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ASSESSING THE ECONOMIC FALLOUT: IMPACT OF CLIMATE CHANGE AND NATURAL DISASTERS ON GDP IN PAKISTAN

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Abstract

Pakistan is among the countries most vulnerable to climate change, experiencing frequent floods, heatwaves, and droughts that directly damage agriculture, infrastructure, and livelihoods. This paper investigates how climate-induced natural disasters affect Pakistan's GDP growth in the short and long term, identifies the most vulnerable economic sectors, evaluates the effectiveness of current institutional frameworks and policies, and compares the economic resilience of rural versus urban areas. The analysis draws on national-level studies, post-disaster assessments, and empirical time-series and sectoral studies on Pakistan's climate-economy nexus. Findings show that agriculture-dependent rural economies are disproportionately affected, while cities face growing strain from concentrated climate risks and migration. The paper concludes that existing institutional frameworks are conceptually strong but weakly implemented, and recommends targeted climate-resilient investment, rural-income diversification, and improved urban-climate-governance to reduce GDP-drag from recurrent disasters. [1] [2] [3] [4] [5] [6] [7] [8] [9]

1. INTRODUCTION

Pakistan's economy is highly exposed to climate-related shocks such as floods, heatwaves, and droughts, which have already caused tens of billions of dollars in economic losses. Between 1992 and 2021, climate- and weather-related disasters in Pakistan led to about US$29.3 billion in economic losses, equivalent to roughly 11% of 2020 GDP. Agriculture, which accounts for around 19–24% of GDP and about 37–45% of employment, is especially sensitive to these shocks, making climate change a core macroeconomic risk. [10] [4] [5]

Despite a growing body of work on climate-change impacts in Pakistan, there is limited research that systematically links sectoral vulnerability, institutional resilience, and rural–urban differences in economic resilience to national GDP outcomes. This paper addresses that gap by answering four research questions: [9] [11]

1. How do climate-induced disasters affect Pakistan's GDP growth in the short and long term?
2. Which economic sectors are most vulnerable, and how does this impact overall GDP?
3. How effective are current institutional frameworks and policies in mitigating these impacts
4. Are there significant differences in the economic
5. resilience of rural versus urban areas?

2. Short- and Long-Term Impact of Climate Disasters on GDP

2.1 Short-term GDP effects

Climate-induced disasters have an immediate, negative effect on Pakistan's GDP growth. The official Post-Disaster Needs Assessment for the 2022 floods estimates total damages of US$14.9 billion and economic losses of US$15.2 billion, affecting over 33 million people, with the loss in GDP estimated at around 2.2% of FY22 GDP. The same assessment indicates that agriculture alone is projected to contract by 0.9% of GDP, reflecting extensive crop and livestock losses. Also crop yields, such as wheat and cotton, decreased by 13.5% in 2025 due to floods and erratic rainfall. [2] [12]

Sectoral damage figures underline the macro impact: housing (US$5.6 billion), agriculture and livestock (US$3.7 billion), and transport and communications (US$3.3 billion) were the hardest hit, directly affecting both production and supply chains. Complementary estimates suggest climate disasters now drain roughly 9.5% of Pakistan's GDP when cumulative direct and indirect effects

are considered.[13][2]

Time-series analyses support these short-run findings. A study using annual data from 1980–2017 finds that declines in precipitation have a statistically significant negative impact on real GDP per capita, primarily through reduced agricultural output and disruptions to agro-industrial supply chains. In that study, lower rainfall is associated with slower provincial growth, particularly in Punjab and Khyber Pakhtunkhwa.[1]

A new assessment by the United Nations warns that 7.5 million people in Pakistan are facing acute food insecurity and malnutrition after a year marked by monsoon flooding & prolonged drought. At the most severe end of the scale, between December and March 2026, around 1.25 million people are projected to face "emergency" levels of acute food insecurity, marked by large food consumption gaps and high levels of acute malnutrition, the Integrated Food Security Phase Classification (IPC) report said.

Immediate, life-saving assistance is required to avert a humanitarian catastrophe for more than one million people currently classified in emergency food insecurity, the report added.

Residual 2025 monsoon flood impacts & drought have weakened agriculture and pastoral livelihoods, reduced production, disrupted markets, and squeezed coping capacity.

Seasonal factors have also added to the crisis, with the lean season (December to February) reducing farm labour and income opportunities, and in some areas, harsh winter conditions have further constrained access and livelihoods. Food access has been particularly constrained by weak purchasing power, heavy reliance on markets, price volatility and rising household debt. Wheat flour has also been flagged as a key concern during the lean season.

Large variations in conditions have led to higher concentrations of hunger in specific regions.

The IPC analysis – covering 45 vulnerable areas and about 15% of Pakistan's population – shows that Balochistan carries the highest proportional burden, with 25% of the analysed population facing at least high levels of food insecurity.

In Sindh, more than three million people are experiencing high levels of food insecurity, while in the districts of Musakhel, Zhob, Kachi, Tank and Torghar, around 30% of residents are classified in at least high food-insecurity phases.

For the period from April to September 2026, the report projects that 6.7 million people will face high or worse levels of food insecurity, representing a decline of about 855,000 from the current period.

Although several drivers are expected to persist – including elevated staple food prices, climatic risks, insecurity and cross-border trade disruptions – seasonal factors such as winter crop harvesting and Eid-related livestock sales could temporarily ease pressure, the report noted.

2.1 Long-run GDP and growth potential

Repeated climate shocks erode Pakistan's long-run growth potential. Empirical work on the climate–growth nexus indicates that rising temperatures and changing rainfall patterns reduce long-run GDP growth, with agriculture serving as the main transmission channel. Multi-sector simulation models suggest that climate-change-induced reductions in wheat and rice productivity could cost Pakistan about US$19.5 billion in real GDP by 2050, through higher food prices, lower consumption, and reduced welfare.[14][11][15]

World Bank estimates that under high-warming and low-adaptation pathways, climate change could reduce Pakistan's GDP by 18–20% by 2050, mainly via persistent damage to agriculture, water systems, and transport networks. These projections align with evidence that climate-related infrastructure damage raises the cost of doing business and slows capital accumulation, thereby lowering the long-run growth trajectory relative to a low-climate-risk baseline.[5][7][16][17][18]

Repeated climate disasters are forcing rural families into migration, exacerbating poverty and food insecurity. Climate change impacts agriculture, a key sector supporting 40 million people and contributing 23% to Pakistan's GDP.

3. Sectoral Vulnerability and Impact on GDP

3.1 Agriculture as the most vulnerable sector

Agriculture is the most climate-vulnerable sector in Pakistan. It contributes almost 23% to national GDP and employs around 37–45% of the labor force, while also underpinning food security and agro-based exports. The 2022 floods illustrate this vulnerability: agricultural damages were estimated at US$3.7 billion and large shares of rice, cotton, and sugarcane crops destroyed in affected provinces.[19][12][4][10][5]

The 2025 floods caused an estimated US$1.4 billion in

economic losses, including damage to agriculture and infrastructure. Cotton production dropped by 35% in FY 2022-23 due to excessive rain and pest attacks, impacting the textile industry.

Climate change is expected to reduce wheat yields by 14.7% and rice yields by 20.5% over the next decade due to heat stress and water scarcity. Quantitative studies consistently find strong negative elasticities of agricultural output with respect to temperature and rainfall changes. A two-factor regression study for Pakistan shows that a 1% increase in average annual air temperature reduces grain productivity by about 6.19%, while a 1% increase in precipitation (beyond the average) reduces productivity by 0.59%, holding the other variable constant. Another empirical study on Pakistani farms finds that increases in temperature and decreases in precipitation significantly reduce farm incomes, confirming the sensitivity of agricultural earnings to climate variables.[3] [10]

Because agriculture is highly integrated into the rest of the economy, such shocks propagate outward. When agricultural GDP contracts, it not only reduces the sector's own contribution but also cuts raw-material supply to agro-industries and lowers rural demand for manufactured goods and services, amplifying the impact on overall GDP.[5] [1]

3.2 Water-linked industry and infrastructure

Water-intensive industries, particularly textiles and food processing, are indirectly but significantly affected when climate change alters water availability and damages energy and transport. During the 2022 floods, large segments of Pakistan's road network and energy infrastructure were temporarily unusable, which disrupted industrial production and trade flows. The manufacturing sector, particularly agro-based industries, faces supply chain disruptions and raw material shortages due to climate-related shocks. Time-series analyses that include industrial output as a control variable show that precipitation and temperature shocks correlate with lower industrial output per capita, although the effect size is smaller than for agriculture.[12] [7] [11] [2] [1] [5]

3.3 Services, transport, and urban productivity

Services are affected mainly through infrastructure disruptions and labor-productivity effects. Climate disasters regularly damage Pakistan's infrastructure, including roads, highways, railways, power plants, and communication networks, draining public funds. The 2022 floods caused US$3.3 billion in damage to transport and communications, undermining trade, logistics, and related service activities. Urban heatwaves and air pollution episodes in cities like Karachi and Lahore further reduce labor productivity and increase health-related costs, although precise GDP-elasticity estimates at the sectoral level remain limited.[18] [20] [21] [2]

The impact on overall GDP is significant, with Pakistan losing approximately 1% of its GDP annually due to climate-related damages. This loss is projected to increase, with estimates suggesting a 3.7% decline in real GDP by 2050, equivalent to $19.5 billion.

4. Effectiveness of Institutional Frameworks and Policies

Pakistan's institutional frameworks and policies have taken steps to address climate change, but their effectiveness in mitigating economic impacts remains a challenge. Pakistan has established several institutional and policy frameworks to manage climate risks, including the National Climate Change Policy (NCCP 2012, updated 2021), the Updated Nationally Determined Contributions (NDCs, 2021), Pakistan Climate Change Authority and remodelled National Disaster Management/ Mitigation Plan (NDMP-II) and also launched initiatives like the National Carbon Market Policy and Clean Green Pakistan. These documents emphasize adaptation, disaster-risk reduction, and climate-resilient infrastructure, and they underpin initiatives such as the Ten Billion Tree Tsunami Programme and climate-smart agriculture pilots.[22] [23] [24] [25] [18]

The Global Climate Change Impact Studies Centre (GCISC) is working on climate resilience, adaptation, and mitigation strategies. They've collaborated with international organizations like the Asian Development Bank (ADB) and the United Nations Environment Programme (UNEP) to develop Pakistan's NDCs. Some key initiatives include:

- 4RF Strategy: A comprehensive plan for flood recovery and systemic resilience, focusing on climate-responsive public investment and coordinated disaster governance.
- Resilient and Accessible Microfinance: A World Bank-funded project to enhance climate resilience in Pakistan's microfinance sector.
- Climate Risk Fund: A $125 million fund with liquidity and insurance mechanisms to support climate-vulnerable

communities.

However, several barriers hinder implementation, including:

- Lack of Coordination: Disjointed governance and unclear lines of coordination among federal, provincial, and local entities.
- Insufficient Funding: Limited budget allocation (around 1% of GDP) and reliance on international finance.
- Weak Institutional Capacity: Inadequate expertise and resources for effective policy execution.

Post-event assessments point to mixed effectiveness. The 2022 floods' PDNA explicitly notes that early-warning information did not always translate into timely evacuations and protective measures, contributing to the scale of human and economic losses. Policy reviews argue that disaster-management institutions remain under-resourced and fragmented, leading to slower-than-optimal recovery and prolonged GDP impacts after large shocks.

Climate-finance analyses suggest that Pakistan faces a significant adaptation-finance gap, with actual climate-related spending falling short of needs identified in national documents, which constrains scaling up of resilient infrastructure and social-protection schemes.[7] [8] [26] [27] [28][2] [9]

In summary, the policy architecture is conceptually aligned with resilience goals, but empirical evidence from recent disasters indicates that it has only partially mitigated economic losses, reducing but not preventing major growth shocks.[8] [2] [7]

Climate Resilient Punjab Vision Update; Under Chief Minister Punjab Maryam Nawaz Sharif's Climate Resilient Punjab Vision 2024, the Annual Development Programme (ADP) of the Environmental Protection Agency (EPA) and Climate Change has been finalized with effective measures for environmental protection, smog control, and climate governance. Work is progressing rapidly on 38 development schemes. After providing 5,000 super seeders on 60 percent subsidy this year, an additional 15,000 super seeders, 5,000 balers, and modern harvesters have also been included in the ADP to eliminate crop residue burning and reduce smog. 15 anti-smog guns have covered more than 47,000 kilometers so far, resulting in a 30 to 45 percent reduction in PM10 levels. Additionally, to strengthen smog control efforts, 30 modern fog cannons will be installed on electric trucks at a cost of PKR 3 billion, which will help reduce dust and air pollution in major urban and industrial areas. Before the next smog season in 2026 end, phased relocation of industries from Lahore, establishment of plastic-free zones across Punjab, and identification of pollution hotspots are underway. Similarly, a modern EV-1 system is being introduced for two- and three-wheelers to significantly reduce carbon emissions.

Punjab's first Climate Observatory in the region is being established, and the Punjab Climate Change Act and Observatory Act will be presented to the Cabinet within the next six months (by August 2026). In addition, the Lahore Air Improvement Framework is being launched at a cost of PKR 2.25 billion, under which the "One City, One Policy" approach and super stations will enable real-time identification of pollution sources. More than 50 modern air quality monitors have been installed across Punjab, and an automated quality assurance system has been implemented. Furthermore, 15 modern water quality monitoring stations have been activated on five rivers, monitoring 15 different parameters through telemetry.

Punjab Climate Watch and a real-time dashboard have been launched, enabling digital monitoring of the performance of 10 to 15 departments. Under the anti-plastic campaign, more than 461,000 kilograms of banned plastic bags have been confiscated, and over 36,000 citizens and institutions have pledged to avoid plastic use.

Punjab Green School Program has been expanded to 41 districts, with more than 18,000 schools registered. Work has also been completed on establishing a Low Emission Zone in Lahore and GIS-based mapping of emission hotspots. Progress is also underway on the indigenous emission trading system, green credits registry, green entrepreneurship, and green banking ecosystem. Approval of over PKR 6.45 billion has been granted for the upgradation of the Punjab Environmental Reference Laboratory and EPA laboratories, including modern equipment, forensic facilities, and specialized units for vehicle emission analysis. An allocation of PKR 700 million has been made for establishing the Environment & Climate Delivery Unit, which will monitor project performance through KPIs, digital dashboards, and modern monitoring systems. A modern regulatory framework is also being developed to ensure effective enforcement of environmental laws and pollution control.

An Environmental Museum and Eco-Amusement Park will be established in Lahore at a cost of PKR 1.5 billion to promote public awareness, eco-tourism, and green employment opportunities. Launch of PKR 500 million

biomass circular economy project aimed at eliminating crop residue burning and promoting alternative energy, which will significantly contribute to smog reduction.

5. Rural–Urban Differences in Economic Resilience

5.1 Rural economic resilience

Rural areas are more vulnerable due to:

- Dependence on Agriculture: 60% of rural households rely on agriculture, making them susceptible to climate-related crop failures and livestock losses.
- Limited Adaptive Capacity: Rural areas lack access to financial services, technology, and climate information, hindering adaptation.
- Poor Infrastructure: Inadequate roads, healthcare, and communication networks exacerbate climate impacts.

Rural areas in Pakistan face high exposure and limited adaptive capacity. Rural livelihoods are dominated by crop agriculture and livestock, which are directly exposed to floods, droughts, heatwaves, and salinity intrusion. People-centred field studies in rural Pakistan report that households experience significant income losses, rising indebtedness, and increased distress migration in response to climate events, with thin social-protection coverage.[6] [29] [5]

Climate change is expected to increase rural poverty rates, with projections suggesting 25-28% of rural populations living below the poverty line by 2050, compared to 10% in urban areas. Heatwaves are killing animals, reducing milk yields, and threatening household nutrition and income in southern Pakistan.

Empirical work on rainfall-growth linkages shows that provinces with more rain-fed agriculture, such as parts of Khyber Pakhtunkhwa and Balochistan, experience stronger growth slowdowns when precipitation falls below average, indicating lower economic resilience. Survey-based research on farm incomes similarly finds that higher temperatures and lower rainfall are associated with statistically significant declines in household agricultural income, highlighting the vulnerability of rural income to climate variability.[10] [1]

5.2 Urban economic resilience

In contrast, urban areas have:

- Diversified Economies: Urban sectors like manufacturing and services are less directly exposed to climate shocks.
- Better Infrastructure: Improved access to healthcare, finance, and technology enhances resilience.
- Higher Incomes: Urban households often have more savings and assets to buffer against disasters.

Large cities such as Karachi, Lahore, and Islamabad enjoy relatively better infrastructure, administrative capacity, and diversified economies, which can support faster post-disaster recovery. Urban-resilience studies note the emergence of city-level climate initiatives, including improved drainage projects, heat-action plans, and urban-planning reforms.[20] [30] [31] [32]

However, cities face concentrated climate risks. Urban flooding, exacerbated by inadequate drainage and unplanned settlements, has caused repeated disruptions to transport and commerce in Karachi and Lahore, with documented episodes of business closures and transport paralysis. Rapid rural-to-urban migration-partly driven by climate-related rural distress—has increased pressure on housing, water, and sanitation, reducing the effective resilience of many urban centers despite their stronger institutions.[21] [29] [30] [32] [20]

5.3 Implications for national GDP

Rural and urban resilience patterns combine to shape national GDP outcomes. Rural climate shocks reduce agricultural GDP and farm incomes, and they can push workers into lower-productivity informal urban jobs, thereby lowering average productivity. Urban shocks, in turn, disrupt high-value services, trade, and finance, generating large localized GDP losses that quickly transmit to the national level. The literature therefore supports the view that rural areas are more vulnerable in livelihood and welfare terms, while urban areas are institutionally stronger but under growing strain, creating a complex spatial pattern of resilience.[4] [30] [6] [18] [20] [1]

6. Data and Empirical Results

This section summarizes empirical findings from key studies that estimate the quantitative relationship between climate variables, disasters, and economic outcomes in Pakistan.

6.1 Climate variables and GDP growth

A time-series study for 1980–2017 uses real GDP, precipitation, temperature, industrial output, and investment to estimate the climate–growth nexus via ARDL-type models. Descriptive statistics from that study

show mean real economic growth at 7.39% (SD 1.94), with mean precipitation of 4.21 (SD 1.91) in log-transformed units, highlighting substantial climate variability over time.[1]

Regression results indicate that decreases in annual precipitation have a statistically significant negative impact on GDP per capita, with provinces like Punjab and Khyber Pakhtunkhwa showing stronger negative coefficients than others, reflecting their agricultural base. The authors conclude that lower rainfall reduces agricultural production, disrupts supply chains for agro-based industries, and ultimately slows aggregate economic growth.[1]

6.2 Temperature, precipitation, and agricultural output

A two-factor regression study on Pakistan's grain productivity finds that a 1% increase in average air temperature reduces productivity by about 6.19%, while a 1% increase in precipitation (beyond the average) reduces productivity by 0.59%, both statistically significant. These elasticities confirm that both excessive heat and abnormal rainfall patterns are harmful for crop yields, consistent with field evidence of heat stress, flooding, and water-logging.[3]

Complementary micro-level work on Pakistani farms shows that farm incomes decline significantly when temperatures rise and rainfall decreases, underscoring the income-channel through which climate variability affects rural welfare and aggregate demand.[10]

6.3 Disaster-event evidence: the 2022 floods

The 2022 floods provide a recent and well-documented case study. According to the PDNA, the floods caused: US$14.9 billion in damage, US$15.2 billion in economic losses, and GDP losses equivalent to about 2.2% of FY22 GDP, with agriculture projected to contract by 0.9% of GDP. Housing, agriculture and livestock, and transport and communications were the most affected sectors, with damages of US$5.6 billion, US$3.7 billion, and US$3.3 billion, respectively.[2][12]

Additional reporting notes that around 1.84 million acres of Punjab's farmland were devastated, including losses of approximately 60% of rice, 35% of cotton, and 30% of sugarcane in certain districts, implying substantial shocks to both domestic supply and export potential. These sectoral figures help explain the sharp slowdown in GDP growth in 2022–23.[19]

6.4 Long-term projections

A model-based assessment combining global climate, crop, and economic models estimates that climate-induced reductions in wheat and rice yields would cost Pakistan US$19.5 billion in real GDP by 2050, mainly through higher commodity prices and lower private consumption.

Macro-scenario analyses further warn that, without strong adaptation, climate change may reduce Pakistan's GDP by 18–20% by mid-century under high-emissions scenarios.[16][17][14]

These empirical results validate the paper's main claims: climate variability and disasters have statistically significant negative effects on GDP and sectoral outputs, both in event-years and cumulatively over time.

7. Discussion and Policy Implications

The empirical evidence shows that climate-induced natural disasters in Pakistan have significant short- and long-term negative effects on GDP, with agriculture-linked rural economies bearing the heaviest burden. Existing institutional frameworks such as the NCCP, NDCs, and NDMP-II provide a solid foundation for climate-resilience, but their effectiveness is constrained by weak implementation, fragmented institutions, and financing gaps, as demonstrated by the scale of losses in 2022.[12][7][8][9][2][3][1]

To strengthen GDP resilience, Pakistan needs:

- Targeted climate-resilient investment in agriculture (climate-smart farming, water-efficient irrigation, drought- and flood-resistant crop varieties) and infrastructure (drainage, roads, energy).[7][18][5]
- Enhanced rural income diversification and safety nets to reduce dependence on climate-sensitive agriculture and cushion rural households from shocks.[29][6]
- Stronger urban-climate governance, including upgraded flood-drainage systems, heat-action plans, and climate-resilient housing and transport policies, to protect cities' growing GDP share.[30][32][20]
- Better coordination across federal, provincial, and local agencies, along with more predictable climate-finance flows, to ensure that early-warning systems translate into early action and rapid recovery.[8][9][7]
- Decentralized Governance: Strengthening local institutions and community engagement.
- Climate-Smart Planning: Integrating climate resilience into development policies and budgets.

- Innovative Financing: Exploring green bonds, climate insurance, and public-private partnerships.
- Invest in climate resilience and adaptation measures, such as flood-proof infrastructure and climate-smart agriculture.
- Transition to renewable energy sources and promote sustainable practices.

8. Conclusion

Climate change and related natural disasters are already exerting measurable pressure on Pakistan's GDP through recurrent floods, droughts, and heatwaves. Experts stress an urgent need for coordinative strategy to avoid far-reaching impact of the climate changes on Pakistan, because it ranks among the top 10 most vulnerable countries in the world.

We live in what scientists described as the era of 'global boiling' record-breaking temperature accelerated glacial melt, intensified cyclones, and rising sea levels are no longer future projections—in fact these are unfolding realities. Climate change is no longer an environmental issue alone, it is a development, infrastructure and economic challenge, particularly for climate-vulnerable countries like Pakistan. Recent floods in Pakistan, heat waves, water stress and urban challenges clearly demonstrate that resilient infrastructure is critical to national stability and growth. Pakistan is on the frontline of the climate crisis and the main challenges are: water security, catastrophic floods, water scarcity, air pollution, urban smog, ecosystem degradation, deforestation, riverine erosion and critical threat to the Indus Delta.

Pakistan has already seen and experienced devastating climate change impact; especially the Northern Areas were badly hit by the floods which washed away many regions. Climate change is a global phenomenon. The water level of the rivers is rising which has far-reaching consequences, floods in Pakistan has become an increasing concern and there were rules about climate change tackling but they were not implemented in letter and spirit.

Empirical studies confirm that variation in rainfall and temperature significantly reduces GDP growth and agricultural productivity, while event-based assessments such as the 2022 PDNA quantify large, discrete losses to output and capital. These shocks disproportionately affect agriculture-dependent rural economies, while cities face growing strain from concentrated climate risks and migration-driven urbanization. Current institutional frameworks and policies are a step toward climate resilience but remain insufficiently implemented to fully insulate GDP from major shocks. A sustained, coordinated strategy combining rural-adaptation, urban-resilience, and strengthened governance is essential to limit the long-term GDP-fallout from climate change in Pakistan.[14] [4] [6] [9] [18] [20] [30] [2] [3] [12] [5] [7] [8] [1]

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