, which contributes nearly 19% to the national GDP and provides livelihoods for around 38% of the workforce (FAO, 2023). Floodwaters inundated millions of hectares of cropland, destroying standing crops such as rice, maize, cotton, and sugarcane in Punjab and Sindh, which are the main agricultural hubs of Pakistan (NDMA, 2025). According to early damage assessments, more than 2.5 million hectares of cultivated land were submerged, leading to an estimated crop loss worth billions of dollars (FAO, 2025).

Livestock production also suffered severely. Thousands of cattle, buffaloes, and goats perished due to drowning, starvation, and disease outbreaks caused by water contamination (WWF Pakistan, 2025). Pastures and fodder supplies were washed away, aggravating food insecurity among rural households dependent on mixed farming systems. The floods also destroyed vital agricultural infrastructure, including irrigation canals, tube wells, storage facilities, and rural roads, disrupting supply chains and access to markets (World Bank, 2022).

The destruction of cotton crops, in particular, has serious implications for Pakistan's textile industry, which is the country's largest export sector. Similarly, the loss of rice paddies not only threatens domestic food availability but also reduces Pakistan's ability to meet its export commitments, particularly to Middle Eastern and African countries (FAO, 2025). These cascading effects demonstrate the vulnerability of Pakistan's agriculture to climate extremes and the urgent need for climate-resilient farming practices such as flood-tolerant crop varieties, improved drainage systems, and adaptive water management.

Public Health Concerns

The 2025 Pakistan floods created a severe public health emergency, primarily due to the contamination of drinking water, overcrowding in temporary shelters, and the collapse of healthcare infrastructure. Floodwaters damaged hundreds of

rural health centers and district hospitals, leaving millions without access to essential services (NDMA, 2025). As a result, both acute and chronic health challenges emerged.

Waterborne diseases surged in affected regions, with outbreaks of cholera, dysentery, typhoid, and acute watery diarrhea reported by the World Health Organization (WHO, 2025). Stagnant water also facilitated the breeding of mosquitoes, leading to an alarming increase in malaria and dengue fever cases, particularly in Sindh and Punjab (Kakar et al., 2022; WHO, 2025). These disease outbreaks were compounded by shortages of clean water, food, and medicines, further overwhelming already fragile health systems.

Maternal and child health was disproportionately affected. Pregnant women faced reduced access to antenatal care, emergency obstetric services, and safe delivery facilities, while children under five experienced heightened vulnerability to malnutrition and infectious diseases (UNICEF, 2025). Malnutrition rates, already high in Pakistan before the floods, worsened as food insecurity intensified in flood-affected districts (FAO, 2025).

The mental health impact of the disaster is also significant but often overlooked. Survivors reported increased levels of anxiety, depression, and post-traumatic stress disorder (PTSD), stemming from the loss of homes, livelihoods, and family members (Hameed et al., 2023). Mental health services, however, remain scarce and underfunded in Pakistan, creating a critical gap in disaster response.

Collectively, these challenges underscore the need for an integrated health preparedness framework that includes disease surveillance, rapid deployment of medical teams, strengthened vaccination campaigns, and mental health support in disaster-hit regions.

Impact on Ecosystems

The 2025 floods had profound consequences on Pakistan's ecosystems, particularly wetlands, riverine habitats, and mountain ecosystems. Vast areas of natural habitat were submerged, disrupting ecological balance and threatening biodiversity. Floodwaters inundated critical wetlands such as the Indus Dolphin Reserve and the Uchhali Wetlands Complex, leading to habitat degradation for migratory birds, freshwater dolphins, and endemic fish species (WWF Pakistan, 2025). The Indus River dolphin (*Platanista gangetica minor*), already classified as endangered, faced increased risk due to altered water flow patterns, pollution from floodwaters, and habitat fragmentation (Khan et al., 2021).

Terrestrial wildlife was also severely affected. Reports documented displacement of species such as hog deer (*Axis porcinus*), smooth-coated otters (*Lutrogale perspicillata*), and Punjab urial (*Ovis vignei punjabiensis*), which were forced to move to higher ground due to inundation of low-lying areas (IUCN Pakistan, 2025). Such displacement not only increases human-wildlife conflict but also disrupts breeding cycles and food availability.

The floods intensified soil erosion, deforestation, and land degradation in hilly areas of Khyber Pakhtunkhwa and Gilgit-Baltistan, particularly in regions affected by cloudbursts and glacial lake outburst floods (GLOFs) (Ali et al., 2022). Loss of vegetation cover and increased sedimentation in rivers further destabilized ecosystems and reduced water quality. Aquatic ecosystems suffered from chemical contamination due to runoff of fertilizers, pesticides, and industrial pollutants into floodwaters, threatening both biodiversity and human health (UNEP, 2023).

Ecosystem services that sustain rural communities such as freshwater supply, soil fertility, pollination, and carbon sequestration were significantly disrupted. These ecological imbalances will have long-term consequences, undermining climate resilience, food security, and sustainable development goals. The crisis highlights the urgent need for ecosystem-based disaster risk reduction (Eco-DRR), restoration of degraded wetlands, and strict regulation of deforestation and land use changes in flood-prone areas.

Challenges and Vulnerabilities

The 2025 floods in Pakistan exposed deep-rooted vulnerabilities in governance, infrastructure, and social systems that magnified the disaster's impacts. Climate change has intensified monsoon variability, glacial melt, and extreme weather patterns, with Pakistan consistently ranked among the most climate-vulnerable countries in the world (Germanwatch, 2021; Eckstein et al., 2021). The

heavy cloudbursts in Chakwal, Buner, and Gilgit-Baltistan, coupled with irregular rainfall, underscored the growing unpredictability of monsoonal systems linked to global warming (IPCC, 2022).

Weak disaster preparedness remains a critical challenge. Despite the existence of the National Disaster Management Authority (NDMA), local early warning systems were inadequate to protect vulnerable rural and mountainous communities (NDMA, 2025). Many residents received little or no warning prior to flash floods, and the evacuation infrastructure in hilly regions was insufficient, leading to preventable casualties and mass displacement (Ahmed & Mughal, 2023).

Agricultural dependence is another major vulnerability. With nearly 40% of Pakistan's labor force engaged in farming, extreme floods devastate livelihoods, undermine food security, and intensify poverty cycles (World Bank, 2023). The destruction of irrigation canals, storage facilities, and rural roads further hindered recovery, while smallholder farmers, who form the majority, lacked crop insurance or financial safety nets (FAO, 2025).

Urban areas also exhibited systemic weaknesses. Major cities like Karachi and Lahore faced severe urban flooding due to poor drainage, unregulated urban expansion, and encroachment on natural waterways (Hasnain et al., 2022). Informal settlements, home to millions of urban poor, were disproportionately affected due to inadequate infrastructure, unsafe housing, and limited access to healthcare.

Social inequalities magnified disaster risks. Women, children, elderly populations, and persons with disabilities faced barriers in accessing relief, healthcare, and safe shelter (UN Women, 2023). Furthermore, internally displaced persons (IDPs) from flood-hit regions often lacked legal protections, increasing their exposure to exploitation and poor living conditions.

Collectively, these vulnerabilities demonstrate that while the 2025 floods were driven by natural hazards, the scale of devastation was largely a result of systemic socio-economic weaknesses, institutional shortcomings, and insufficient climate adaptation planning. Without structural reforms, Pakistan will remain highly exposed to recurrent flood disasters in the future.

Mitigation Strategies

Mitigating the impacts of catastrophic floods like those of 2025 requires a multi-dimensional approach that integrates climate adaptation, technological innovation, ecosystem-based management, and institutional reforms.

1. Climate-Resilient Agriculture

Introducing flood-tolerant crop varieties, crop diversification, and raised-bed farming can reduce agricultural losses during floods. The FAO (2025) has emphasized the need for climate-smart agricultural practices such as direct seeding of rice, conservation tillage, and rotational cropping to restore soil fertility after flooding. Adoption of crop insurance schemes and financial safety nets is also essential to protect smallholder farmers from livelihood shocks (World Bank, 2023).

2. Strengthening Early Warning Systems

Pakistan's current disaster management relies heavily on manual data collection. Integrating satellite monitoring, AI-based predictive models, and community-level alert systems can significantly reduce casualties. Successful pilot projects in Bangladesh and Nepal demonstrate that localized early warning systems linked with mobile technology can improve preparedness and reduce losses (Shrestha et al., 2021; Ahmed & Mughal, 2023).

3. Public Health Preparedness

The public health crisis triggered by floods requires stronger investment in mobile healthcare units, vaccination drives, and provision of clean water. Deployment of portable water purification systems, as recommended by WHO (2025), can reduce outbreaks of cholera and diarrhea. Strengthening primary healthcare infrastructure and training health workers in disaster response is also critical to prevent system collapse during crises (Khan et al., 2022).

4. Ecosystem Restoration and Eco-DRR

Ecosystem-based disaster risk reduction (Eco-DRR) is a cost-effective strategy to enhance resilience. Reforestation of degraded slopes in KP and GB can

reduce soil erosion and landslide risks, while wetland restoration in Sindh can enhance natural water storage capacity and support biodiversity (WWF Pakistan, 2025). Glacial lake monitoring and controlled drainage can mitigate glacial lake outburst floods (GLOFs), a growing risk in northern Pakistan (Ali et al., 2022).

5. Policy and Institutional Reforms

Addressing structural weaknesses requires strong governance. Policies must prioritize zoning laws that prevent construction in floodplains, investment in urban drainage systems, and green infrastructure in major cities (Hasnain et al., 2022). Farmer compensation programs, disaster risk financing, and integration of climate resilience into the national development agenda are essential for long-term security (UNDP, 2023).

6. Community Engagement and Awareness

Local communities play a central role in flood preparedness. Capacity-building programs, disaster drills, and community-based disaster risk management (CBDRM) initiatives can enhance grassroots resilience. Experiences from community-driven flood management in Bangladesh and Sri Lanka show that empowering local institutions can significantly reduce human and economic losses (Shrestha et al., 2021).

Together, these strategies highlight the need for an integrated framework that combines technology, ecological management, health resilience, and social protection. Pakistan's path forward depends not only on reactive relief measures but also on proactive, long-term climate adaptation and disaster risk reduction planning.

Conclusion

The 2025 floods in Pakistan represent one of the most severe climate-induced disasters in the nation's history, devastating agriculture, ecosystems, and public health. Beyond the immediate destruction, the floods have highlighted chronic vulnerabilities rooted in weak disaster preparedness, socio-economic inequalities, and unsustainable land use practices. Agricultural losses threaten food security and rural livelihoods, while outbreaks of waterborne and vector-borne diseases strain an already fragile healthcare system. Simultaneously, the inundation of wetlands, forests, and glacial ecosystems has disrupted biodiversity and reduced ecosystem services essential for human well-being.

However, these challenges also provide an opportunity to rethink Pakistan's resilience strategies. Climate-smart agriculture, advanced early warning systems, mobile healthcare interventions, and ecosystem-based disaster risk reduction can provide sustainable solutions. Equally important are structural reforms in governance, urban planning, and policy frameworks that integrate climate resilience into national development agendas.

Ultimately, the 2025 floods underscore the urgency of a paradigm shift from reactive relief measures to proactive, integrated disaster risk management. Only through coordinated efforts involving government institutions, international organizations, local communities, and civil society can Pakistan build resilience against future climate-induced disasters and safeguard its socio-economic and ecological future.

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