INTERNATIONAL JOURNAL OF SOCIAL SCIENCES BULLETIN
ISSN: (E) 3007-1917 (P) 3007-1909
Volume 4, Issue 3, 2026

CLIMATE CHANGE AND ITS EFFECTS ON A DEVELOPING COUNTRY: THE CASE OF PAKISTAN

M. Tanveer Arshad[*1], Dr. Robina Yasmin[2]

*[*1]PhD Scholar, Department of Pakistan Studies, The Islamia University of Bahawalpur, Pakistan.*
[2]Associate Professor, Chairperson, Department of Pakistan Studies, The Islamia University of Bahawalpur, Pakistan

[*1]tangooc79mas@gmail.com

Corresponding Author: *
M. Tanveer Arshad
DOI: https://doi.org/10.5281/zenodo.23613319

Received	Accepted	Published
20 January 2026	05 March 2026	19 March 2026

ABSTRACT

The countries which have emitted the least GHGs continue to suffer the greatest burden of the climate crisis. This paper aims to analyze Pakistan as an example of such imbalance. The analysis, based on intergovernmental considerations, peer-reviewed studies of climate change impacts, post-disaster needs assessments and official national policy documents, indicates that Pakistan emits less than one per cent of global greenhouse gas emissions but was the most impacted country by extreme weather in 2022, according to the German climate risk index. The discussion covers the country's multi-hazard exposure, the aggravation of glacial melt in the Hindu Kush-Karakoram-Himalaya region, the increased intensity of monsoon extremes, deadly heatwaves, saltwater intrusion into Indus Delta, and water stress, followed by implications for agriculture, public health, and water security, the coastal zone, and macro-economic stability. The central case is the super-floods of 2022 that impacted 33 million people and caused damages and economic losses of more than US$30 billion. The next review is of Pakistan's policy response, including the updated Nationally Determined Contribution, the National Adaptation Plan and various nature-based mitigation and adaptation strategies, amidst the broader policy landscape of climate finance and loss-and-damage. The paper builds on this diagnosis and presents a series of geographically differentiated measures, including cross-cutting measures of governance, finance, and social protection, as well as a sequence of implementation measures for the mountain, plains, and urban, deltaic, and arid zones. Three general take-home messages round out the conversation: Vulnerability is as much socially-defined as geographically-defined; adaptation funding is far below demand; and the credibility of the international climate regime ultimately depends on how much money flows alongside the words of climate justice.

Keywords: *Climate Change, Pakistan, Developing Countries, Vulnerability, Adaptation, Loss and damage, Floods, Heatwaves, Indus Basin; Climate Finance*

Introduction

Climate change is very unevenly distributed. The countries that industrialized first and emitted the most carbon have the most robust infrastructure and institutions to deal with climate change shocks, while the countries that emitted virtually nothing are facing the effects of climate change with limited resources. This asymmetry is not about history as a commodity, but it does have implications for political, financial and practical adaptations today. It is Pakistan which has one of the starkest examples of this pattern. At 240 million people, it is the fifth most populous nation, where people are clustered around a single river system, the Indus, which is supplied by one of the highest ice masses outside the Polar Regions. The country is contributing less than one per cent of global GHGs but is consistently among the most

vulnerable countries to climate extremes (UNEP, 2023).

The record is there in the form of empirical observations and there is little doubt about it. In 2022, Pakistan was featured in the German watch Climate Risk Index 2025 as the most climate-vulnerable country in the world, for which the catastrophic super-floods played a major role in 2022. Those floods left behind over 8 million victims, and caused an estimated US$30 billion in damages and losses (German watch, 2025; Boston University, 2023).

The mean temperature of the country has increased by around 0.5 °C per year on annual basis in the last 50 years, along with changing trends in precipitation and accelerated glacial melting (United Nations Development Programme [UNDP] Pakistan, 2022). But a longer-term view needs to be nuanced. In the overall 1993-2022 index period, Pakistan scored significantly below average, suggesting that it has climate risk patterns that are episodic, high impact, with chronic stressors (water scarcity, heat stress, ecosystem degradation) layered on top of them, but not by exposure to a uniformly extreme climate each year (Boston University, 2023).

Moreover, due to its low historical responsibility and high current susceptibility, the country of Pakistan is at the forefront of discussions on climate justice. The country's experience also sheds light on the practical constraints of adaptation in the context of limited domestic fiscal space and a substantial reliance on foreign financing, which typically comes in the form of loans. It is therefore important to understand how physical hazards interact with social, institutional and economic conditions, both at the national policy design level and for the broader architecture of global climate support. The Indus basin is a hydrological system in itself with links between changes of the cryosphere, flood-drought dynamics and coastal processes. Policy interventions will not be effective if they consider these processes separately, as they may shift risk between different parts of the basin.

This paper has four related objectives. First, it is an integrated compilation of the physical drivers of Pakistan's climate risk, bundled within a set of five related hazard domains. Second, it looks at the impact on key sectors and the economy overall, focusing on the 2022 floods as a key example. Third, it examines Pakistan's national policy actions and international finance architecture on which developing countries rely for adaptation and loss and damage support. Fourth, and most directly of practical application, it sets out practical measures corresponding to the country's geographical areas. The discussion is based on peer-reviewed attribution studies, World Bank Post-Disaster Needs Assessment and Country Climate and Development Report, and official documents like Pakistan's updated Nationally Determined Contribution (NDC) and National Adaptation Plan (NAP). The article is a policy-oriented synthesis of previous evidence and not a new empirical study; the recommendations in Section 6 are based on author's reading of the evidence and institutional context within which any response should be implemented.

The rest of the paper is organized as follows: In section 2, geophysical architecture of vulnerability is mapped. Part 3 examines the effects on individual sectors and the macro economy. A review of domestic policy and the climate-finance dilemma follows in Section 4. Lessons are drawn in Section 5. Section 6 is a geographically differentiated resilience agenda and Section 7 concludes.

The Geophysical Architecture of Vulnerability

Climate risk for Pakistan is not from a single dominant hazard. Instead, it emerges as a result of a combination of physical processes that happen at different scales both in space and time, but at a similar scale in the respective river basins and towns. Five of the most impactful processes are considered here and how they reinforce each other.

Cryospheric Instability and Glacial Lake Outburst Floods

The Hindu Kush, Karakoram and Himalayan ranges of Pakistan have the highest concentration of glacial ice outside the polar regions, which is more than 13,000 glaciers. The glaciers are major sources of water for

agriculture and economy of Pakistan (MoCC Pakistan, 2021). This cryosphere is destabilising because of increasing temperatures. In 2013, the remote-sensing inventory of the Hindu Kush – Karakoram – Himalaya region of Pakistan detected 3,044 glacial lakes encompassing an approximate surface area of 134.8 km². The area of lakes increased by 7 percent in the last 13 years (2001 to 2013), and the number of lakes increased by approximately 26 percent, with 36 lakes considered potentially dangerous (Ashraf et al., 2017). National and UNDP assessments put the number of hazardous lakes at 33, lakes capable of producing glacial lake outburst floods (GLOFs) sudden releases of millions of cubic metres of water and debris within hours. Over 7.1 million residents of Gilgit-Baltistan and KPK are exposed to such events (UNDP, 2021; MoCC Pakistan, 2021).

The dangers are not just with the sudden floods. The Indus basin is the world's longest-running irrigation system and relies on regular supply of meltwater from glaciers and snow. The shrinking glaciers cause a temporary increase in river flow and an increase in the flooding potential, followed by a decrease in river flow as glacier stores are depleted. This "peak water" shift turns what was once a fairly reliable pool of water into an unreliable one with downstream impacts to food and water security. The timing of this shift differs from sub-basin to sub-basin, but in most of the upper Indus, this shift is in a direction (Immerzeel et al., 2020). Seasonal peaks and inter-annual variability are an increasing challenge in communities that depend on glacier-fed streams for irrigation and domestic use.

The settlements, roads and hydropower installations are located in narrow valleys which exacerbates the risks of GLOF. Many of these assets have been located with the assumption that glacial conditions were relatively stable. While the use of early-warning systems and controlled drainage of the most dangerous lakes can minimize loss of life, such measures may be less effective in mitigating the physical phenomena of cryospheric change. Long-term adaptation thus needs hazard monitoring and a step-by-step reconsideration of settlement and infrastructure patterns in the high mountains. The risk is even greater in the valleys where major hydropower projects and strategic road corridors exist – damage to these could have wider economic and security implications.

Monsoon Destabilization and Extreme Precipitation

The 2022 floods are the most significant manifestation of monsoon destabilisation so far. Pakistan received 243 percent above average rainfall between mid-June and late August 2022 and August 2022 was the wettest August since 1961 when records began. According to World Weather Attribution [WWA] 2022, Sindh had 726 percent more than its usual amount of rainfall in August, while Balochistan had 590 percent above its average rainfall for the same time of year. The Indus flooded on thousands of square kilometres, creating a lake that was about 100 kilometres wide in Sindh. Finally, one-third of the country was flooded and 33 million people were impacted (International Labour Organization [ILO], 2022).

Climatic contribution to the event has been quantified using attribution science. According to the peer-reviewed World Weather Attribution analysis, heavy rain over Sindh and Balochistan has increased by approximately 75 percent as a result of the 1.2 °C of warming, while rainfall over the Indus basin in the first sixty days of the monsoon is about 50 percent heavier. For some models, the intensity of rainfall over short durations (e.g. 5 minutes) is increased by up to 50 percent, suggesting an approximate one in a hundred year return period for this event under current conditions (Otto et al., 2023; WWA, 2022). The same study also notes that the disaster scale was no solely weather related. A severe meteorological event triggered by settlement on floodplains, conventional river management practices, widespread poverty and lack of advance risk reduction exacerbated to a full humanitarian crisis.

A subsequent attribution of the deadly monsoon in 2025 concluded that the 30-day maximum rainfall for the north of Pakistan has increased by approximately 22 percent

from an un-warmed climate, suggesting that this is becoming a growing trend, and not just a single event (WWA, 2025). The results support the importance of flood management that is based on the expectation of increased and more concentrated rain instead of the historical design standards that no longer reflect the extreme upper bound of the rain distribution. Conventional river control methods, which rely on embankments to hold back the river from its banks, can, under extreme conditions, exacerbate the flood damage when the embankments fail, due to the sudden release of flood water into highly populated floodplains. It is equally significant to restore space for the river and improve drainage to allow flood water to recede more quickly, than to raise the height of protective structures.

Extreme Heat

Extreme heat is the most fatal climate risk in cumulative terms in Pakistan. During the June 2015 heatwave in Karachi, during the holy month of Ramadan, while the city was facing power power failures, which affected water pumping and cooling, deaths of over 1200 people were reported and more than 65000 hospitalisations were reported due to heatstroke (NOAA, 2015; Ghumman & Horney, 2016). During April to May 2022, a long hot wave during pre-monsoon heat made the situation hot and dry in Jacobabad, where the temperature reached 49 °C on 30 April, which was 6–9 °C higher than the seasonal normal. The event was at least 30 times more likely due to climate change caused by humans, as determined by World Weather Attribution modelling (Zachariah et al., 2022; Washington Post, 2022). Here the 2022 heat wave and the subsequent floods happened in the same calendar year, highlighting the compounding "whiplash" nature of the risk of climate in Pakistan, which involved extreme heat surface preparation, greater thermal low to draw monsoon moisture and early glacial melting in the north.

Heat stress does not only occur during extreme events. Increase in average temperatures lowers labour productivity in outdoor and informal sectors, cooling demand in cities already suffering from power shortages and the risk of heat-related illness increases among vulnerable groups such as children, elderly, outdoor workers and people with special health conditions. These impacts are exacerbated in urban areas, particularly in built-up areas where the tree canopy is low and there is little ventilation. Early warning, cooling centers, and public messaging and protected working hours have all proven to be effective when followed consistently, and have also been shown to reduce mortality when implemented in combination to create heat-action plans (NOAA, 2015). Urban and southern districts are thus focusing on expanding this kind of plans to a few large cities and making sure that key sectors like water supply and hospital power are not affected when extreme events occur.

Sea-Level Rise and the Degrading Indus Delta

At the downstream end of the Indus system the delta is retreating. The delta is about 600,000 ha in size and used to flow into the Arabian Sea via 17 major creeks. Seawater has pushed as far as 54 kilometres upstream in the river, with salinity levels reaching 25–35 parts per thousand in the water column, due to lower fresh water flows below the Kotri Barrage which were accentuated by a period of drought and rising sea levels (IUCN 2018). Today, only one of the Indus' channels is in use and flows to the sea (Florida Institute of Technology, 2020). Modelling under different Shared Socioeconomic Pathways (SSPs) projects between 307 km2 and 7,151 km2 of inundation of delta land by 2150, with mean projections showing losses of over 550 km2 of agricultural land and 535 km2 of mangroves by 2150 (Syvitski et al., 2022).

However, there's a partial counter-narrative. Past satellite analysis of mangrove cover between 1988 and 2024 indicates that restoration of the mangrove can be achieved where governance enables it, with a total national change of approximately 44,486 hectares to 106,637 hectares at 3.88 per cent annual change rate (Abbas et al., 2024). Mangroves offer coastal protection, contribute to fisheries, and sequester carbon; successful recovery and rehabilitation of mangroves shows the potential for NbS if long-term financing and community

participation are available. However, environmental flows below Kotri Barrage are still very critical as they are vital for the delta ecology and for the backwash of saline invasion. Even if the Mangrove programmes are successful they will be restricted in further reach if there are insufficient flows.

Water Scarcity

Under the sudden disasters, there is a slow-moving pressure too that is currently unfolding in Pakistan; the country is moving from water-stressed to water-scarce. Reduced water availability on a person-to-person basis in the Indus Basin, where the country's farming is based, due to changes in the timing of snowmelt, more variable monsoons and higher evaporative demand (Kirby et al., 2017). The impact of water scarcity for food production alone would be greater than 4.6 per cent of GDP per year by mid-century, without the losses due to flooding and heat, according to the World Bank's Country Climate and Development Report, 2022a. Over-pumping groundwater in the irrigated plains exacerbates the depletion of groundwater resources that can be used to offset the surface water variability of the past. Water scarcity will continue to limit growth and food security without increased efficiency, demand management and coordination at the basin level. The relationship of water scarcity with other hazards is especially significant. Droughts can make soils and vegetation more susceptible to flooding damage, and hot weather can evaporate water from reservoirs and canals, while sea-level rise decreases the available freshwater in the lower Indus. Therefore, integrated water resources management, which views the basin as a whole and integrates water storage, allocation, efficiency and environmental water, is a precondition for climate resilience and not an agenda.

Sectoral and Macroeconomic Consequences

Physical hazards are manifested as social and economic losses in sectoral terms. The sectors that are especially vulnerable include Agriculture, Health, Infrastructure, and labour productivity. The key impact pathways are summarized in the following subsections and quantified where possible; in the final analysis, the implications for growth and poverty are explored.

Agriculture and Food Security

Agriculture makes up approximately 19–23 percent of the GDP of Pakistan, exports around 60 percent of the country's total exports and provides employment to around 45 percent of the labour force, thus supporting the livelihoods of some 68 percent of the rural population (UNEP-GRID, 2021; Kirby et al., 2017). Climate-induced yield losses are expected to be 15–20 percent in cereals and 20–30 percent in livestock both cotton and wheat, sugarcane and maize, and rice (Kirby et al., 2017). It was actually realised during the 2022 heatwave when abnormally high temperatures during the grain filling stage of wheat production resulted in a decrease in production to 10.84 million tons versus the expected 11.32 million tons (Zachariah et al., 2022).

Agricultural damage and loss of livestock was estimated at US$3.7 billion on the agriculture and livestock sector and estimated loss of livestock at US$0.8 billion, while more than 90 percent of the sectoral damage was inflicted in Sindh and Balochistan due to the subsequent floods that wiped 4.4 million acres of agricultural land, killed an estimated 0.8 million livestock, and caused US$9.2 billion in losses and US$3.7 billion in damages to agriculture and livestock sector (World Bank, 2022b).

The impact of production losses is not limited to food-security consequences. Transportation disruption, loss of storage facilities, and market disruption after large floods lead to price increases and poor households' decreased access to markets. Food and nutrition outcomes are already precarious in many rural and peri-urban communities, and worsen as diet diversity decreases and disease prevalence increases. Some of these impacts can be mitigated through climate smart agriculture.

Heat and drought resistant crops, adjusted sowing schedules, better water management and index based insurance are some of the methods that have shown to be effective, but they need continued investment in research,

extension and rural finance. The loss of the losses in Sindh and Balochistan also underscores the need for region specific support instead of blanket national programmes, which may not be able to make it to the most affected areas.

The 2022 Floods as a Macroeconomic Shock

The Post-Disaster Needs Assessment (PDNA) by the Government of Pakistan and the Asian Development Bank (ADB), European Union and United Nations (UN) and World Bank, estimated total damages above US$14.9 billion, economic losses of about US$15.2 billion and the need for resilient reconstruction, at least US$16.3 billion, which is approximately 1.6 times the total budgeted national development expenditure for the following fiscal year (2022b, World Bank). Over 1,730 people lost their lives, 780,000 homes were destroyed, 1.27 million were damaged and more than 2,000 health facilities were inundated. The direct GDP impact was estimated at approximately 2.2 percent of FY22 GDP, which would push 8.4–9.1 million people further below the poverty line and by 5.9 percent increase the multidimensional poverty rate (World Bank, 2022b; Washington Post, 2022).

Such events have macro-economic impacts beyond the year of the disaster. Reconstruction takes up fiscal resources that could be used for development spending; debt increases if the recovery is funded with debt; and private investment can be postponed as private households and firms hold off on investment while they are spending on rebuilding. Repair damaged assets. Frequent such shocks deplete capital stocks and have a negative impact on long-term growth. The challenge of "building back better" in the context of limited fiscal resources is highlighted by the fact that reconstruction costs were greater than one year's worth of development spending. And international assistance is often in the form of loans, not grants.

Health

Climate change impacts on Pakistani health include direct mortality from hot weather, as well as indirect impacts via its effects on health systems, such as water-borne and vector-borne disease outbreaks after the flooding in 2022, and malnutrition pathways, with 40 percent of children under five already stunted before the flooding (Washington Post, 2022). The effects of maternal health are becoming increasingly evident, such as the rise in the incidence of miscarriage and low birth weight, which were reported by clinicians in Sindh due to heat stress and deprivation following the disaster. So it is important to increase maternal and child nutrition programmes in high risk districts, keep health facilities open during extreme events, and strengthen disease surveillance as part of climate adaptation. The health system is also vulnerable: flooded facilities, disrupted supply chains and displacement of staff decrease the ability to respond at the right time and right place.

Long-Run Growth and Poverty Trajectories

According to Worldbank's Country Climate and Development Report, the impact of climate and environmental risks on the country's economy could cost 18-20 per cent of annual GDP losses by 2050, without any mitigation measures. Expenses due to climate change amount to 6.5-9.0% of GDP annually when calculated in isolation, through the following channels: lower yields of crops and livestock; damage to infrastructure; loss of labour productivity caused by heat; health effects (World Bank, 2022a). Under pessimistic scenarios agricultural and industrial output could decline by as much as 17 percent by 2050. The modelling exercise indicates that, by the end of the century, damages to the economy are likely to be close to 2% of GDP under the low-emissions scenario, and close to 10% under the high-emissions scenario, and represents a quantification of the stakes of global mitigation for a single developing country (World Bank, 2022a). These estimates are long-term ones and important for policy prioritisation. They suggest that the total costs of inaction are far greater than the cost of sound investment in adaptation – and that global mitigation is adaptation for countries like Pakistan. They also stress the need to ensure that the poorest families are protected,

who generally lack the ability to cushion shocks and have limited coping and recovery options.

Displacement and Climate Migration

Over eight million individuals were displaced by floods in 2022 (Boston University, 2023). In addition to the people displaced by sudden events, slow onset drivers such as water stress, loss of crop productivity and sea level rise are expected to drive up to 40 million people to become internal climate migrants in South Asia by 2050, bringing the total number of internal climate migrants up to 216 million across six world regions. That scale can be cut in half by up to 80 percent with early and concerted mitigation and development action (World Bank, 2018, 2021). There will be a need for both climate change mitigation measures to lower the incentive to migrate, and measures to support migrants, such as access to housing, services and livelihoods in the receiving regions, to deal with climate migration. Gendered dimensions of internal displacement: women and children may be at special risk in temporary settlements and in return and recovery.

Table 1. Key quantified climate impacts on Pakistan

Domain	Indicator	Magnitude	Source
Global ranking	Most affected country, 2022 (CRI 2025)	Rank 1	Germanwatch
2022 floods	Total damages + losses	>US$30 billion	World Bank
2022 floods	People affected / displaced	33 million / >8 million	ILO
2022 floods	Additional people pushed into poverty	8.4–9.1 million	World Bank PDNA
Attribution	5-day extreme rainfall intensity increase	~75% vs. pre-warming climate	WWA
Heat	2015 Karachi heatwave deaths	>1,200	Ghumman & Horney
Cryosphere	Hazardous glacial lakes / people at GLOF risk	33 / 7.1 million	UNDP
Agriculture	Projected cereal / livestock yield decline	15–20% / 20–30%	Kirby et al.
Macro	Annual GDP loss by 2050 (climate + environment)	18–20%	World Bank CCDR
Emissions	Share of global GHG emissions	<1%	UNEP

Policy Response and the Climate Finance Dilemma

Domestic Policy Architecture

The formal climate structure in Pakistan has come a long way in the last decade. The National Climate Change Policy and its implementation framework in the 2014–2030 timeline and other subsequent policies like the Sindh Climate Change Policy include various sectoral measures including mangrove plantation, construction of coastal barriers, and river management to reduce saltwater intrusion (Florida Institute of Technology, 2020). The new NDC of 2021 promises Pakistan a 50 per cent cut in emissions from projected emissions levels by 2030, which amounts to 15 per cent unconditional and 35 per cent conditional emissions.

It would take an estimated US$101 billion to cover the cost of the energy transition. The NDC also aims for 60 percent renewable energy and 30 percent electric vehicles by 2030 and also bans the use of imported coal. The national emissions were 489.87 MtCO in 2018 (Government of Pakistan, 2021). There are significant ecosystem recovery initiatives that integrate the creation of jobs with the recovery of ecosystems, like the Ten Billion Tree Tsunami Programme, Protected Areas Initiative, Recharge Pakistan and the Living Indus Initiative. If the tree programmes are fully implemented they are expected to sequester around 500 MtCO by 2040 (Government of Pakistan, 2021; MoCC Pakistan, 2021).

Local level heat action plans developed after the 2015 disaster in Karachi, and adapted in other cities, show that early-warning and

response systems can significantly save lives for heat-related deaths (NOAA, 2015; Washington Post, 2022). These are examples of institutional learning, but they are on a small scale compared to the size of the risks identified in Sections 2 and 3. Implementation gaps, capacities across provinces and lack of dedicated predictable funding streams persist, limiting impact.

The Adaptation Finance Gap

The problem is a fiscal one. According to the Pakistan's first National Adaptation Plan, the total investment requirements for climate resilient development in Pakistan are around US$348 billion from 2023 to 2030, of which US$152 billion is needed for adaptation and resilience. The government of Pakistan estimates that during the same timeframe, the amount of public finance and public–private infrastructure that has been transacted equals approximately US$48 billion, which still leaves a huge gap (Government of Pakistan, 2023). The key constraints outlined in the plan are inconsistent policies between sectors, inconsistent institutional capacity, lack of dedicated funding streams, data gaps, limited national–provincial coordination, and limited awareness of stakeholders. Independent evaluations have pointed out that no mechanisms have been provided for the mobilization of private finance and for the implementation of the proposed National Climate Change Fund (Centre for Strategic and Contemporary Research [CSCR], 2023).

The 2022 floods' international response is a reflection of both the capability and the deficiencies of the current system. In January 2023, the Islamic Development Bank (IDB) (US$4.2 billion), the World Bank, the Asian Development Bank (ADB), and bilateral donors pledged US$10.57 billion at a Geneva conference, which is more than Pakistan requested (US$8.15 billion) (Brookings Institution, 2023). Many of those pledges were, however, in the form of loans, not grants, and increased the debt load on a already stressed national budget. One month after the initial UN flash appeal for US$816 million, it had only received 13.7 percent of the funds required (World Bank, 2022b). At global level, the amount of finance actually being deployed to developing countries for adaptation is 5 to 10 times less than what is estimated, which is expected to increase to more than US$300 billion annually by 2030 (UNEP, 2023).

This is a not just a quantitative gap. It is not only the quantity of finance that is important but also the quality. These loans can crowd out expenditures on adaptation and social protection, which are likely to be driven by the debt service burden.This may push out domestic spending on adaptation and social protection. The preparation for projects and accreditation process for multilateral funds may result in delayed disbursement and may end up after the critical period for recovery and risk reduction. Making things easier to access, moving towards a greater proportion of grants, and agreeing conditions of finance ahead of time that can be activated by defined indicators is just as vital as increasing headline finance.

Climate Justice and Loss and Damage

The year 2022 was a turning point in Pakistan's political landscape. The floods provided a clear moral impetus to the development of a dedicated climate loss and damage fund at COP27 in November 2022 (Brookings Institution, 2023). The justice argument is based on simple calculations: Pakistan emits less than 1 per cent of the world's emissions, one estimate puts it at 0.3 per cent, but is also at a higher risk of death because of climate extremes compared to high emitters. More than half of emissions worldwide are emitted by China, the United States, the European Union and India (International Growth Centre [IGC], 2023). A study that is also based on the attribution principle has taken a step further, estimating the direct economic losses in the range of US$60 billion that have occurred in Pakistan due to the emissions of the largest historical polluters (IGC, 2023).

The extent to which the Loss and Damage fund will be funded to match such estimates will be a true measure of the climate-justice principle. What the Fund does will also affect how it operates. The Fund will be a useful tool or a hollow signal depending on how it is implemented by ensuring a direct, fast path

for countries suffering from extreme events, fair eligibility rules that do not impose undue administrative burdens on countries, and a governance system that empowers vulnerable countries. Pakistan's lessons from past appeals indicate that to lessen vulnerability, as opposed to exacerbating it, finance must be both fast and delivered based on the need.

1. Discussion

Three observations come from Pakistan experience and are more pertinent to the developing countries. Vulnerability is a co-produced entity, first. Attribution studies have revealed that the 2022 disaster was caused by the climate-driven intensification of the hazard coupled with people living on floodplains, an outdated river-management system, poverty and insufficient pre-disaster risk reduction (Otto et al., 2023). Therefore, investments in adaptation are not only compensatory, but highly productive, as adaptation increases the resilience of society to the same hazard, and leads to significantly lower losses. Thus, investments in early warning, land-use regulation, resilient housing and social protection bring significant gains in terms of damages avoided and human suffering reduced. This productivity claim is crucial for the debate on adaptation in the domestic budget as well as for negotiations at the international level: adaptation is not the use of scarce resources as a residual but a productive investment for the public good. Second, there's a clear economic argument for doing something. This indicates that the gap between how much damages roughly 2 percent of GDP and how much damages would be 10 percent at the end of the century under low- and high-emission scenarios would be the maximum mitigation that can be done in Pakistan is the greatest Pakistan adaptation. Meanwhile, the domestic measures, including heat-action plans and expanding GLOF early-warning systems, both in the north and facilitated by UNDP and the Green Climate Fund, have high returns on investment (World Bank, 2022a; Green Climate Fund, 2021). The challenge is not cost-efficient options are not available, but that they need to be identified and that financing is available and accessible. Gaps that need to be filled include more support from international community and better domestic systems to prioritize, implement and monitor adaptation investments.

Third, the international climate system also has further credibility issues that emerge from the Pakistani situation. The assessed adaptation needs of a country that has a budget of only US$10.9 billion is simply beyond its means, even if it has to pay for these adaptation costs from debt service and recovery costs. If most “climate finance” is in the form of loans, then vulnerability to climate change may end up being a debt trap. The extent of mangroves recovered in the coast of Pakistan (from 44,500 to 106,600 ha in 36 years) is a testimony to what can be achieved with sustained and financed programmes, and it remains to be seen whether this will become the norm or the exception. The extent of finance that gets to the ground will be a better measure of credibility than the number of words in conference declarations.

The findings have a practical corollary which will be unfolded throughout the remainder of this article. Pakistan has hazards which are geographically and spatially differentiated, glacial and slope hazards in the north, water stress and riverine floods in the plains, extreme heat in the cities, saline intrusion at the delta and aridity in the west, therefore remediation measure should be made geographically and spatially differentiated and anchored in institutions. Financial arrangements that are able to be extended to the provincial and district level. A national programme will assume a single fit for all won't capture the particular risk profiles and institutional capacities of different regions. Recommendations in the subsequent section are thus arranged by geographic zone, followed by cross-cutting recommendations on governance, finance and social-protection reforms.

Remedial Measures: A Geographically Differentiated Resilience Agenda

The recommendations which follow are based on four principles stemming from the preceding analysis. (i) Prevention first: Vulnerability is a co-produced entity, so smaller

losses from early warning and better standards for infrastructure, combined with land use rules, generate larger benefits than do relieving efforts after a disaster. (ii) Basin-scale thinking: a single action at the headwaters, in the irrigated plains and at the delta has to be planned together, as the Indus is one hydrological system. (iii) Preference for nature-based & low regret options: It is prudent under deep uncertainty to start with nature-based and low-regret options. (iv) Equity and realistic finance: the measures must be adopted in the poorest and most flood-exposed districts and the way in which they are financed must not be a strain on the country's debt service.

The Mountain North: Hindu Kush, Karakoram, and Himalaya

2. **Glacier/glacial-lake monitoring:** Improve the number and quality of automatic weather and hydrological stations at high elevations, and establish a system for regular updates of the glacial-lake inventory through satellite observations, allowing continuous monitoring of the 33 hazardous lakes and 36 potentially dangerous lakes, instead of just sporadic monitoring.
3. **Community-based GLOF early-warning systems:** Expand the sensor and siren system and train and deploy local volunteers within the districts of all valleys that have hazardous lakes, including evacuation routes and drills, in connection to the Provincial Disaster Management Authorities (PDMAs) and the National Disaster Management Authority (NDMA).
4. **Structural risk reduction:** Reduce lake level (controlled drainage) where engineering is warranted and protect settlements, bridges and hydropower, and road infrastructure, using spillway capable and debris resistant design.
5. **Hazard-zoned land use:** Legally establish no build and restricted areas on steep streams, debris-flow fans and flood terraces; require tourism and road development to be hazard assessed.
6. **Mountain livelihoods:** Promote climate-smart orchards, tourism diversification, high-value crops, and that forests and watersheds that stabilize slopes are protected under the national tree programmes.

These measures will complement each other. Without early-warning systems, there is no monitoring; without evacuation routes and drills, early warning is not effective; and without land-use controls, structural works can give communities a false sense of security, leading to still more settlement in dangerous areas. Implementation should thus take place as a package with defined roles of NDMA, PDMAs, the Pakistan Meteorological Department and local authorities.

The Indus Plains: Floods, Agriculture, and Water (Punjab, Sindh, southern Khyber Pakhtunkhwa)

1. **Modernize flood management:** Implement a basin-wide, impact-based system to forecast floods that incorporates rainfall, snow and glacier melt, reservoir operations, and translates the flood warning information into evacuation plans at the district level several days before peak flood water levels.
2. **Re-establish space for the river:** Identify and legally protect floodways and retention areas, remove or realign encroachments and, wherever possible, set back embankments allowing floodwaters to be stored and/or conveyed without flooding high-density development. Restore natural drainage systems and outfall drains, ensuring that standing water is reduced in weeks, not months as during the last monsoon season in Sindh 2022.
3. **Floodplain zoning and resilient housing:** Adhere to building code and plinth height requirements in flood-prone areas; foster locally appropriate, low-cost, flood resistant and resilient housing with community involvement; and leverage reconstruction to minimize future vulnerability and risk, not rebuild the vulnerability.
4. **Climate-smart agriculture:** Encourage the use of drought and heat tolerant, short-duration and flood-tolerant crops; modify sowing seasons and dates so as to avoid periods of heat during grain filling; establish precision land levelling, bed-and-furrow planting and drip and sprinkler irrigation, especially for high-value crops.

5. **Efficient irrigation and good governance of groundwater:** Rehabilitate and, if cost-effective, line watercourses/canals, and introduce volumetric water charges and gradually enhance them; manage groundwater abstraction and encourage managed aquifer recharge to counterbalance declines in groundwater at the peak of demand; and manage groundwater abstraction and encourage managed aquifer recharge to buffer against peak-water declines.
6. **Risk sharing for farmers:** Develop index-based and parametric crop and livestock insurance that has low subsidy rates and is based on early-warning data, enabling compensation to be delivered to farmers within weeks.
7. **Storage and food security:** Improve post-harvest storage and grain reserves in dry areas where floods are unlikely and diversify crops to reduce over-reliance on heat sensitive staple food crops.

The plains recommendations focus on actions that will minimize exposure and enhance the ability of the natural and built environment to absorb the impact. Restoring space for the river and better drainage deal with the specific failure modes experienced during 2022 when water was on the land for months. Slower onset of yield decline and water scarcity are tackled in agricultural and irrigation reforms. Risk transfer and risk storage: These two solutions cover the remaining risks that cannot be eliminated physically.

Cities and Heat-Exposed Districts

1. **Heat action plans for all major cities:** Expand the strategy implemented in Karachi to all cities and heat prone districts using stepped warning strategies based on temperature and humidity, cooling centers and mandatory preparedness in hospitals.
2. **Protect power, water in times of heatwaves:** As the 2015 mortality fell during electricity and pumping outages, consider water supply and hospital electricity as critical infrastructure and prioritize supply and backup (including solar-plus-storage).
3. **Cooler urban form:** Implement cool roof and reflective roof and surface requirements; increase urban tree canopy and shaded public space; preserve or create urban wetlands; and update building codes for passive cooling.
4. **Outdoor-worker protection:** Implement regulated working hour changes, water breaks and resting periods, and heat-illness reporting for construction workers, brick kiln workers, agricultural and informal workers.
5. **Urban drainage:** Enlarge and clear storm water drains, prevent the development of natural mullahs and provide early warning systems for low-lying neighborhoods.

The Indus Delta and Coastlines

1. **Environmental flows:** Ensure and control sufficient releases of fresh water and sediments at the Kotri Barrage, in accordance with inter-provincial water apportionment schemes, to halt saline intrusion and maintain the ecological processes of the delta.
2. **Expand mangrove restoration efforts:** Finance long-term mangrove restoration, promote community co-management and mangrove species-specific planting, and have independent mangrove survival monitoring.
3. **Managed retreat and coastal protection:** Use mangrove/dune buffers and strategically engineered defences, at key assets, and develop voluntary, compensated relocation strategies for communities that are likely to become uninhabitable.
4. **Saline-adapted livelihoods:** Encourage the use of salt-tolerant crops, brackish-water aquaculture and sustainable fisheries management; ensure safe drinking water in coastal communities by small-scale, renewable powered desalination or by rainwater harvesting.

Arid and Semi-Arid Zones (Balochistan, Thar, Cholistan, and the Potohar plateau)

1. Harvesting and storing water. Rehabilitation of traditional irrigation system like 'Karez' and development of flood spreading systems like small dams, delay action dams, ponds and roof water capture.
2. Early warning and response to drought. Implement a water drought monitoring system, set up agreed water drought thresholds and response to drought, such as livestock feed,

water by tanker, cash transfer.

3. The resilience of rangelands and livestock. Restore rangelands, develop drought resistant livestock stocks and fodder banks, increase the provision of veterinary and livestock insurance, in the context of the expected 20-30% reduction in livestock yields.

6.1 Cross-Cutting Governance, Finance, and Social Protection

Implement the National Climate Change Fund with a transparent public mandate, a pipeline of bankable projects and dedicated windows for provinces and districts. Include federal and provincial budgets in climate tagging and separate out expenditure for adapting to climate change annually.

1. **Improve institutional coordination:** Create a permanent federal–provincial body with specific responsibilities of the Ministry of Climate Change, NDMA, PDMAs, the Pakistan Meteorological Department, WAPDA, IRSR, and provincial irrigation and agriculture departments to overcome the policy gaps and poor coordination mentioned in the NAP.
2. **Plan disaster finances prior to the disaster:** Combine a properly sized national contingency reserve with contingent credit lines and catastrophe linked/p parametric tools to ensure that funds are available in affected areas within days of a disaster without going to the trouble of emergency borrowing.
3. **Ensure social protection's responsiveness to shocks:** Leverage current cash-transfer initiatives like the Benazir Income Support Programme to rapidly expand coverage prior to or soon after the hazard, ensuring that registries are kept current for districts affected by floods as well as heat.
4. **Build health system resilience to climate impacts:** Implement health and climate surveillance activities (heat illness, malaria, dengue, water-borne disease), flood proof health facilities and scale up nutrition programmes for mothers and children in the most affected districts.
5. **Enhance data, science and local capacity:** Build a national Climate-Data Platform, develop downscaled projections for each basin and perform periodic postevent attribution and loss accounting. Train district officials and communities; include women, who suffer most from displacement and heat, in planning and provide support specific to their needs.
6. **Treat mitigation as a part of adaptation:** Take measures to implement the unconditional elements of the NDC and the renewable energy and electric mobility goals; and acknowledge that only efforts to reduce emissions in Pakistan can help reduce the vulnerability to hazards. Progress on the domestic level should be cited to build the case for international assistance, which is limited to selected areas and delivered on the basis of need.

Measures Required from the International Community

There is a gap of about US$152 billion that can only be filled if there are dramatic changes at home as well as available resources of US$48 billion. Pakistan and other countries in similar situations must push for: (a) a well-funded Loss and Damage Fund that provides simple access that is easy to use and fast; (b) A substantially larger proportion of grants or highly concessional loan financing of adaptation; (c) Debt relief or debt-for-climate swaps to free up budget space for adaptation; (d) Suspension clauses in loan contracts to allow for suspension of debt payments after a declared disaster; (e) Easier access to the Green Climate Fund and the Adaptation Fund, including support in project preparation; (f) Technology and capacity support for monitoring, early warning, and design of climate-resilient infrastructure. These are not intended to take the place of home effort, but rather so that home effort can be effective at the level required.

Sequencing and Monitoring

An indicative sequencing of priority measures is given in Table 2. Low cost, institutionally feasible and highly life protective activities are short term, capital investment and legal reform are medium term, and structural transformation of land, water and settlement

systems are long term.

Table 2. Indicative sequencing of remedial measures

Priority measure	Primary zone	Lead institutions	Horizon
Impact-based basin flood forecasting and evacuation plans	Indus plains	PMD, Federal Flood Commission, PDMAs	0–3 years
GLOF early warning and lake monitoring	Mountain north	NDMA, PDMAs, PMD, UNDP/GCF Partners	0–3 years
Heat action plans and critical-infrastructure backup	Cities, south	Provincial/municipal governments, health depts.	0–3 years
Operationalise National Climate Change Fund; budget tagging	National	Ministry of Climate Change, Finance, Planning	0–3 years
Shock-responsive cash transfers; parametric crop insurance	Plains, arid zones	BISP, provincial agriculture depts., regulators	1–5 years
Floodway protection, drainage rehabilitation, resilient housing	Indus plains	Provincial irrigation & housing depts., local govt.	3–10 years
Environmental flows and mangrove scale-up	Indus Delta	Sindh govt., IRSA, forest & wildlife depts.	3–10 years
Irrigation modernisation and groundwater governance	Indus plains	Provincial irrigation depts., WAPDA, IRSA	5–15 years
Managed retreat and relocation planning	Coast, high-risk floodplains	Provincial governments, NDMA	5–20 years

A few easily quantifiable indicators should be used to monitor implementation, the percentage of hazardous glacial lakes equipped with early-warning systems; the percentage of flood-prone districts with enforced zoning and updated evacuation plans; the number of people dying from heatwaves per heatwave day; the percentage of climate finance received as grants; and time taken between a declared disaster and the release of the first climate finance funding. Independent reviews of these indicators over the course of two to three years could provide further scope for course correction and, for the better, hold affected communities and international partners to account.

Conclusion

The essence of the imbalance of the climate crisis is what Pakistan has seen over the past ten years. A nation which has contributed a minuscule percentage of the global emissions has experienced the costliest flood, repeated deadly heatwaves, escalating glacial hazards, and a slow erosion of its delta and water security. The statistics of US$30 billion in flood losses and damages, 9.1 million people pushed into poverty and potentially a loss of up to 1/5th of GDP by mid-century make Pakistan the clearest example of climate change in the developing world. Meanwhile, its policy work ranging from its ambitious conditional NDC to early heat-action plans and plans to restore ecosystems demonstrates that institutions can still learn and adapt in limited situations. While much remains to be done, the implementation of the following practical measures in the paper shows that a great deal can still be achieved: a good deal of early-warning systems in the mountains, more space for the river, better water use on the plains, heat protection in the cities,

freshwater flows and mangroves at the delta, and water harvesting in the dry west, all supported by social protection measures that respond to shocks, finance pre-arranged before disaster strikes, and tightened federal–provincial coordination. The actual restriction, though, is international. The lack of adaptation finance, through its modest financing (primarily grants) and an appropriately resourced loss-and-damage fund, will directly result in the loss of lives, livelihoods and development this decade, with funding requirements at about US$152 billion and available sources at US$48 billion. In this regard, Pakistan is a warning for researchers and a test for decision-makers on the possibility of making climate justice a reality on the ground. Future work should explore the cost effectiveness of the proposed measures at the district level, calculate the finances that each zone actually needs and explore the political barriers to reforming floodplain and water governance.

References

Abbas, S., et al. (2024). Mangrove cover change and restoration potential along the Pakistan coast: A satellite-based assessment, 1988–2024. *Science of the Total Environment*.

Ashraf, A., Naz, R., & Roohi, R. (2017). Glacial lake outburst flood hazards in Hindukush, Karakoram and Himalayan ranges of Pakistan: Implications and risk analysis. *Environmental Earth Sciences*, 76, Article 45. https://doi.org/10.1007/s12665-016-6361-3

Boston University. (2023). Analysis of the 2022 Pakistan floods and Climate Risk Index rankings. Boston University research briefing.

Brookings Institution. (2023). The Geneva conference on Pakistan's flood recovery and the Loss and Damage Fund.

Brookings analysis.

Centre for Strategic and Contemporary Research (CSCR). (2023). Independent assessment of Pakistan's National Adaptation Plan: Gaps in private finance mobilisation and institutional design. Islamabad: CSCR.

Florida Institute of Technology. (2020). Saltwater intrusion and ecological change in the Indus Delta. Research report.

Germanwatch. (2025). *Global Climate Risk Index 2025*. Bonn: Germanwatch e.V.

Ghumman, U., & Horney, J. (2016). Characterizing the impact of extreme heat on mortality, Karachi, Pakistan, 2015. *International Journal of Environmental Research and Public Health*.

Government of Pakistan. (2021). *Updated Nationally Determined Contributions 2021*. Islamabad: Ministry of Climate Change.

Government of Pakistan. (2023). *National Adaptation Plan of Pakistan*. Islamabad: Ministry of Climate Change.

Green Climate Fund. (2021). Scaling-up of glacial lake outburst flood (GLOF) risk reduction in Northern Pakistan.

Project documentation.

Immerzeel, W. W., et al. (2020). Importance and vulnerability of the world's water towers. *Nature*, 577, 364–369.

International Growth Centre (IGC). (2023). Pakistan's emissions share, climate justice and attributable loss estimates. IGC working paper / analysis.

International Labour Organization (ILO). (2022). Impact of the 2022 floods on employment and livelihoods in Pakistan. ILO reporting.

International Union for Conservation of Nature (IUCN). (2018). Indus Delta: Status of freshwater flows, salinity and ecosystem health. IUCN assessment.

Kirby, M., et al. (2017). The impact of climate change on water resources and agriculture in the Indus Basin.

Agricultural Water Management / PMC.

Ministry of Climate Change (MoCC) Pakistan. (2021). National climate change policy documents and glacial lake assessments. Islamabad: MoCC.

NOAA. (2015). Attribution analysis of the 2015 Karachi heatwave. NOAA climate attribution study.

Otto, F. E. L., et al. (2023). Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan. *Environmental Research: Climate* (IOP Publishing).

Syvitski, J., et al. (2022). Sea-level rise and delta inundation projections for the Indus under Shared Socioeconomic Pathways. Coastal modelling literature / PubMed.

United Nations Development Programme (UNDP). (2021). Adaptation and GLOF risk reduction in Northern Pakistan. UNDP programme documentation.

United Nations Development Programme (UNDP) Pakistan. (2022). Climate and development overview for Pakistan. UNDP country analysis.

United Nations Environment Programme (UNEP). (2023). *Adaptation Gap Report 2023*. Nairobi: UNEP. UNEP-GRID. (2021). Agriculture, livelihoods and climate exposure in Pakistan. UNEP-GRID data brief.

Washington Post. (2022). Reporting on the 2022 Pakistan heatwave, floods, health impacts and poverty projections. World Bank. (2018). *Groundswell: Preparing for Internal Climate Migration*. Washington, DC: World Bank.

World Bank. (2021). *Groundswell Part II: Acting on Internal Climate Migration*. Washington, DC: World Bank. World Bank. (2022a). *Pakistan Country Climate and Development Report*. Washington, DC: World Bank Group.

World Bank. (2022b). *Pakistan Floods 2022: Post-Disaster Needs Assessment*. Washington, DC: World Bank / Government of Pakistan / partners.

World Weather Attribution (WWA). (2022). Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan. Rapid attribution study.

World Weather Attribution (WWA). (2025). Attribution of the 2025 northern Pakistan monsoon extremes. Rapid attribution study.

Zachariah, M., et al. (2022). Climate change made the 2022 South Asian heatwave at least 30 times more likely.

World Weather Attribution / NOAA-linked analysis.

IEER
Institute for Excellence in Education & Research