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# PAKISTAN'S CLIMATE CRISIS: AN INTEGRATED ANALYSIS OF FLOODS, GLACIAL MELT, DROUGHTS, WATER SCARCITY AND BIODIVERSITY LOSS

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**ABSTRACT**

Pakistan faces an escalating and interconnected climate crisis, ranking among world's most vulnerable countries. This integrated analysis examines five core hazards: floods, glacial melt, droughts, water scarcity, as well as biodiversity loss. Using a primarily qualitative, the exploratory approach incorporating descriptive quantitative trend analysis and thematic content analysis of the secondary sources (2000-2024), the research reveals these hazards are intensifying in the frequency and severity, driven by rising temperatures besides anthropogenic pressures. Their compounding effects create vulnerability loop: catastrophic floods (e.g., 2022: 33 million affected, >$30bn damage) cause displacement and infrastructure loss; the recurrent droughts cripple agriculture and drive migration; the rapid glacial melt threatens long-term water security while triggering floods; critical water scarcity (<900 $m^3$/capita) undermines the food systems; and biodiversity collapse degrades ecosystem services. The results provide significant and leading information in highlighting an urgent need for integrated climate governance, resilient infrastructure, nature-based solutions & significantly scaled-up adaptation finance to address this multi-faceted emergency in particular context.



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## INTRODUCTION

The climate change stands as one of the most critical global challenges of the 21st century, exerting profound effects on ecosystems, economic systems, and human societies (Malhi, Franklin, Seddon, Solan, Turner, Field & Knowlton, 2020). Driven by anthropogenic activities such as fossil fuel combustion, deforestation, and unsustainable land use, the rapid increase in greenhouse gas (GHG) concentrations has intensified global warming (Isah, 2013). Intergovernmental Panel on Climate

Change (IPCC) reports that Earth's surface temperature has already risen by 1.1°C since the pre-industrial era, and it is likely to exceed 1.5°C by 2030—ushering in more frequent and intense climate-related hazards including floods, droughts, biodiversity collapse, and resource scarcities (Mukherji, 2023). While, effects of climate change are global, they are not uniformly manifested. Developing countries though contributing minimally to global emissions—often bear the brunt of these consequences. Pakistan ranks among the top ten most climate-vulnerable nations, despite contributing less than 1% of global GHG emissions (Arshed, Saeed, Salem, Hanif & Abbas, 2023). It's geographic and socioeconomic profile, home to the fragile Hindu Kush–Karakoram–Himalaya (HKH) glacial region, a vast agrarian economy, along with rapidly growing urban populations, renders it especially susceptible towards the climate-induced disasters (Mukherji, Scott, Molden & Maharjan, 2018).

Pakistan is currently grappling with spectrum of overlapping & interconnected climate challenges. These include recurring catastrophic floods, which devastated one-third of the country in 2022, displacing millions, causing over $30 billion in economic damages (Mahmood, Abbas & Hussain, 2024); accelerating glacial melt, particularly in HKH region, threatening long-term water security and triggering glacial lake outburst floods (GLOFs) (Rather, Ahmed, Bansal, Mir, Ahmed, Malik & Varade, 2024), severe droughts, especially in Sindh and Balochistan, leading to crop failures and rural livelihood loss, intensifying water scarcity crisis, with per capita water availability dropping below 1,000 $m^3$—indicating water stress status (Janjua, Hassan, Muhammad, Ahmed & Ahmed, 2021), and accelerating biodiversity loss, impacting critical ecosystems like Indus Delta mangroves and Himalayan forests (Saifullah, 2017). The 2025 season, brought new disasters including fatal cloudbursts in the GB, deadly flash floods in Punjab, underscoring the country's growing climate vulnerability (Hussain, 2025). These hydro meteorological & ecological impacts are compounded by extreme heat waves, with cities like Jacobabad & Sibi recording temperatures exceeding 50°C, placing immense strain on public health & urban infrastructure (Hussain, Zhang, Muneer, Kamran & Ahmed, 2022).

Agriculture, which employs 42% of workforce and contributes 19% to GDP, is highly sensitive to climatic fluctuations. Crop yields are declining due to irregular precipitation & rising temperatures, while livestock and food security face increasing pressure (Fahad & Wang, 2020). Climate change is also contributing to rural poverty, urban migration, and growing gender-based vulnerabilities, particularly for women and children in underserved regions (Cutter, 2017; UNDP, 2024). Despite the enactment of national policies like the Climate Change Act (2017) and the National Climate Change Policy (2012), institutional limitations, inadequate financing, and implementation failures hinder effective climate governance (Ali, Khan & Shakeel, 2019). Pakistan currently spends less than 1% of its GDP on climate adaptation, while it's estimated annual climate financing needs range from $7 to $14 billion (UNDP, 2024). This research aims to provide integrated analysis of Pakistan's five key climate-induced environmental crises: floods, glacial melting, droughts, water scarcity, and biodiversity loss. These issues are interconnected within a fragile ecological system where one crisis amplifies another. By drawing on literature, the climate risk assessments, and policy analyses, this study seeks to:

1. To examine the causes, trends, and impacts of these climatic hazards in the particular context.
2. Explore socio-economic & ecological consequences, emphasizing their compounding nature.
3. To identify the policy gaps as well as propose integrated, multi-scalar adaptation responses.

## LITERATURE REVIEW

### Climate Change: The Global Context

Climate change, driven primarily by the anthropogenic emission of greenhouse gases (GHGs) such as carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$), has emerged as a defining the environmental challenge of the 21st century (Jain et al., 2015; IPCC, 2021). Resulting from fossil fuel combustion, deforestation, and unsustainable development, these emissions have led to significant alterations in Earth climate system, including changes in precipitation patterns, bigger frequency and intensity of temperature extremes, and accelerated glacial retreat (Ummenhofer & Meehl, 2017). UNFCCC (1992) acknowledges natural climate variability but attributes rapid escalation observed in recent decades primarily to human activity (Kuyper et al., 2018). Research consistently shows rising global sea levels due to thermal expansion a well as melting ice sheets, while projected warming poses severe threats to freshwater systems and significantly increases global flood risks (Hinkel et al., 2014; Adnan et al., 2024). While climate change is a global phenomenon, its impacts are highly uneven. In this linking, the developing countries like Pakistan face disproportionate vulnerabilities. (Abbas & Guo, 2023). The literature underscores that the country faces an array of interconnected environmental threats jeopardizing together with the ecological integrity as well as socioeconomic stability.

### Climatic and Geographic Diversity of Pakistan

Pakistan's climate is marked by exceptional geographic and climatic diversity, stretching from the snow-covered peaks of the Karakoram and Himalayan ranges in the north to the arid deserts and coastal belts in the south (Qasim, Ali & Aqeel, 2024). The country experiences four distinct seasons monsoon (July–September), winter (December–February), summer (March–June), and transitional post-monsoon period (October–November), with a predominance of arid to semi-arid conditions across nearly 75% of its landmass (Haider & Adnan, 2014; Khan & Hasan, 2019). The northern highlands, home to some of the world largest non-polar glaciers including those in the Karakoram Range—store vital water reserves feeding Pakistan's Indus River System (Sheikh, Manzoor, Adnan, Ashraf & Khan, 2009; Hunt, Turner & Shaffrey, 2020). These regions, rich in biodiversity, lakes, and forests, are acutely sensitive to rising temperatures driving glacial melt. In this connection, moving southward, the terrain transitions into Sub-Montane region, dominated by the monsoonal rainfall—followed by Western Highlands and the Punjab Plains, central to Pakistan's agricultural desired productivity.

The Indus River Basin, comprising fertile floodplains and a dense irrigation network, serves as the backbone of Pakistan's food and water systems but is highly vulnerable to both flooding and water scarcity (Nawaz, Li, Chen, Guo, Wang & Nawaz, 2019; Memon & Ahmed, 2022). The Balochistan Plateau and the Coastal Belt present further climatic variation. Balochistan is predominantly arid with complex topography, minimal rainfall, and erosion-prone soils (Naz, Dars, Ansari Jamro &

Krakauer, 2020; Akhtar et al., 2021). Thus, the coastal region, stretching over 990 km—includes ecologically critical mangrove forests in Sindh and barren stretches in Balochistan, vulnerable to sea-level rise and saline intrusion (Sheikh et al., 2009). This diverse geography renders Pakistan highly susceptible to environmental stressors, including recurring floods, prolonged droughts, glacial lake outburst floods (GLOFs), water scarcity, and habitat degradation. Research consistently indicates these climate events are increasing in the frequency and severity, exacerbating socio-environmental exposures across country's major ecological zones (Bhatti, Anwar & Hussain, 2023). Thus, understanding this spatial and climatic complexity is essential for any integrated analysis of Pakistan's climate crisis.

### Climate Hazards in Pakistan: A Synthesis of Research

Existing research paints a concerning picture of intensifying climate hazards in Pakistan. Studies highlight increasing frequency, severity, and geographic spread of key threats: Floods: Research identifies intensified monsoon patterns and glacial melt as primary drivers, compounded by scarce infrastructure. The studies document a trend of increasingly catastrophic events (e.g., 2010, 2022), causing massive displacement & economic damage (Mahmood, Abbas & Hussain, 2024). Droughts: Rising temperatures, erratic rainfall, deforestation, and water mismanagement lead to frequent and severe droughts, particularly in Balochistan and Sindh, with devastating impacts on agriculture and rural livelihoods (FAO assessments). Pakistan ranks among top ten most climate-vulnerable nations, despite contributing less than 1% of the global GHG emissions Glacial Melting: Scientific studies confirm rapid glacial retreat in HKH region (ICIMOD reports), highlighting the formation of hazardous glacial lakes & growing risk of GLOFs, posing immediate dangers and threatening long-term water security.

Water Scarcity: The research by institutions like Pakistan Council of Research in Water Resources (PCRWR) reports a precipitous decline in per capita water availability, attributing it to glacial retreat, population growth, inefficient irrigation, poor governance, and climate variability, pushing Pakistan towards absolute scarcity (Begum & Ali, 2025). Biodiversity Loss: Studies (e.g., WWF-Pakistan) link climate stress (habitat shifts, extreme events), anthropogenic pressures (deforestation, pollution) to the degradation of critical ecosystems like the Indus Delta mangroves and Himalayan forests, leading to species decline, loss of ecosystem services (Qureshi et al., 2017). Extreme Weather: Literature reports rising trends in heat waves (Jacobabad beyond 50°C), erratic monsoon behavior causing urban flooding, and worsening winter smog episodes, with significant public health and economic consequences. The 2025 season has intensified these trends, marked by fatal cloudbursts in Gilgit-Baltistan and deadly flash floods in Punjab. This body of work establishes Pakistan's acute vulnerability & underscores interconnectedness of these hazards, demanding integrated assessment and response strategies.

## RESEARCH METHODOLOGY

This study adopts a qualitative, explanatory research design to examine the five major climate hazards in Pakistan: floods, glacial melting, droughts, water scarcity, and biodiversity loss. Given the complexity and interdependence of these phenomena, the approach incorporates descriptive quantitative trend analysis where the relevant data was available (e.g., temperature trends, water

availability decline, flood impact statistics). In this linking, this approach is well-suited to capture the contextual, social, ecological, and temporal dimensions of the climate crisis, providing both depth in understanding impacts and policy gaps, along with the evidence of changing hazard and associated intensity.

### Data Sources

The present research study relies primarily on secondary data collected from a range of credible academic, institutional, and governmental diverse sources. These include: Peer-reviewed academic literature (journals, books), Reports and datasets from international agencies (IPCC, FAO, UNDP, World Bank, WFP), National reports, statistics, and policy documents from Pakistani institutions (Pakistan Meteorological Department – PMD, National Disaster Management Authority – NDMA, Ministry of Climate Change, and Pakistan Council of Research in Water Resources – PCRWR) in the current study.

### Data Collection & Review Process

A systematic review approach was used to gather data on the selected climate hazards. Key search terms included: "climate change Pakistan", "flood impacts Pakistan", "drought frequency Pakistan", "glacial melting Himalayas Karakoram", "water scarcity Indus Basin", "biodiversity loss climate stress Pakistan", "extreme weather Pakistan". The literature published between 2000 and 2024 was prioritized to ensure recency and relevance. The collected documents underwent screening process using the following criteria: Relevance: Directly related to Pakistani context and five core hazards. Credibility: Source reputation, methodological rigor, and transparency. Recency: Prioritization of data & analyses from last decade (2014-2024), while including seminal earlier works. Consistency of data points across multiple sources where possible. Selected materials were then systematically cataloged for analysis.

### Thematic Content Analysis

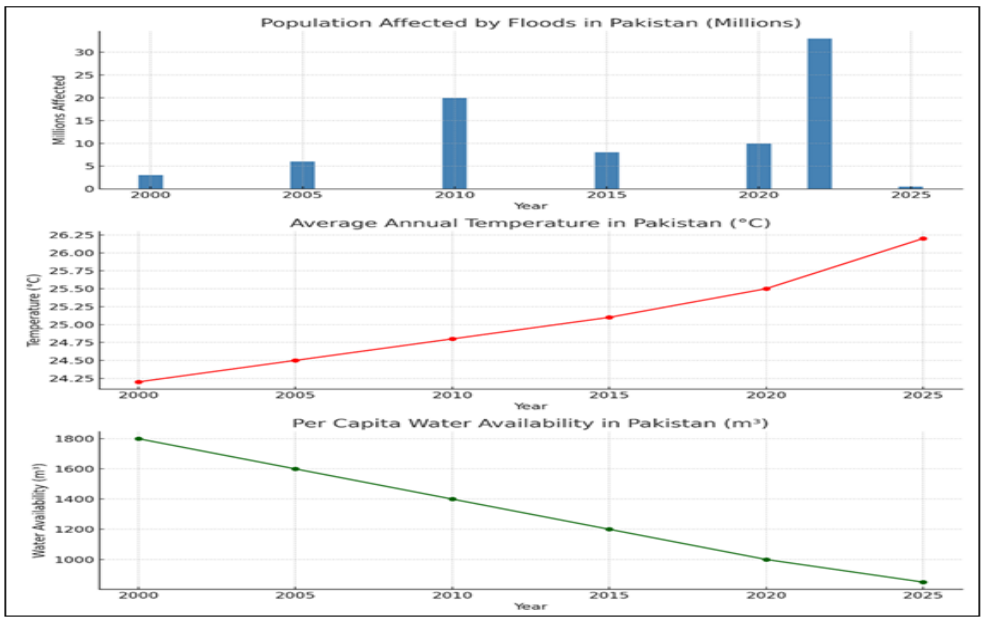
The analysis followed structured thematic content analysis approach, as involved: Familiarization: Thorough reading of all selected materials. Initial Coding: Generating initial codes capturing key concepts related to each hazard (for floods: causes, frequency, impacted regions, socio-economic impacts, responses). Coding was primarily deductive, based on predefined hazard categories, but allowed for inductive emergence of sub-themes (gendered impacts within displacement). Theme Development: Grouping related codes into overarching themes and sub-themes for each hazard. Core themes for analysis included frequency, trends & geographic distribution, underlying causes (climatic & anthropogenic), socio-economic, ecological impacts, documented responses & adaptation gaps. Reviewing Themes: Refining themes for internal consistency and distinctiveness. Defining and Naming Themes: Clearly defining scope and content of each theme. Synthesizing findings within, across themes, identifying patterns, interlinkages, and implications. The comparative and trend analyses were conducted using available quantitative data, focusing on key benchmark years (e.g., 2010, 2014, 2022).

## RESULTS & DISCUSSION

This section presents the key findings derived over thematic content analysis and descriptive trend analysis of secondary data. The results are structured around five core climate hazards, joining

socio-economic and ecological impacts within each subsection, followed by synthesis and regional analysis. Three figures visualize critical trends: Figure 1: Comparison of major flood impacts based on NDMA/UNDP data; people affected. Figure 2: Rising average annual temperature in Pakistan (2000-2025)- Based on PMD data, showing increase from ~24.25°C to ~26.25°C. Figure 3: Declining per capita water availability ($m^3$) in Pakistan (2000-2025), based on PCRWR data, showing drop from 1800 $m^3$ to <900 $m^3$.

Figure 1 Floods: Recurrent Catastrophe




Flooding remains Pakistan's most visible and disruptive climate hazard. Analysis confirms a trend of increasing severity. As shown in Figure 1, 2022 floods affected nearly 33 million people (double the 2010 impact), caused damages exceeding $30 billion. Southern provinces (Sindh, Balochistan, Southern Punjab) are disproportionately affected due to flat terrain, inadequate drainage, high poverty & downstream location receiving flood surges from north. Beyond immediate infrastructure damage and loss of life, floods cause widespread displacement (over 8m in 2022), disease outbreaks (waterborne, vector-borne), destruction of housing and livelihoods, long-term agricultural losses from submerged crops and degraded land. The recent 2025 monsoon season has further intensified this crisis, with multiple cloudbursts and flash flood events reported in July. A severe cloudburst near Babusar Top (Gilgit-Baltistan) on July 21–22 triggered flash floods and landslides that killed at least five people, stranded more than 200 tourists, destroyed roads, bridges and communication effective networks.

Just days earlier, cloudbursts in Ghizer and Shiroot valleys damaged irrigation channels, triggered landslides, and further destabilized the fragile high-mountain terrain. In Punjab's Chakwal district, 423 mm of rainfall within 24 hours overwhelmed urban drainage systems, killing at least 54 people, many of them in low-income settlements lacking flood protections. These back-to-back events

reflect a dangerous convergence of intensified rainfall and rapid glacial melt, both of which are swelling river volumes and increasing the frequency and unpredictability of the flash floods. The compounding factors include intensified monsoon rainfall, rapid glacial melt adding to the river volumes, and systemic weaknesses in flood control infrastructure and early warning dissemination. The recurrence of high-fatality flood events within 3 years illustrates that Pakistan current disaster preparedness and climate adaptation frameworks remain grossly inadequate for scale of evolving climate threats.

Table 1 Major Flood Events in Pakistan (2010–2025)

| Year | Event Location(s) | People Affected | Deaths | Key Drivers | Major Vulnerabilities Exposed |
|---|---|---|---|---|---|
| 2010 | Nationwide | ~20 million | 1,985 | Record monsoon rains | Poor flood defenses, river encroachment |
| 2022 | Sindh, Balochistan, South Punjab | ~33 million | 1,739 | Intense monsoon + glacial melt | Infrastructure collapse, widespread displacement |
| 2025 | GB (Babusar Top, Ghizer), Punjab (Chakwal) | 500,000+ est. | 242+ | Cloudbursts, monsoon extremes, GLOFs | Inadequate early warning, urban drainage failure |

## Droughts: The Creeping Crisis

The droughts are a persistent and intensifying threat, particularly in the arid/semi-arid regions (Balochistan, Tharparkar, Southern Punjab). Rising temperatures (Figure 2) accelerate evaporation and soil moisture loss, while rainfall becomes more erratic. Drought frequency and duration are increasing. Impacts are profound: agricultural yields decline by 30-40% in severe drought years, leading to crop failures and loss of livestock due to fodder and water shortages. This drives rural poverty, malnutrition (especially among children), and distress-induced migration towards urban centers. In this regard, water table depletion exacerbates scarcity for communities and irrigation. Therefore, mismanagement of surface water and groundwater over-extraction significantly worsen drought vulnerability.

## Glacial Melting: The Looming Water Threat

The HKH region, particularly Gilgit-Baltistan and Chitral, hosts over 13,500 glaciers vital to Indus River System. Analysis reveals alarming retreat rates of 10–15 meters per year. Over 3,000 glacial lakes have formed, with 33 identified as high-risk for the Glacial Lake Outburst Floods (GLOFs) (ICIMOD, 2025), posing immediate dangers to mountain communities. This threat materialized in July 2025, when a cloudburst near Babusar Top triggered deadly flash floods that killed at least five people, stranded over 200 tourists, and destroyed road infrastructure and communication lines. Days earlier, heavy rains in Ghizer & Shiroot valleys caused disruptions, damaging irrigation systems and triggering landslides. These events underline how GLOFs, extreme precipitation is converging to increase frequency and unpredictability of disasters in high-altitude regions. Beyond GLOFs, the long-term threat is to water security. Glaciers act as natural reservoirs; their accelerated melt initially increases river flows (contributing to floods), but ultimately leads to long-term depletion, threatening water supply for irrigation (>90% of Indus water used for agriculture), drinking water,

& hydropower for millions downstream. This represents fundamental threat to Pakistan ecological and economic foundation.

### Freshwater Scarcity: An Existential Challenge

Water scarcity has reached critical levels, as Figure 3 starkly shows, per capita water availability has plummeted from over 1800 $m^3$ in 2000 to below 500 $m^3$ in 2025, placing Pakistan firmly in the water-scarce category (<1,000 $m^3$) and nearing absolute scarcity (<500 $m^3$). This crisis results from the confluence of glacial retreat (reducing long-term supply), population growth, highly inefficient irrigation (over 60% loss in conveyance and application), groundwater over-extraction, pollution, & poor water governance. Agriculture, consuming >90% of freshwater, faces severe stress, directly impacting food security and rural incomes. The urban centers suffer from the intermittent supply, contamination, rising conflicts over water allocation. Climate variability disrupts rainfall patterns and river flows.

### Biodiversity Loss: Degrading the Ecological Foundation

The climate change acts as a major threat multiplier for Pakistan's biodiversity. Key ecosystems are under severe stress: Indus Delta Mangroves: Reduced Indus River flows (due to dams, diversions, scarcity), sea-level rise cause salinization and mangrove die-back, destroying critical fish nurseries & coastal protection. Himalayan Forests: Rising temperatures and changing precipitation alter habitats, increase forest fires, and facilitate invasive species, threatening endemic flora and fauna. Arid Zone Ecosystems (Balochistan/Thar): The intensified droughts and desertification degrade habitats, impacting native species like the Chinkara gazelle. Similarly, specific species, such as the endangered Indus River Dolphin, face habitat fragmentation and pollution. Deforestation, driven by fuel wood needs and land conversion, exacerbates climate vulnerability. The biodiversity loss degrades ecosystem services (pollination, water purification, soil stabilization, as well as carbon sequestration) vital for the human well-being along with climate resilience, creating a dangerous feedback loop.

### Cross-Cutting Stress: Extreme Weather and Food Insecurity

The core hazards are amplified by increasing extreme weather volatility: Heat waves: Cities like Jacobabad and Turbat regularly exceed 50°C (Figure 2 trend supports this), causing heatstroke deaths, reducing labor productivity, and straining energy grids. The IPCC identifies these as among the world's most dangerous wet-bulb temperature events. Erratic Monsoon/Cloudbursts: Cause devastating urban flash floods (e.g., Karachi 2020, Islamabad 2022), overwhelming inadequate drainage. Smog: Winter smog, worsened by climate-influenced inversions, agricultural burning, and urban pollution, engulfs cities like Lahore, causing severe respiratory illness and economic disruption. This volatility, combined with the direct impacts of floods, droughts, and water scarcity, critically undermines agriculture and food security: Declining Yields: Wheat yields projected down 6%, Basmati rice down 15-18% due to heat/water stress. Seasonal Shifts: Altered rainfall & temperature disrupt traditional sowing/harvesting calendars. Pest/Disease Outbreaks: Warmer, more humid conditions favor pests like locusts. Livestock Stress: Heat and fodder/water scarcity reduce productivity and increase mortality. Thus, with over 58% experiencing malnutrition and 20% chronically food insecure (ranking 106th on GHI), Pakistan's food insecurity is intrinsically

linked to climate hazards. Vulnerable populations, especially women and children in rural areas, bear heaviest burden.

### Regional Disparities in Climate Impacts

The impacts of these unified hazards are starkly uneven across Pakistan's regions, as summarized in the Table 2:

Table 2 Regional Vulnerability to Key Climate Hazards in Pakistan

| Hazard | Primary Regions Affected | Key Contributing Factors | Major Documented Impacts |
|---|---|---|---|
| Floods | Sindh, Southern Punjab, Balochistan | Intense monsoon, downstream location, flat terrain, poor drainage | Massive displacement, infrastructure destruction, disease outbreaks, crop loss (e.g., 2022: 33m affected) |
| Droughts | Balochistan, Tharparkar (Sindh), Southern Punjab | Low/erratic rainfall, high temps, groundwater depletion | Crop failure, livestock loss, acute water scarcity, malnutrition, distress migration |
| Glacial Melt & GLOFs | Gilgit-Baltistan, Chitral | Rapid temperature rise, steep topography, fragile geology | GLOF destruction, infrastructure damage (roads, bridges), long-term water security threat |
| Water Scarcity | Punjab, Sindh, Quetta Valley | High agricultural demand, inefficient irrigation, population pressure, reduced glacial inflow | Agricultural stress, urban water rationing, conflicts, declining water tables |
| Biodiversity Loss | Indus Delta (Sindh), HKH Forests (GB/KP), Balochistan Drylands | Habitat fragmentation, pollution, climate stress (SLR, drought, temp rise) | Mangrove degradation, forest fire increase, species decline (e.g., Indus Dolphin), loss of ecosystem services |
| Heatwaves | Jacobabad, Turbat, Multan, R. Y. Khan | Aridity, urban heat island effect, global warming | Heatstroke deaths, reduced outdoor labor, energy demand surges, public health crises |
| Urban Flooding/Smog | Lahore, Karachi, Faisalabad, Islamabad | Poor drainage, impervious surfaces, industrial/ vehicular emissions, agricultural burning | Transport disruption, property damage, respiratory illnesses (smog), economic losses |

### Institutional Failures and Finance Gaps

Institutional failures have been a serious issue. NDMA's failure to disseminate early warnings to tourists in Babusar Top led to avoidable casualties. Illegal construction on riverbanks continues. Of the $10B pledged post-2022 floods, only $2.8B has materialized. Climate financing shortfalls are stalling recovery.

### Synthesis: A Compounding Crisis

The findings unequivocally demonstrate that Pakistan's climate crisis is not a future threat but a present one, intensifying emergency characterized by compounding and cascading hazards. Floods destroy infrastructure needed for drought resilience; droughts deplete resources needed to recover from floods; glacial melt threatens the primary water source sustaining agriculture and cities amidst scarcity; biodiversity loss degrades natural buffers against floods and droughts; and extreme

weather events amplify all other risks. In this connection, this creates a vicious vulnerability loop, disproportionately impacting the poorest regions and populations. Existing adaptation efforts are fragmented, underfunded (<1% GDP), and often reactive, failing to match the scale and systemic nature of the challenge highlighted by the $7-14 billion annual financing gap (UNDP, 2024). The findings underscore the critical call for the integrated, multi-scalar, and adequately resourced climate action.

## CONCLUSION

This integrated analysis reaffirms that Pakistan is confronting a deepening climate crisis shaped by the compounding and cascading impacts of extreme floods, recurrent droughts, rapid glacial melt, critical water scarcity, and biodiversity collapse. The qualitative synthesis and longitudinal trend assessment (2000–2025) demonstrate that these hazards are not isolated, but rather interact to form a self-reinforcing "vulnerability loop," driven by rising temperatures, ecosystem degradation, and anthropogenic pressures. The catastrophic 2022 floods impacting 33 million people and inflicting over $30 billion in damages (Figure 1)—exposed the country's acute fragility to climate extremes. However, the 2025 season has offered further evidence of Pakistan's escalating risk profile. In this linking, the flash floods triggered by cloudbursts in Gilgit-Baltistan, deadly urban flooding in the Chakwal, and glacial lake outburst threats underscore how converging hazards such as intensified monsoon rainfall and accelerated glacial retreat are now manifesting with greater frequency and unpredictability.

These trends place immense pressure on already strained infrastructure, ecosystems, governance systems. Ultimately, the current study aims to contribute to an evidence-based understanding of the Pakistan's interconnected climate emergency and inform policy discussions on the sustainable resilience and environmental governance in South Asia. Pakistan consistently ranks among the top ten countries most affected by climate-related disasters, despite minimal contribution to global emissions (<1%). Concurrently, the country's per capita water availability has declined to less than 500 $m^3$ (Figure 3), signaling transition from water stress to near absolute scarcity. This has profound implications for the agriculture, drinking water access, and hydropower generation. Biodiversity degradation exemplified by the mangrove depletion and forest loss further weakens ecosystem resilience. Heat waves, erratic weather, seasonal anomalies add new layers of public health and economic vulnerability.

These intersecting challenges impose severe socio-economic values: widespread displacement, food and livelihood insecurity, health emergencies, infrastructure degradation, as well as rising inequality particularly among rural populations, women, and children. The 2025 disasters have emphasized disturbing trend: over 50% of flood-related fatalities were children, emphasizing the urgent need for the inclusive, equity-centered climate responses. Thus, Pakistan's climate crisis is accelerating through converging the hazards—2025's flash floods, GLOFs, droughts, and urban collapses are the latest confirmation. With child mortality rising and only partial fulfillment of global climate finance pledges, resilience now demands more than technical plans—it requires climate justice, institutional reform, and systemic transformation. The time for incremental reform is over. Without bold, integrated, and well-funded adaptation anchored in intergenerational

equity, climate change will continue to erode the Pakistan's development trajectory and long-term ecological stability.

## Policy Recommendations

### Short-Term Priorities (1–3 Years)

1. Strengthen Early Warning Systems
   - ✓ Upgrade hydro-meteorological monitoring in high-risk flood, GLOF, and heatwave zones.
   - ✓ Improve community alert systems, especially in remote areas like Gilgit-Baltistan.
   - ✓ Boost rapid response capacity of disaster management agencies (NDMA, PDMAs).
2. Emergency Water Security Measures
   - ✓ Deploy rainwater harvesting and repair water infrastructure in the drought-hit regions (Balochistan, Tharparkar).
   - ✓ Provide mobile water supply for vulnerable communities.
3. Heat wave Preparedness in Cities
   - ✓ Implement heat action plans in Jacobabad, Turbat, Lahore, and Karachi.
   - ✓ Set up cooling shelters, adjust the work hours, and improve healthcare for heat-related illnesses.

### Medium-Term Priorities (3–10 Years)

1. Build Climate-Resilient Infrastructure
   - ✓ Strengthen embankments, drainage systems, and flood shelters.
   - ✓ Improve irrigation efficiency (drip/sprinkler systems) and regulate groundwater use.
2. Promote Climate-Smart Agriculture
   - ✓ Introduce drought/flood-resistant crops and adjust the planting schedules.
   - ✓ Support farmers with soil/water conservation and livelihood diversification.
3. Restore Ecosystems & Reduce Pollution
   - ✓ Replant mangroves (Indus Delta), forests (HKH, Balochistan), and protect watersheds.
   - ✓ Enforce bans on open waste burning and industrial emissions in cities.

### Long-Term Priorities (10+ Years)

1. Establish Strong Climate Governance
   - ✓ Create a centralized Climate Coordination Authority to align the policies across sectors.
2. Scale up Nature-Based Solutions
   - ✓ Prioritize mangrove restoration, afforestation, and urban greening for resilience and carbon capture.
3. Secure Sustainable Climate Finance
   - ✓ Access international funds (Green Climate Fund, Adaptation Fund).
   - ✓ Develop domestic financing (climate bonds, green taxes) with transparent tracking.
4. Build Public Awareness & Local Capacity
   - ✓ Integrate climate education into schools and launch national awareness campaigns.
   - ✓ Train local governments and communities in adaptation strategies.

### Key Implementation Challenges

- ✓ Overcome funding gaps, institutional fragmentation, and weak enforcement.
- ✓ Implement strong monitoring & evaluation to track progress.
- ✓ Treat climate change as a national emergency, not just an environmental issue.

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