Pakistan's Climate Resilience Crisis: Evaluating SDG 13 Through Water Mismanagement and Agricultural Adaptation (2015–2025)

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Abstract:

Pakistan's progress toward Sustainable Development Goal 13 (SDG 13) has been hindered by persistent water mismanagement and inadequate agricultural adaptation. Pakistan, being an agricultural country that heavily relies on the Indus River System, faces water scarcity that is increasing with per capita availability dropping below 1,000 cubic meters annually. Continuous climate change, along with inefficient water policies, has increased agricultural susceptibility, putting food security at risk. This study examines Pakistan's climate resilience by analyzing water resource management and agricultural adaptation strategies from 2015 to 2025. A review of policy documents, government reports, and case studies, particularly the devastating 2022 floods, assesses the effectiveness of existing measures. The floods, which affected 33 million people, highlighted weaknesses in infrastructure, disaster preparedness, and adaptation strategies, highlighting the urgency of integrated water governance and climate-smart agriculture. Findings indicate that Pakistan, despite adopting the SDGs as a national agenda, has inadequate planning and poor policy implementation, which have slowed progress. The country remains highly vulnerable to harsh weather conditions, which mainly affects agriculture, the livelihood of approximately 38% of the workforce. Without urgent reforms in water conservation and crop diversification, climate-related disruptions will continue to threaten livelihoods and economic stability. This research emphasizes the need for sustainable water management and climate-resilient agricultural practices. Strengthening institutional capacities, improving disaster response mechanisms, and fostering community engagement are essential steps toward achieving SDG 13. Future studies should explore innovative water conservation techniques and adaptation models tailored to Pakistan's unique climatic challenges.

1. Objectives and Research Questions

Pakistan faces growing climate pressures that threaten its development gains. Despite committing to **SDG 13 (Climate Action)**, which explicitly calls for strengthening resilience and adaptive capacity to climate hazards due to which the country's water and agricultural sectors remain highly vulnerable. This paper investigates how **water governance failures and insufficient agricultural adaptation** have undermined Pakistan's climate resilience over the past decade. The main research objectives are to identify key obstacles to climate resilience in Pakistan's water and farming systems and assess progress toward SDG 13 targets. Specifically, this paper addresses:

- **Research Questions:**
    1. How have water management policies and governance affected Pakistan's ability to cope with climate change (SDG 13) during 2015–2025?
    2. What adaptation measures have Pakistani farmers and institutions adopted to enhance agricultural resilience under changing climate conditions?
    3. In what ways did the 2022 mega-floods illustrate gaps in resilience and inform policy needs?

The study aims to synthesize evidence from policy documents, reports, and case studies to answer these questions, informing climate adaptation strategies in Pakistan.

2. Theoretical/Conceptual Background

Climate Resilience and SDG 13: Climate resilience refers to the capacity of societies to **prepare for, respond to, and recover from climate-related shocks** with minimal damage. In policy terms, SDG 13.1 explicitly mandates strengthening resilience and adaptive capacity to climate hazards. In Pakistan's context, this means enhancing the ability of communities, institutions, and ecosystems to withstand floods, droughts, and temperature extremes without undermining development. Resilience is often conceptualized as a multi-dimensional outcome of adaptation actions that reduce vulnerability.

Water Governance: Effective water governance, the institutional rules, policies, and practices guiding water allocation and use, is critical for resilience. Concepts like **Integrated Water Resources Management (IWRM)** and **adaptive governance** emphasize coordinated management of water at the basin and local levels. In many developing countries, including Pakistan, poor governance (weak institutions, fragmented policies) is a major barrier to climate adaptation. For example, studies on Pakistan highlight that *"poor governance has been identified as one of the most pressing reasons for ineffective action to tackle ... climate-water issues"*. Key elements include political leadership, institutional capacity, stakeholder engagement, and regulatory frameworks. In the absence of coherent policies (e.g., delayed National Water Policy approvals), climate stresses like floods and droughts exploit governance weaknesses.

Agricultural Adaptation: Agriculture is Pakistan's economic backbone, but also its most climate-sensitive sector. Adaptation here means changing practices to maintain productivity under climate stress. The concept of **Climate-Smart Agriculture (CSA)** is widely cited: it aims to increase productivity, enhance resilience, and reduce emissions. CSA techniques include drought-tolerant crop varieties, improved irrigation (e.g., drip, sprinkler systems), integrated pest management, and diversified cropping. These strategies are intended to *"minimize climate impacts and preserve natural resources"*. Importantly, adaptation and resilience are complementary: effective adaptation actions (e.g., new irrigation, crop choices) build resilience, but maladaptive investments (like inefficient mega-projects) can sometimes undermine long-term resilience. A holistic, multi-sectoral approach, one that integrates water, agriculture, and social dimensions, is therefore theorized to be necessary for true climate resilience.

3. Methods

This study employs a qualitative, thematic review of literature and official documents. Data sources include peer-reviewed journal articles (e.g., Water Policy, Scientific Reports, and APN Science Bulletin) and publications from international organizations (FAO, World Bank, UN) and the Pakistani government. Key policy texts (e.g., Pakistan's National Climate Change Policy, National Water Policy), reports (e.g., FAO working papers, UN SDG country reports), and case studies (notably the 2022 floods) were examined. The study observes content analysis to extract information on water governance, climate impacts, and adaptation measures, which incorporated:

- **Systematic Literature**: Building on methodologies like Yasin et al. (2020), we identified major themes in climate-water governance and adaptation in Pakistan.
- **Official Assessments**: We reviewed Pakistan's Post-Disaster Needs Assessment (World Bank et al. 2022)and FAO reports to obtain data on flood impacts and water sector challenges.
- **Case Study Analysis**: The 2022 floods serve as a focal case. Satellite-derived loss assessmentsand government/NGO reports were utilized to analyze the floods' causes and consequences.

4. Key Findings

Water Governance and Scarcity

Pakistan's water system is under severe stress. Agriculture accounts for over **85% of total water withdrawals**, far outstripping domestic (5%) and industrial (2%) use. Croplands cover ~23.4 Mha, of which 18.6 Mha are irrigated (mostly in Punjab and Sindh). Despite this heavy demand, Pakistan's storage capacity is very low – about 14% of the mean annual river flow (against a global average of ~40%). Siltation and the lack of new dams have further eroded storage. The irrigation infrastructure itself is aging and inefficient: canal networks lose water through seepage and evaporation, and groundwater tables are falling in many areas. A recent FAO analysis notes *"limited storage capacity … debilitated infrastructure, and poor water conservation practices"* are degrading Pakistan's water supply.

These physical constraints coincide with governance gaps. Studies observe that political commitment, institutional coordination, and regulatory enforcement for water are weak. For example, Pakistan's National Water Policy was delayed for two decades amid inter-provincial disputes. Fragmented management between federal and provincial agencies hampers basin-wide planning. Consequently, there is poor monitoring of glaciers and rivers, inadequate accounting of water use, and little implementation of pricing or conservation incentives. Climate change has exacerbated these problems: the Indus Basin's flows depend heavily on glacier/snowmelt and monsoon rains, both of which are becoming more erratic. Pakistan's agriculture is "extremely dependent on surface water systems predominantly fed by snow/glacial sources", which are "highly vulnerable to rising temperatures". In short, governance shortcomings and infrastructure deficits have limited Pakistan's ability to adapt its water sector to a hotter, more variable climate.

Agricultural Adaptation Measures

Faced with climate risks, Pakistani agriculture is gradually adopting adaptation measures, but on a limited scale. Extension programs and pilot projects emphasize **Climate-Smart Agriculture (CSA)**. Experts recommend high-efficiency irrigation (sprinkler, drip, pivot systems) to reduce water use, since traditional flooding methods waste water (and contribute to waterlogging). A recent capacity-building project produced CSA resource kits and trained extension officers in Baluchistan and Khyber Pakhtunkhwa. Key recommended practices include Integrated Pest Management (reducing pesticide use) and planting stress-tolerant crop varieties (drought-, heat-, and salinity-resistant). These are crucial given Pakistan's frequent droughts, heatwaves, and irregular rainfall.

The FAO, Green Climate Fund "Transforming Indus Basin" project exemplifies institutional efforts: its components aim to improve climate information systems (via remote sensing and e-agriculture tools) and to build on-farm resilience by training farmers in water-efficient practices. For instance, component 1 uses state-of-the-art monitoring and data-sharing to inform farmers and planners, while component 2 helps farmers adopt new technologies and engage with adaptation services. However, adoption remains uneven. Many farmers still lack access to credit for new irrigation hardware, and awareness of CSA is limited among smallholders. In summary, while promising CSA interventions are underway (e.g., drip irrigation promotion, improved seed varieties), these have not yet reached scale, leaving many farming systems still vulnerable to climate shocks.

2022 Floods: Impacts and Lessons

The unprecedented 2022 monsoon floods starkly illustrated Pakistan's resilience deficit. Between July and September 2022, extreme rainfall, up to 300% above average in some areas, inundated roughly one-third of Pakistan. About 33 million people were affected, and over 1,700 lives were lost. The economic toll was immense: initial assessments estimate damages of ~US$15 billion and losses of US$15 billion, with rebuilding needs of US$16.3 billion to "build back better." Agriculture was hit especially hard. In Sindh alone, 2.5 Mha (18% of the province) was submerged, and an estimated 57% of croplands were damaged. Crop losses were staggering: cotton yields fell by 88%, rice by 80%, and sugarcane by 61% relative to expectations. The World Bank's post-

flood analysis projects the sector to contract ~0.9% of GDP due to flood impacts, with knock-on effects on food security.

Scientific attribution studies confirm climate change amplified these events: for example, one analysis found the heaviest rainstorms in 2022 were about 75% wetter due to global warming, making the floods **"much more likely"**. The deluge overwhelmed drainage and embankments, and stagnant waters have since fueled disease outbreaks. Critically, the floods revealed chronic shortcomings: weak flood forecasting, insufficient drainage infrastructure, and poorly maintained dams contributed to the scale of the disaster. They also underscored socio-economic inequities, as poorer rural communities suffered disproportionately and struggled to recover. In sum, the 2022 floods confirmed that Pakistan's climate resilience remains low: extreme events lead to catastrophic impacts on water systems and agriculture.

5. Conclusions and Implications

Pakistan's experience from 2015–2025 shows a climate resilience **crisis** driven by water mismanagement and lagging adaptation. Despite some policy frameworks (e.g., Climate Change Act 2017, National Water Policy 2018), implementation has been weak. Key conclusions include: Pakistan's centralized, aging water infrastructure and shortage of storage leave the country highly vulnerable to variability; governance gaps (coordination failures, lack of enforcement) exacerbate these vulnerabilities. Agriculture remains the dominant water user but suffers from inefficient irrigation and limited uptake of resilient practices. The 2022 floods magnified these issues, causing widespread crop loss and threatening food security. These findings indicate that SDG13 targets on resilience have seen limited progress, urgent action is needed to break the cycle of crisis.

Policy Implications and Recommendations: To enhance climate resilience, Pakistan should adopt integrated, multi-sector policies and investments. Key recommendations are:

- **Strengthen Water Governance:** Implement the National Water Policy fully, increase water storage (dams, small reservoirs), and modernize irrigation (canal lining, on-farm efficiency). Enforce watershed management and recharge programs to buffer variability. Enhance inter-provincial coordination and transparency.
- **Scale up Agricultural Adaptation:** Accelerate adoption of climate-smart practices across all provinces. Subsidize or finance high-efficiency irrigation systems (drip, sprinklers). Distribute stress-tolerant and early-maturing crop varieties. Expand extension services and farmer training on CSA, building on successful local CSA resource kits. Promote integrated pest management to reduce yield losses and protect ecosystems
- **Enhance Climate Information Services:** Invest in meteorological and hydrological monitoring (e.g. better gauges, real-time river data) and make data accessible to farmers and planners. The FAO–GCF project's work on e-agriculture platforms is a model: Pakistan should institutionalize such systems nationwide.
- **Build Institutional Capacity:** Create or strengthen a dedicated climate-resilience agency or empower existing bodies (e.g. NCCWP) to coordinate adaptation efforts. Ensure local governments have the resources for disaster risk reduction in line with SDG 13.1.
- **Mobilize Finance:** Leverage international climate funds (Green Climate Fund, Adaptation Fund) and public-private partnerships for infrastructure and adaptation programs. Given

the magnitude of losses (over US$30B in 2022 alone), external support and green finance are critical to supplement domestic budgets.

Areas for Future Research: This review highlights the need for continued, interdisciplinary research. Future studies could include: (a) **Monitoring and Evaluation of Adaptation:** rigorous assessment of which CSA interventions improve yields and income under climate stress; (b) **Social Vulnerability Mapping:** localized studies of which communities (e.g. by gender, poverty, region) are most exposed to water/climate shocks; (c) **Transboundary Water Studies:** analysis of Indus Basin Treaty dynamics under climate change, as glacier melt alters flows; (d) **Scenario Modeling:** integrated climate-hydrology-economic models to project future water supply-demand gaps and test policy scenarios. Filling these knowledge gaps will inform more precise, equitable resilience strategies in Pakistan.

6. Keywords

- Climate Resilience
- SDG 13 (Climate Action)
- Water Governance
- Agricultural Adaptation
- Pakistan

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