From Apathy to Action

Building Resilience in Pakistan's Agriculture

Acumen

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Contents

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Remarks from Country Director

This has been a hot summer – and things are getting worse. Pakistan remains on the frontlines of the climate emergency, regularly experiencing its consequences with devastating impact on the most vulnerable. The need for urgent action is imperative – and nowhere is this more apparent than in the critical agriculture sector that continues to suffer brutal climate impacts on an already fragile and fragmented ecosystem. There are serious challenges ahead, but it is our belief that social entrepreneurs and builders will play a crucial role in solving them.

At Acumen we believe that entrepreneurship holds the key to unlocking the agriculture sector's full potential. We invest Patient Capital in exceptional entrepreneurs whose companies' goods and services go where they are most needed, solving some of the most challenging problems around the world - off-grid energy, microfinance, resilient agriculture, and dignified work. To date, we have invested $168 million in 193 companies across seven regions, and impacted the lives of almost 650 million people across our work in Patient Capital and funds as of 31st December 2023, excluding Acumen Academy.

With over 20 years on the ground in Pakistan, Acumen has spent significant time understanding the market, learning from entrepreneurs, farmers, corporates, and the public sector. We've listened to their stories, understood their challenges, and witnessed their resilience firsthand. This deep connection to the land and its people allows us to offer insights and recommendations that are not just theoretical but are grounded in the experiences of those most affected by climate change. Building resilience in Pakistan's agriculture sector requires a concerted effort from all stakeholders. By prioritizing climate adaptation, investing in innovative solutions, and addressing structural challenges, Pakistan can safeguard its food security, protect livelihoods, and ensure a sustainable future for its agricultural sector in the face of climate change.

We believe that investing in agribusinesses is a crucial step towards achieving this. By providing companies with the necessary capital and support, we can unlock their potential to drive innovation, implement climate-smart practices, and create a ripple effect throughout the value chain. This approach not only strengthens the resilience of farmers and communities but also fosters a thriving private sector that can attract further investment, create jobs, and contribute to sustainable economic growth.

We invite you to explore this report and join us in advocating for a future where Pakistan's agriculture sector not only adapts to the challenges of climate change but emerges stronger and more sustainable. As Pakistan becomes increasingly climate vulnerable, it is critical that we bridge the realities on the ground and the potential for transformative change.

Dr Ayesha Khan
Country Director, Acumen Pakistan

1. Executive Summary

Pakistan's agriculture sector, a cornerstone of its economy and food security, faces an existential threat from climate change. Contributing 24% to GDP and employing half the workforce, the sector's productivity lags behind global standards. Climate change is compounding these existing structural challenges, creating a perfect storm for the sector. Pakistan's vulnerability to climate change is stark. Ranked in the top 10 most vulnerable countries, it faces rising temperatures, unpredictable rainfall, and devastating extreme weather events. The escalating frequency of heatwaves and floods contributes to a rise in waterborne and heat-related illnesses, jeopardizing public health. Moreover, unpredictable rainfall and temperature spikes are impairing crop yields, threatening both food security and the availability of water for agricultural and human consumption. The 2022 floods alone caused over USD 30 billion in economic losses, underscoring the urgent need for climate resilience. These events disrupt agricultural production, increase food insecurity, and exacerbate poverty.

Agriculture is poised to face disproportionate impacts. Crop yields for staples like wheat and rice are already lower than regional averages and are expected to be further strained due to climate change (losses reached 30% for wheat and 600,000 acres of rice due to extreme weather events in 2022). The water crisis is escalating, with per capita water availability plummeting to a critical 1,017 cubic meters in 2021. Climate change is amplifying existing vulnerabilities, such as low productivity (already 30-50% lower than global averages) and fragmentation in the agriculture value chain. These multifaceted challenges highlight the urgent need for comprehensive climate resilience and adaptive strategies across the agriculture sector.

Innovative agribusinesses are emerging, offering locally relevant solutions to build resilience. High-potential business models are addressing key challenges across the value chain:

i. Farmer-focused solutions: improved input efficiency, information access, and financial services targeting smallholder farmers who are on the frontlines of climate change

ii. Smart farming: optimization of on-farm productivity and promotion of climate-resilient practices to improve yields and build resilience at the farm level

iii. Post-harvest storage and logistics: reducing food loss, providing efficient storage solutions and enhancing value addition. Includes end to end climate-resilient value chains.

However, these businesses face significant barriers to scaling. One of the major obstacles hindering their growth is the limited access to patient equity financing. The total assets under management (AUM) of private equity and venture capital funds in Pakistan is a mere USD 600 million compared to over USD 126 billion in India, highlighting the substantial financing gap. In addition, private credit to the agriculture sector remains bound between 6-9% on average annually. This lack of capital limits the ability of businesses to invest in expansion, innovation, and working capital. Many agribusinesses lack the expertise and capacity to scale their ventures as they are family-run businesses with informal practices and limited access to talent and operational support. This lack of professional management can hinder their ability to make strategic decisions, manage risks, and attract investment. The regulatory context also poses significant challenges for agribusinesses. The absence of tax incentives, complex regulations, and a challenging investment climate can discourage entrepreneurs and investors, creating a difficult operating environment.

Efforts to scale climate solutions face many hurdles, but this report focuses on three key areas where targeted interventions can unlock significant progress. These recommendations focus on overcoming barriers related to access to financing, expertise, and regulatory support:

- Develop and support high-quality, bankable projects that can attract investment and leverage climate finance efficiently.
- Engage experienced climate investors, corporates, and experts to provide technical support and enable technology transfer to local climate solutions.
- Develop a supportive regulatory context to build and scale high-priority climate solutions.

By providing these enterprises with the necessary capital and support, we can unlock their potential to drive innovation, implement climate-smart practices, and create a ripple effect throughout the value chain. This approach not only strengthens the resilience of farmers and communities, but also fosters a thriving private sector that can attract further investment, create jobs, and contribute to sustainable economic growth.

Pakistan's agricultural sector stands at a critical juncture. The challenges are immense, but so are the opportunities. By embracing innovation, investing in resilience, and fostering collaboration, Pakistan can build a sustainable and prosperous agricultural future, ensuring food security and economic growth for generations to come.

2. The Climate Crisis

2.1. Where are we now?

The summer of 2024 is a hot one – the hottest one yet. In fact, every month since June 2023 has ranked as the planet's hottest since records began in 1850, with the ten warmest years occurring during the last decade (2014–2023). Over that same decade Pakistan also began to consistently rank in the top 10 most vulnerable countries to climate change. This is no surprise to anyone who lives here, as 2023 was the hottest year on record where global average temperatures breached the critical 1.5°C warming benchmark every single month. Some of the highest temperatures in the world were recorded in Sindh in Jacobabad and Dadu (51°C) and are classified as too high for the human body to withstand.

Things have been challenging before. As Pakistan continues to struggle with the aftermath of the catastrophic flooding of 2022 (see Annex A for more details) while navigating a plethora of social, political and economic crises, it seems likely that things will get worse. Already this year has been marked with extreme temperatures and flooding. Since February 2024, flooding has affected various regions across the country, including Sindh, Balochistan, Khyber Pakhtunkhwa, and Gilgit-Baltistan. In addition to loss of life and injuries, the flooding caused widespread destruction, disrupting normal life and damaging infrastructure, and led to the government declaring a state of emergency in several areas.

This was not always the case. Historically, in South Asia, the summer monsoons were largely well-organized and predictable. In one of the more fertile agricultural regions in the world, the rainy season was welcomed as it brought much needed water for the summer crops and temperate weather, a key reason why the Indus Valley civilization, among other ancient settlements, prospered in this region. Fast forward to recent times, and the monsoon season is no longer welcomed. Rather, it needs to be confronted with fortified defenses - which is why this year, for the very first time, Pakistan developed an inter-agency National Monsoon Contingency Plan to manage the impacts of severe rainfall events and associated flooding at a national level.[1] The Plan is in place to manage the disaster response and particularly mentions prioritizing vulnerable regions where communities are still displaced, residing in flood damaged homes and vulnerable from the 2022 floods.

As Pakistanis struggle to deal with scorching heat, water scarcity and unpredictable floods, the climate crisis we feared no longer seems to be around the corner, but is happening now for Pakistan. And in that light, it is imperative and urgent to develop effective, multifaceted and comprehensive climate resilience.

2.2. Climate change as an existential threat

Pakistan is on the frontlines of climate change. The nation faces rising temperatures, unpredictable rainfall, droughts, landslides, and devastating extreme weather events like the 2022 floods, which caused over USD 30 billion in economic losses. By the end of the 21st century, under the worst greenhouse gas (GHG) emissions scenario, Pakistan is projected to warm by 5.3°C which is 20% higher than the global average of 4.4°C. Similarly, Pakistan is expected to face an increase in rainfall of 26.4% as compared to the South Asia average of 25.1%. Higher temperatures and precipitation will increase the frequency and intensity of extreme weather events such as floods, droughts, heatwaves and Glacial Lake and Outburst Floods (GLOFs), causing infrastructure damage and loss of life. Increasing temperatures will also increase the pace of glacial melting which will significantly impact the availability of water for the Indus River Basin System, responsible for 90% of Pakistan's agricultural output and 24% of its GDP.[2]

What is climate change?

Climate change refers to the long-term changes in the Earth's climate that are warming the atmosphere, ocean and land. Since the Industrial Revolution in the 1800s, human activities have caused the Earth's average temperature to increase by about 1.2°C – with more than two-thirds of this warming occurring from 1975 onwards. This is already causing significant damage to human societies and natural ecosystems due to extreme weather events, such as more intense and/or frequent hurricanes, floods, heat waves, and droughts, and leading to sea level rise and coastal erosion as a result of ocean warming, melting of glaciers, and loss of ice sheets.

What is mitigation and adaptation?

Climate mitigation refers to any action taken by governments, businesses, or people to reduce or prevent greenhouse gas emissions. Mitigation efforts can include transitioning to renewable energy sources like wind and solar, using energy more efficiently, adopting low carbon or carbon-free transportation such as electric vehicles, and promoting sustainable agriculture and land use.

Climate adaptation refers to actions that help reduce vulnerability to the current or expected impacts of climate change like weather extremes and hazards, sea-level rise, biodiversity loss, or food and water insecurity. Even in very positive scenarios in which we manage to significantly and swiftly cut greenhouse gas emissions, climate change will continue to impact our world for decades to come because of the energy already trapped in the system. This means widespread adaptation is needed to limit these impacts and safeguard people and nature. Adaptation measures include planting crop varieties that are more resistant to drought and practicing regenerative agriculture, improving water storage and use, managing land to reduce wildfire risks, and building stronger defenses against extreme weather like floods and heat waves.[3]

Why is adaptation important?

Carbon dioxide, the heat-trapping greenhouse gas that is the primary driver of recent global warming, lingers in the atmosphere for many thousands of years, and the planet (especially the ocean) takes a while to respond to warming. So even if we stopped emitting all greenhouse gasses today, global warming and climate change will continue to affect future generations. In this way, humanity is "locked in" to some level of climate change.

Because of this, responding to climate change must involve a two-pronged approach:

1. **Mitigating emissions** and stabilize the levels of heat-trapping greenhouse gasses in the atmosphere ("mitigation")

2. **Adapting to the climate change** already in the pipeline ("adaptation")

Nearly 80% of climate financing in Pakistan is focused on mitigation projects.[4] Given the country's existing vulnerabilities to climate disasters, there is an urgent need to invest in adaptation projects due to the high cost of inaction as seen in the scale of the damages in the 2022 floods.

Beyond the devastating 2022 floods, Pakistan suffered at least three additional extreme weather events in 2023 alone, including Biparjoy Cyclone, the first cyclonic storm to originate in the Arabian Sea. As the country simultaneously struggles with various macro-economic challenges and the burden of a growing population, Pakistan will lose up to six percent of its GDP even under the current climate change scenario.[5] Despite accounting for less than one percent of global GHG emissions, Pakistan has already sustained climate related damage worth billions of dollars - and as is the case with most catastrophes, those who are most economically vulnerable suffer disproportionately.

Without robust adaptation and mitigation strategies, climate change will severely impede Pakistan's already unsteady developmental trajectory. Pakistan faces the concurrent challenges of providing basic socio-economic support for its growing population while struggling with national debt and a devaluing currency. Pakistan faces many economic pressures - the country has a large budget deficit, suffers from a circular debt problem and has been in 22 International Monetary Fund (IMF) programs, most recently in 2023. Due to challenging macroeconomic conditions, the Pakistani PKR lost nearly 60% of its value against the dollar since 2022 and inflation rose to a five-decade high. In addition, exogenous shocks such as the COVID-19 pandemic, global conflicts, and natural disasters worsen the situation. The mounting burden of billions of dollars in damages from climate change (USD 30 billion from the 2022 floods alone) further reduces fiscal space to invest in adaptation capacity.

Climate change acts as a risk multiplier across all sectors. At the macroeconomic scale, the domino effect of global warming will dampen GDP forecasts. Intensified and frequent extreme weather events and crop and livestock losses will heighten the threat of poverty, food insecurity, and malnutrition among the most vulnerable populations. Extreme temperatures can lead to the potential uninhabitability of regions and result in surges in migration. In the worst-case scenario, Pakistan's GDP growth could be slashed by 20% by 2050 due to climate-related damages like floods, heatwaves, and reduced agricultural productivity. Even under the best-case scenario, GDP growth is expected to remain constrained.

If global warming continues unabated, the accompanying climate change impacts for developing, agrarian economies like Pakistan will be catastrophic.

By 2050, Pakistan's GDP growth could be slashed by

20%

2.3. Climate impacts – Pakistan's high risk context

Extreme temperatures and heatwaves

Pakistan has some of the highest observed temperatures in Asia. Warming trends in Pakistan are projected to outpace those of any other South Asian country by the end of the century. In the worst-case emissions scenario, Pakistan's warming could reach a staggering 5.3°C, notably higher than the global average of 4.4°C. This rapid rise in surface temperatures escalates the risk of heatwaves, posing a significant threat to Pakistan's agriculture-based economy.

Over the past five decades, Pakistan has grappled with increasingly severe heat waves, often surpassing 50°C. Even during relatively normal years, temperatures in most regions persist above 30°C for extended periods, with maximum temperatures frequently exceeding 40°C. These extreme heat events endanger human health and strain infrastructure. The 2022 heatwave marked Pakistan's hottest March since 1901, with temperatures soaring above 50°C in some areas, leading to water shortages, loss of life, and extensive damage to crops and livestock.

Temperatures surpassing

↑ 50°C

Floods

Over the next 25 years Pakistan will experience a doubling in flood risk. The most affected regions will be Punjab and Sindh, where millions of people are likely to be impacted. In the case of the Indus River System, increasing temperature trends in the future will lead to accelerated snow and ice melting increasing the frequency and intensity of floods.

Since 1999, flooding has become the most common climate hazard faced by Pakistan (68% of all severe weather events have been floods). Since 1991, over 84 severe flood events have occurred, affecting over 65 million people.[6] The country has already faced three major flood events over the last 20 years which were ruinous for the economy. In 2022, changing weather patterns led to unprecedented levels of rainfall which devastated the agriculture sector in particular by destroying key agricultural inputs and infrastructure, leading to USD 30 billion in estimated damages from one event.

USD 30 billion

in estimated damages from one event

Droughts

By the end of the 21st century, Pakistan faces a 75% increase in the severity of droughts and a 65% increase in the duration of droughts. Regions in Southern Pakistan are predicted to experience the highest incidence of droughts. The probability of an extreme drought which is a one in 100-year event will increase to 1 in 20 years according to current projections.[7]

↑ 75%

in severity of droughts

Droughts severely affect food security and frequently require humanitarian relief efforts in vulnerable districts throughout the country. In January 2019, during one drought event three million people in Sindh and 1.8 million in Balochistan were impacted by moderate to severe droughts when annual precipitation dropped by 24% relative to the expected rainfall. Droughts are expected to increase in both frequency and severity in all the provinces of Pakistan.[8]

2.4. Socio-economic impacts of climate risks

Economy

Over the last three decades (1992-2021), the country suffered USD 29.3 billion in economic losses due to climate-related disasters, not including three major flooding events. The total cost of this damage adds up to 11.1% of the country's GDP in 2021. The 2022 floods alone caused damages of nearly USD 30 billion which is equivalent to eight percent of GDP, underscoring the significant burden these events have placed on the nation's economy. The cost of adapting and making the economy resilient to worsening climate impacts is massive and beyond Pakistan's ability to absorb. Pakistan's adaptation needs are conservatively estimated at USD 7-14 billion and are set to rise with the World Bank estimating that Pakistan will need USD 348 billion between 2023 and 2030 to climate-proof its development trajectory.

Figure 1 underscores the threat Pakistan faces from climate change. It shows a regional comparison of annual average losses as a percentage of GDP in three climate scenarios. In the worst-case scenario, Pakistan can lose up to nine percent of its GDP which is the highest in the region.[9]

Health and food security

Over the past decade, Pakistan has experienced numerous natural disasters and climate impacts, all of which have led to significant loss of life, displacement of communities and public health impacts. The 2010 and 2022 floods serve as stark examples, which cumulatively affected nearly 50 million people. These events strain healthcare systems, disrupt emergency services, and create long-term challenges in disaster recovery and management. There will be approximately 9.32 climate-related deaths per million population per year linked to a lack of food availability in Pakistan by the year 2050 under a high emissions scenario.[11] These deaths will be driven due to a lack of fruit and vegetables in diets and health complications caused by the increasing prevalence of undernourishment. Changes in rice and wheat productions brought about by climate change are also anticipated to engender wild price volatilities in the markets.

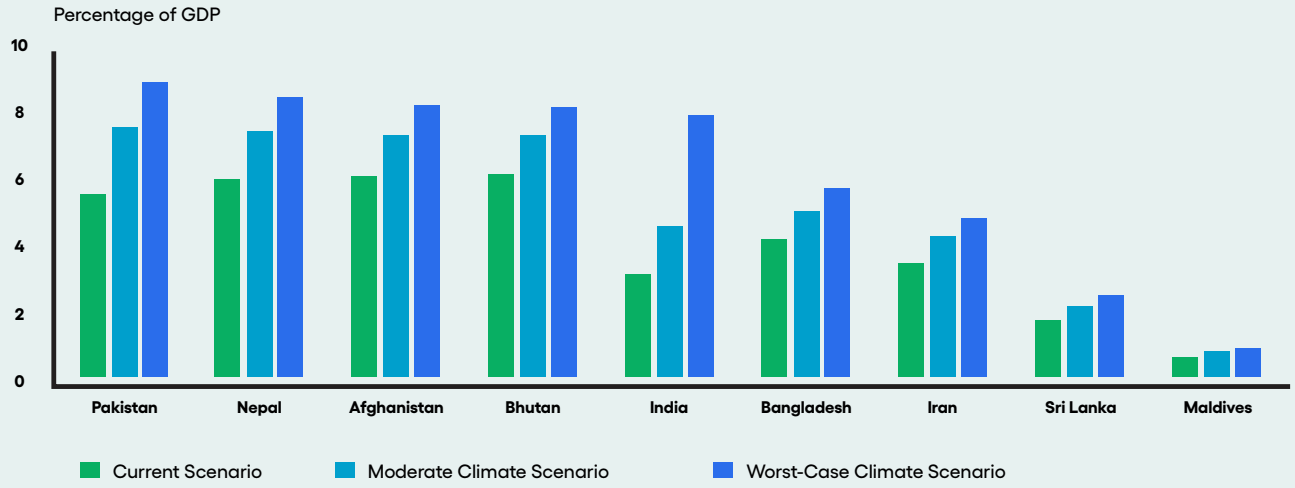

Figure 1: Annual Average losses as a Percentage of GDP[10]
Source: United Nations Economic and Social Commission for Asia and the Pacific

Nearly 26 billion potential labor hours were lost due to heat exposure in 2022, costing Pakistan nearly USD 16 billion in potential income, equivalent to 4.4% of GDP.[12] High temperatures reduce the capacity for physical labor, impacting agricultural productivity and outdoor work, sectors that employ a large portion of the population such as agricultural workers, who were hit the hardest, losing 56% of their potential income in 2022. The resultant heat stress not only diminishes worker productivity but also increases the risk of heat-related illnesses, such as heatstroke and dehydration, which can be fatal.

26 billion

potential labor hours were lost due to heat exposure in 2022

Air pollution is a longstanding health concern in Pakistan, and climate change is exacerbating the problem. Heatwaves trap pollutants closer to the ground, leading to smog and worsening air quality. This rise in air pollution is linked to an increase in respiratory illnesses like asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). Studies suggest a rise in asthma prevalence, particularly among children.[13]

The increase in average temperatures and variability in rainfall has led to a rise in vector-borne diseases such as malaria and dengue fever.[14] Moreover, the frequency of waterborne diseases such as cholera is escalating in the wake of flooding and heavy rains, which often result in contaminated water sources. Data shows a rise in dengue fever cases in recent years, with Karachi experiencing a particularly severe outbreak in 2022. These changes necessitate enhanced public health strategies that include better disease surveillance and control measures, increased public health education, and strengthened healthcare infrastructure to manage the rising tide of climate-related illnesses.

Infrastructure and transportation

Pakistan's infrastructure, already strained by a growing population and limited resources, faces a significant and growing threat from climate change. Infrastructure damage to transport networks, energy generation and distribution, and urban infrastructure systems will worsen as climate impacts increase. The 2022 floods alone resulted in massive infrastructure damage where over 8,000 kilometers of roads and 394 bridges were destroyed or severely damaged, hindering transportation and emergency response efforts. Peak summer electricity demand in Pakistan often exceeds generation capacity and heatwaves further exacerbate this problem. World Bank projections suggest that peak demand could increase by 40% by 2050 due to rising temperatures and increased reliance on air conditioning, putting immense strain on the already stressed power grid.[15]

In low and middle-income countries globally, the direct losses to companies on account of transportation disruption are about USD 107 billion per year.[16] Sea level rise in addition to storm surge during extreme weather events can also increase the frequency and magnitude of floods in coastal areas, such as Karachi, which can lead to serious damage to coastal transportation infrastructure.[17] Primary cities also stand out in terms of risk exposure to infrastructure damage. Lahore and Karachi have the largest settlement areas exposed to riverine and flash flooding from severe rainfall events in Pakistan.[18] These vulnerabilities are compounded by low quality infrastructure which is unable to withstand the severity of heavy rainfall. These cities host an increasing influx of migrants, who tend to settle where land is cheap but also disaster-prone, increasing their exposure to risks and shocks.

In low and middle-income countries globally, the direct losses to companies on account of transportation disruption are about

USD 107 billion

Climate change hits vulnerable groups hardest.

Women are highly vulnerable to climate change impacts, particularly rural women engaged in the agriculture sector. A recent ranking on a climate-agriculture-gender inequality hotspot index shows that Pakistan is ranked number one in Asia.[19] Women and young girls have the fewest resources or agency during climate stress, and the heaviest burdens to bear. Women across the world give up their share of food to family members in a poor harvest thereby showing higher signs of malnutrition; their distances carrying fuelwood and water become longer and perilous; basic health facilities are out of reach when roads are swept away in floods or snowed under; their children die from preventable diseases due to a lack of sanitation and hygiene.[20]

Climate-induced migration and declines in crop production are likely to affect women disproportionately, given their high socioeconomic vulnerability in rural Pakistan.[21] Most data in Pakistan indicate that while male members of poor farmer households out-migrate to add to family incomes, female household members left behind are often forced to undertake additional roles that traditionally resided with men. Future climate extremes such as heatwaves are thus likely to affect women in terms of (i) their traditional household chores (like securing water and energy supplies); (ii) the additional male-dominated tasks they acquire, such as farming, of which they may hold limited traditional knowledge; and (iii) their overall well-being, as their existing socioeconomic vulnerabilities may be exacerbated during climate shocks (e.g. due to low education status, lack of job opportunities, and limited mobility).[22]

Indigenous communities are also particularly vulnerable to the adverse impacts of climate change in Pakistan. Changes in weather patterns, extreme events, and environmental degradation directly affect their agricultural practices and traditional livelihoods, leading to food insecurity, displacement, and heightened socio-economic challenges. For example in the district of Tharparkar, Sindh there has been a marked decrease in rainfall, rise in temperature, and an increase in the frequency of climate extreme events such as droughts. During droughts, a large portion of livestock owned by indigenous communities (such as Dhaat, Vango, Samroti, Parker, Kantho) die due to high temperatures as well as food and water scarcity. These communities lose a substantial portion of their earnings as they generate up to 80% of their income through animal husbandry. This not only decreases their ability to recover from climate events, but also reduces their capacity to preemptively respond to climate extreme events and adapt their agricultural practices to climate change. Furthermore, changing rainfall patterns are also altering the migratory patterns of these communities who are now forced to migrate more frequently to barrage areas where fresh water is available.

Agriculture

The most significant impact of climate change will be on the agriculture sector, likely causing Pakistan's GDP to contract by nearly 4.6%. Given that nearly two-thirds of the rural population is engaged in agriculture, climate change will have a huge impact on rural livelihoods and will significantly impact each stage of the agriculture value chain. Smallholder farmers are the most vulnerable as they do not have the capacity to adapt to the effects of climate risks on yields and any impact on their production will have significant consequences for the country's nutrition and food supply. With an already fragmented value chain, the physical and economic challenges created because of climate variability will worsen food security and health outcomes at a national level.

In conclusion, climate change poses a dire threat to Pakistan's future. From jeopardizing economic well-being to disrupting agricultural production, the cascading effects of extreme weather events will have severe social and economic consequences. Currently, Pakistan is limited in its capacity to adapt and urgent action is needed on multiple fronts: investing in climate-resilient infrastructure, developing adaptation capacity in its vulnerable agriculture sector, and investing in bankable solutions suited to Pakistan's unique local context.

3. Harvests Under Threat: Climate's Impact on Agriculture

3.1. Climate impacts on agriculture sector

Agriculture is widely regarded as the mainstay of Pakistan's economy and is fundamental to food security for its large and growing population. Presently, the sector contributes 24% to the national GDP and provides employment for 37.4% of the country's labor force.[23] Demographically, slightly less than two-thirds of the population lives in rural areas, and more than 65-70% of them are either directly or indirectly dependent on agriculture for their livelihoods, and it is the main income source for 34% and 74% of economically active men and women in Pakistan, respectively.[24] In addition, it supplies key inputs to the country's manufacturing sector and contributes to over 75% of export revenues through agri-based textiles and value-added food products.[25, 26]

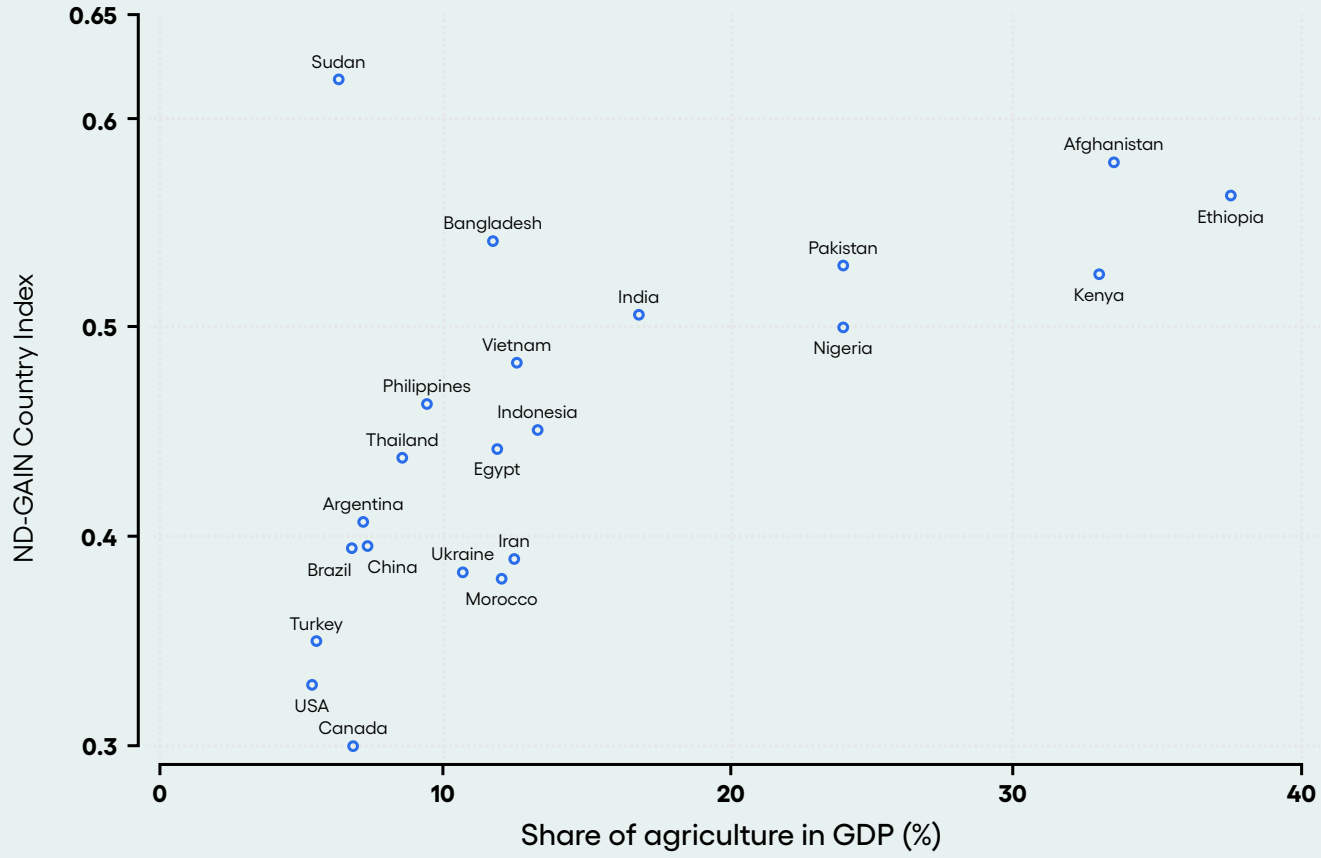

Figure 2. Climate vulnerability (according to ND-GAIN Index score) for 23 agrarian economies [27]
Source: ND-GAIN Country Index, University of Notre Dame

There is significant research on how climate change disproportionately impacts the agriculture sector.[28] Climate change impacts such as extreme temperatures, severe weather events, floods, and shifting rainfall patterns decrease yields and farmer incomes, exacerbate food loss and waste, and alter weather patterns that have been established for centuries. The ND-GAIN Country Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. As seen in *Figure 2*, this underscores Pakistan's significant vulnerability to climate change, even among similarly vulnerable agrarian nations. Compounding the problem, Pakistan's agricultural sector already faces challenges, with yields for dairy, wheat, rice, and other crops averaging 20-40% lower than global averages. Given the sector's critical importance for economic growth and food security, this can increase Pakistan's import dependence in order to ensure adequate food for its population, increase poverty and reduce the productivity of an already under-productive sector.

Table 1 summarizes the impact of climate change on the agriculture sector. Climate change impacts the sector in multiple ways, and compounds the existing issues of inefficiency, low productivity, outdated cultivation methods, fragmentation, etc. The direct effects of climate change manifest as changes in temperature and precipitation patterns. The indirect effects include unexpected and extreme changes in water availability and seasonality, soil erosion, increased occurrences of pests and diseases and the arrival of invasive species.[29]

Table 1. Impact of climate change at each stage of the agriculture value chain

Climate Change Hazards	Impact on Agriculture			
	Production and Harvest	**Processing and Storage**	**Logistics and Retail**	**Pakistan's Context**
High Temperatures and Heat Waves	**Reduced crop yields:** The yield for basmati rice, Pakistan's second largest export, falls by 7.2% for every 10% rise in temperature [30] **Reduced milk, meat quantity and animal fertility:** Heat stress can reduce milk production between 14%-35% [31] **Increase in animal mortality:** The direct effects of high temperatures on livestock health include metabolic disruptions, oxidative stress and immune suppression leading to infections and death [32] **Infrastructure damage and unfavorable driving conditions:** Disruption is caused to farming input supply chains, creating inconsistency of access	**Spread of pests and diseases:** Increasing temperatures can encourage the incidence of pests such as the khapra beetle. Infestations of khapra beetle cost Pakistan cumulatively USD 1B in rice exports between 2011-2014 [33] **Food spoilage:** A 2°C-3°C rise in temperature will likely reduce chilled storage life by half [34]	**Changes in weather can influence consumer behavior:** Warmer temperatures tend to increase beverage sales **Infrastructure damage and unfavorable driving conditions:** Extreme temperatures create unfavorable driving conditions for food carriers and cause damage to road infrastructure	**The 2022 heatwave led to:** • Wide-scale damages to wheat harvest leading to an estimated shortfall of 3M metric tons [35] • 50% reduction in mango yields [36] • 10-30% increase in water demand for crops • Death of up to 200 animals due to the extreme heat in Cholistan Desert, Punjab • 62M hectares, out of 79.6M hectares of land, presently vulnerable to desertification [37]
Heavy Rains and Flooding	**Increase in crop and livestock damage:** Heavy rains and floods can devastate crops due to waterlogging, erosion, and loss of soil fertility, while livestock suffer from habitat destruction and increased disease **Harvest delays:** Flooding causes soil waterlogging which promotes nitrogen loss. This causes harvest delays and reduces crop productivity [38]	**Supply chain disruptions:** Floods can significantly increase the cost of doing business. Headline inflation increased by two percent following the 2010 floods in Pakistan [39] **Damage to buildings, machinery and finished products:** The 2022 floods resulted in a USD 5.3B economic loss for SMEs with nearly 40% operating in the agriculture sector [40]	**Infrastructure damage, unfavorable driving conditions and lack of access to markets:** The 2022 floods damaged 13,000 km of roads and 410 bridges causing significant disruption to transport and people's ability to access markets [41]	**The 2022 Floods led to:** [42] • ~USD 3.7B in losses to the agricultural sector (food, livestock, fisheries) • Loss of 13.3M tons in the production of major crops • Death of 1.2M livestock • Inundation of 2M acres of cultivated land
Droughts	**Reduced crop yields:** Between 2011-2014 farmers in Balochistan, affected by droughts, suffered yield losses of 50%-80% [43] **Drought stress on animals:** Average livestock losses due to drought in Balochistan are 37% [44] **Soil degradation:** Topsoils, due to drought, can become highly vulnerable to erosion. 90% of the total soil loss, in a 20-30 year cycle, can be due to drought breaking rain [45]	**Reduced access to rainfed and groundwater resources:** The severe drought in 2001-2002 resulted in water shortages up to 51% of normal supplies	**Decrease in food supply:** For net food importing countries, such as Pakistan, a drought can cause a 10%-20% decline in food supply [46] **Increase in prices:** Regions in Pakistan, affected by drought, have experienced food price increases of up to 65% [47]	• Across Pakistan, agriculture is facing water shortages of up to 50% [48] **The 2015-2017 drought led to:** [49] • 53% reduced crop harvest • 48% decreased livestock output

Source: Food and Agriculture Organization of the United Nations [50]

As shown above, the physical and economic challenges created because of climate variability not only affect farmer livelihoods and rural economics, but also worsen food security and health outcomes at a national level. The extent of the impact will depend on the geographic area, the types of food commodities and the degree of exposure and vulnerability of actors and infrastructure along the value chain.[51]

3.2. Significant, pre-existing agriculture sector issues

Pakistan's agriculture sector suffers from systemic problems that have exacerbated its vulnerability to global warming. The agriculture sector has struggled to achieve significant growth at scale - even as Pakistan's GDP grew at a rate of 4.1%, between 2001 and 2021, the agriculture sector was only able to grow at an average rate of 2.5% during the same period.[52] This can be attributed to various structural and socioeconomic factors as well as climate change which is magnifying the pre-existing vulnerability of farmers in Pakistan.

The agriculture sector in Pakistan, like many other developing countries, remains fragmented, inefficient, and highly climate vulnerable. The country's agriculture production depends largely on archaic farming methods that have left farmers increasingly vulnerable to factors outside their control (unpredictable weather patterns, disease outbreaks, pricing uncertainty, etc.). Owing to these structural inefficiencies, Pakistan's agricultural productivity is approximately 30%-50% lower than world averages for major commodities like wheat, cottonseed, and rice. Agriculture productivity levels are a further 30% lower than these averages for small farmers, who account for 90% of the total farming population and about half the country's total cultivated land.[53] To compare, even though Pakistan is the 8th largest producer of wheat worldwide, its yield per hectare is 2.9 tonnes - 72% lower than the yield in Ireland, the 60th largest producer of wheat.[54]

Farmers are the most vulnerable as they struggle to manage existing, structural issues. They suffer from a lack of information on topics ranging from seed quality to modern farm management techniques specific to location (geography, soil conditions, etc.) and crop type. This results in lower yields and higher losses at the harvest stage. For example, eight percent of the potatoes produced in Pakistan are lost at the farm level, the majority of which are lost because of mechanical damage that occurs during harvesting due to inadequate training.[55] Furthermore, limited farm-to-market connectivity and poor agriculture marketing systems necessitate farmers to sell their produce at lower prices to local agents, preventing them from accessing high value markets. There is also a limited availability of weather advisory services that enable farmers to prevent losses during the production or harvest stages due to extreme weather events. Due to the negative impact of increased weather variability on yields and subsequent income, it is harder for farmers to invest in ex-ante adaptation solutions.

In addition to inefficient production, Pakistan's agriculture value chains are extremely fragmented. There are multiple middlemen (traders, commission agents, wholesalers, distributors, and retailers), each of whom takes a sizable portion of the final retail price. To illustrate, a farmer's share of the retail price of rice in Pakistan is only 35%, whereas farmers in India and Bangladesh capture approximately two thirds of the final price.[56, 57] Value chain fragmentation impacts farmer incomes and productivity, increases the cost of delivery for value added activities, raises the market price for consumers, and further increases food losses for farmers.[58]

Climate crisis: farmers pay the price

Farmers are the most vulnerable as they are less able to prevent and adapt to climate risks that affect production and yields. Due to their location in the value chain, any impact on farmer activity will inevitably affect all actors further down the agrifood value chain, be it in terms of reduced quantity or quality of product.[59] For instance, storage–processing–transportation facilities that rely on the supply chain of a single food commodity will suffer significant revenue losses if climate hazards impact a specific agricultural product, as they often have little flexibility to shift to other activities.[60]

Farmers often bear the economic brunt of these disruptions due to price and demand fluctuations that are passed along to them.

Farmers take on almost all the risk, but are afforded very little reward. Hence for foods crops with few substitutes, long growing periods, and limited actors, the network interdependency significantly raises the impact of climate hazards throughout the chain.

Beyond simply impacting production, extreme weather events also disrupt food distribution and market access by slowing food shipments and damaging infrastructure, increasing the risks of damaged, spoiled or contaminated produce. This, in turn, will have an effect on incomes and livelihoods, undermining the performance of the value chain as a whole.

3.3. Climate change will amplify vulnerabilities

Increasing food insecurity and food imports

The country is ranked 84 out of 113 countries in the Global Food Security Index.[61] Approximately 90 million people are already food insecure and the number of stunted children under the age of five stands at 38%. As an agrarian country, it is particularly vulnerable to climate variability and extreme weather events, such as floods and droughts, which disrupt crop cycles and reduce yields. Erratic rainfall patterns and prolonged dry spells lead to water scarcity, affecting irrigation systems and diminishing agricultural productivity. A climate-vulnerable agriculture sector that is unable to produce enough affordable food for a growing population will further push the population into increasing risks of food insecurity and malnutrition. Food security is a rising concern for Pakistan, given the 2022 catastrophic weather events and their impact on the yields of staple crops such as wheat (up to 15% of the total crop lost in the heatwave in spring 2022) and rice (over 600,000 acres lost in the 2022 floods).

The agriculture sector's low productivity and yields, Pakistan's rapidly growing population, post-harvest food losses, and climate change have left the government unable to meet local food demand. In order to meet domestic consumption requirements, the government is forced to import food products to address the shortfall. This is demonstrated by the rising share of staple foods in Pakistan's import receipts which has steadily increased over the last five years. Importing food has a negative effect on Pakistan's balance of payments. It also has the effect of exposing vulnerable households to global price volatility thereby reducing their resilience to climate extreme events and economic shocks. Rural households face further financial constraints, with a substantial 41% of their income dedicated solely to food expenses, leaving them without sufficient emergency funds to cope with unexpected shocks.[62]

Food imports have increased by nearly 57% since 2019 and constitute nearly 16% of total imports. Over this period the import of edible oils (palm oil and soya bean oil) and pulses (the most important source of vegetable protein) have increased by 102% and 82% respectively. Importing food has a negative effect on Pakistan's balance of payments. It also has the effect of exposing vulnerable households to global price volatility thereby reducing their resilience to climate extreme events and economic shocks.

Water insecurity crisis mounting

Climate change has exacerbated Pakistan's water insecurity as rising temperatures have accelerated glacial melting while changes in precipitation have increased the variability of river flows. About 92% of Pakistan is classified as semi-arid to arid, and the vast majority of Pakistanis are dependent on surface and groundwater sources from the Indus River basin.[63] The basin's major water sources include glacier melt and seasonal rains (monsoon). However, glaciers are now melting at a rate ten times faster than in the previous century and monsoon rainfall has become increasingly unpredictable shocks.

Nearly 90% of the water supplied to the agriculture sector is dependent on water from the Indus River Basin.[64] Declining water flows are compounded by inefficient water management practices, inadequate infrastructure for water storage and distribution, and escalating water demand due to population growth and urbanization. As a result, Pakistan faces a looming water crisis, with implications for food security, energy production, public health, and ecosystem sustainability. The amount of available water per person has dropped from 1,500 cubic meters in 2009 to about 1,017 cubic meters in 2021.

As a result, Pakistan is teetering on the brink of severe water scarcity, perilously close to the critical threshold of 1,000 cubic meters per person. As seen in *Table 2*, the average water requirement for summer and winter harvests is 103.5 million acre-feet (MAF). However, since 2015, the system has averaged only 91.2 MAF of water available.

Climate change worsening rural-to-urban migration

The world recorded more than 20 million displacements due to natural disasters each year from 2019 to 2022.[65] The World Bank's worst case estimate is that 216 million people could move internally by 2050, as water becomes scarcer and agricultural livelihoods are threatened.[66] The Internal Displacement Monitoring Center estimated that in 2022 Pakistan had the highest number of Internally Displaced Persons (IDPs) in South Asia due to natural disasters.[67] Rural-to-urban migration is clearly related to intensifying climate risks. The urban population in Pakistan is increasing by 3% per year and by 2050, estimates suggest that urban residents will make up 68% of the global population, up from 55% percent in 2018.

While displacement due to sudden-onset disasters is often temporary, migration triggered by slow-onset climate change may be more permanent, rendering entire regions uninhabitable and threatening rural livelihoods. In Pakistan we see slow-onset climate change magnifying the water crisis - in the past two decades, the Indus delta has diminished by 92%, contributing to the designation of Pakistan as the third-most water-scarce country in the world.[68] Permanent migration patterns due to climate change are expected to intensify. Projections by the National Institute of Oceanography indicate that without drastic climate adaptation, substantial areas of southern Pakistan, including Karachi, the country's largest city and home to over 20 million people, could be submerged within 30 years.[69]

Period	Kharif (Summer Harvest)	Rabi (Winter Harvest)	Total	Percentage change over average system usage (103.5 MAF)
Average System Usage	67.1	36.4	103.5	-
2015-16	65.5	32.9	98.4	-4.9
2016-17	71.4	29.7	101.1	-2.3
2017-18	70.0	24.2	94.2	-9.0
2018-19	59.6	24.8	84.4	-18.5
2019-20	65.2	29.2	94.4	-8.8
2021-22	65.1	31.2	96.3	-7.0
2022-23	43.3	29.4	72.7	-29.8

Table 2. Yearly Trend in Surface Water Availability (MAF) for the Indus River System 2015-2023

Developing adaptation strategies for the agriculture sector is critical to Pakistan's future. The shifts in climate not only threaten crop production due to altered rainfall patterns and extreme temperatures but also affect the availability of water and the health of the soil, impacting the very backbone of the country's economy and food security.[70] By focusing on and investing in adaptation measures—such as developing drought-resistant crop varieties, improving water management systems, and enhancing soil health - Pakistan can not only protect and potentially increase its agricultural productivity but also build resilience against future climate uncertainties. Such proactive and informed strategies that prioritize solutions grounded in the local context are imperative in securing the country's agricultural future and the well-being of its population.

4. Local Solutions and their Struggle to Scale

To address the adverse impacts of climate change on the agriculture sector, it is critical to introduce climate adaptation solutions. One way to spur change is through investment that benefits businesses, smallholder farmers, and builds climate resilience within the sector.

Private sector investments in climate-focused agribusinesses present a commercially viable opportunity to address adaptation challenges.

These businesses operate within a sector poised for growth, driven by increasing food demand and a need for import substitution, but is increasingly facing threats from climate change. Local knowledge and ability to drive innovation are critical to successfully implementing climate-smart practices and contribute to long-term sustainability within the sector and economy as a whole.

4.1. Macroeconomic pressures drive local climate resilient solutions

Demand Drivers

Pakistan has the fifth largest population in the world with more than 241M people. The country's annual population growth rate has trended at approximately 2% in comparison to 0.5% in China, 0.8% in Sri Lanka, and 1.3% in India since 2000.[71] Pakistan's population, both substantial and on the rise, has intensified the demand for food to meet the nutritional requirements of the country's inhabitants. However, Pakistan's food production capacity has remained largely unadjusted, presenting a significant challenge in keeping pace with escalating demand. What is more alarming is that United Nations projections estimate that Pakistan's population could reach 403 million by 2050, one of the highest in the world.[72] It is crucial to enhance the country's food production capacity in order to adequately address this escalating demand.

Pakistanis spend nearly half their income on food. As seen in *Figure 3*, the average monthly expenditure on food in urban areas of Pakistan is much higher than regional peers at approximately 45% of a resident's income as compared to 32% in India and 28% in China. In rural areas, the percentage of expenditure allocated to food is even higher, at around 50% as lower-income households tend to spend a higher proportion of their income on food. Food expenditure in Pakistan is projected to be the largest consumer spending category by 2040.[73]

High urbanization and a growing middle-class will spur demand for diverse agricultural produce. Urbanization increases the demand for processed and convenience foods. Urban middle

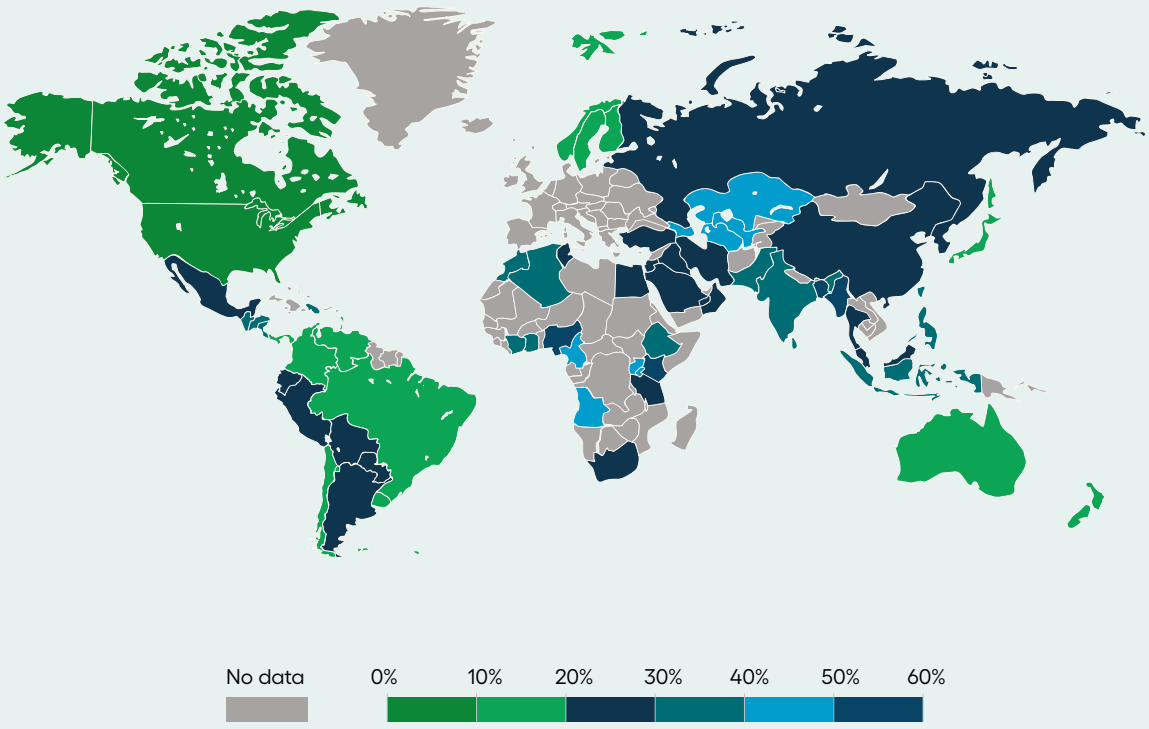

Figure 3: Share of consumer expenditure spent on food, 2022 [74]
Source: USDA Economic Research Service (ERS) (2023)

classes generally have a higher purchasing power and expect a larger variety of better quality food. The combination of urbanization and rising incomes has caused a shift in dietary patterns in Pakistan. The demand for protein-rich foods, fruits, vegetables, and processed foods is increasing. This phenomenon has been observed in various regions; for example, urban populations consume more meat than rural populations in Pakistan, China, and Indonesia. [75] This change in dietary preferences requires structural changes and diversification in production to meet evolving demand, necessitating increased agricultural productivity and value-added food processing.

Market developments are pushing the sector to optimize and therefore increase commercial viability. Consumer demand for agricultural products in Pakistan is rising due to several factors including a growing population, rapid urbanization rates, a shift towards import-substitution driven by high inflation, and a focus on export-oriented businesses. Businesses are now expanding into export markets to stimulate growth and enhance foreign exchange earnings.

Overall the sector and companies of all sizes are responding to global supply chain disruptions that have been exacerbated by climate change, through building resilience into their supply chains. In Pakistan, this has led to climate-focused agribusinesses building commercially viable solutions.

Supply Drivers

Pakistan has a high import dependency due to a low ability to build local capacity. The country's share of food imports has consistently increased, with imports playing a critical role in meeting the shortfall in domestic food production. Climate change, low productivity and yields in the agri sector, and Pakistan's rapid population growth have all left the government unable to meet local food demand and have forced the country to rely on imported food. This is demonstrated by the increasing share of food groups in Pakistan's import receipts which has steadily risen over the last 5 years. Amongst other consequences, importing food has a negative effect on Pakistan's balance of payments.

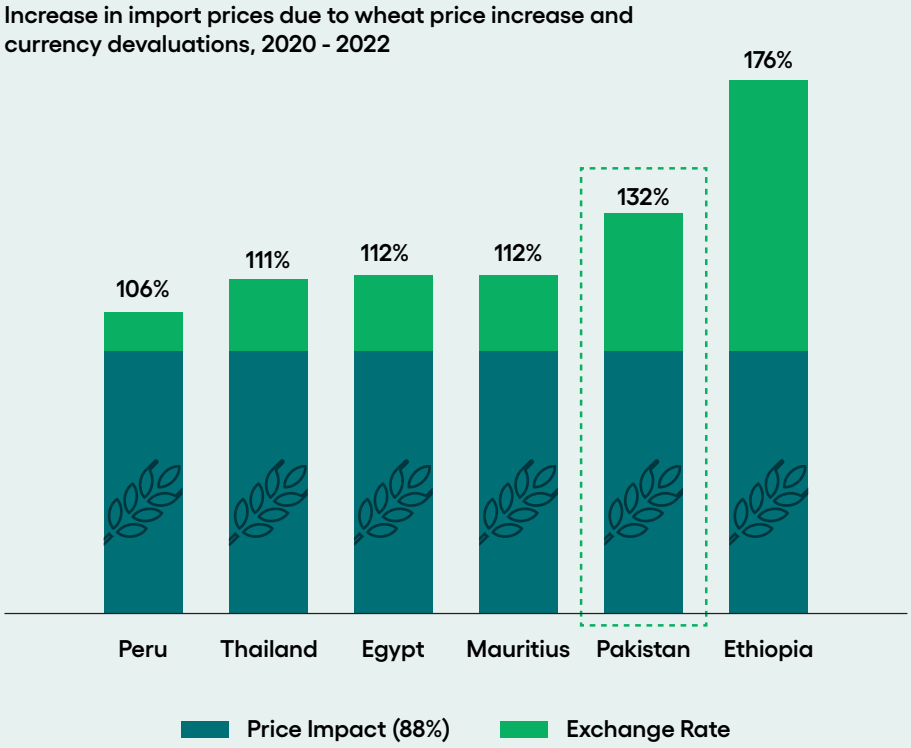

Figure 4: Increase in Import prices of wheat due to currency devaluation, 2020-2022 [76]
Source: UNCTAD secretariat calculations

Furthermore, devaluation of the Pakistani PKR in the last two years has significantly raised the prices of these imported products, forcing consumers to seek substitutes. *Figure 4* highlights the effects of the USD exchange rate on the price of wheat, a dietary staple, for net food importing countries. The average increase in the US dollar ranged between 10-46% whereas the price increase for wheat ranged between 106-176%.[77] Hence, it is paramount to promote local production of food items to ensure a steady and consistent supply for the local population, in light of the country's large trade deficit.

There is increasing demand from the market to localize supply chains. Due to devaluation of the local currency, along with rising costs and import restrictions, agribusinesses that were previously import-dependent are increasingly opting to localize their supply chains. Specifically, rising costs for inputs and raw materials have increased the demand for local solutions offered by Pakistani agribusinesses, who are working with local farmers. A positive consequence of this demand is that it is facilitating backward-integration of supply chains and reducing import-dependence. Rising Consumer Price Index (CPI) inflation is pushing consumers towards lower-cost decisions. Pakistan's CPI inflation rate rose to 36.4% in April 2023, the highest value since 1973, while food price inflation amounted to 48.1%. Consistent increases in food prices have forced consumers to seek cost efficient alternatives due to a stark rise in the cost of living. Food inflation in Pakistan averaged 10.9% from 2011 until 2024, reaching an all time high of 48.6% in May 2023 and eroding the purchasing power of households by as much as 38 percent.[78] The CPI annual food inflation decreased from 27.5% in December 2023 to 24.7% in January 2024, which is still significantly high compared to the inflation rates in neighboring countries.

Additional commercial viability can be achieved by tapping into significant export potential. Abundant cheap labor, fertile land, and favorable weather conditions offer a competitive export opportunity to agribusinesses. Pakistan is surrounded by Central Asian and Middle Eastern countries, which are lucrative and accessible markets and have historically been a destination for Pakistani food exports (with 11% of Pakistan's total exports going to the Middle East between Jul-May, FY23).[79] Expanding export markets for agricultural products can stimulate agricultural growth and enhance foreign exchange earnings. Developing quality standards, promoting brands, and improving market access can enable Pakistani agricultural products to compete internationally. This can be seen as local corporates operating in the textile and pharma sectors are diversifying operations into food and aquaculture to take advantage of this opportunity.

4.2. High potential business models

In the face of mounting climate challenges, a wave of innovative agribusinesses are emerging in Pakistan, offering promising solutions to enhance the resilience and productivity of the agricultural sector. A confluence of macroeconomic demand and supply side factors make this a viable time to scale sustainably, locally and internationally. These enterprises are leveraging local knowledge, resources, and technology to transform traditional farming practices and create a more sustainable and climate-resilient future for Pakistan's farmers and communities.

Building climate adaptation: business models that work

Access to financial services - agri-financing institutions and microfinance providers: Financial institutions specializing in agricultural financing have developed business models specifically catering to the financial needs of farmers. They offer tailored credit products with flexible repayment schedules, such as crop loans, equipment financing, and working capital loans. By addressing the challenge of limited financial resources, these institutions enable farmers to invest in inputs, machinery, and technologies that improve their pre-production operations.

Small farm focused mechanization - farm mechanization services at farm-gate: Companies that offer rental or leasing services for farm machinery and equipment help small-scale farmers access modern tools without high upfront costs. This improves efficiency, reduces labor requirements, and enables timely farm operations. Entities providing farm mechanization services to farming communities help reduce dependence on inefficient manual labor, while offering additional value-added services.

End-to-end value chains - manufacturing and marketing of farm-gate processors for small and medium-sized farmers: Entities specializing in developing modular and portable processing units. These businesses design, manufacture, and sell compact processing units that can be deployed directly at the farm-gate or near farming communities. These units are tailored to specific processing needs, such as solar dehydrating, grain milling, fruit juice extraction, or dairy products manufacturing. The company provides farmers with turnkey solutions, including installation, training, and ongoing technical support. By offering cost-effective and efficient processing units, this business empowers farmers to add value to their agricultural products, reduce post-harvest losses, and access new market opportunities.

Therefore, upon analysis of the agriculture value chain and key areas necessary for building both climate and economic resilience of the sector, solutions should focus on three critical areas: farmer focused solutions; smart farming; and post-harvest storage and logistics. These sectors directly address some of the obstacles faced by the climate-vulnerable agriculture sector, in addition to addressing the extreme fragmentation that has historically existed. Furthermore, they present commercially viable opportunities due to the current under-investment in these areas and the high-growth potential of Pakistan's agriculture sector, offering significant gains for first movers.

1) Farmer focused solutions include models tailored to farmers' needs, including access to finance, high-quality inputs, and connectivity across the value chain. Digitizing the value chain, especially by providing financial connectivity, plays a crucial role in linking various components of the value chain, enhancing resilience and efficiency. Solutions emerging within this theme concentrate on three major verticals:

- **Improving input efficiency:** Technologies, practices and resources designed to boost agricultural production and efficiency, which will improve farmer incomes and therefore their resilience to unpredictable factors like adverse weather conditions and pests. Using technology to connect farmers with stakeholders across the value chain for greater farmer access to input- and end-markets, helping to build-up the ecosystem surrounding farmers.

- **Information access services:** Platforms that bridge information gaps across the value chain, offering weather forecasts, market data, and agricultural advisories. It is imperative to ensure everyone has the information they need and to create fair markets, improve access to inputs, and connect farmers with retailers/final consumers.

- **Financial services:** Formal finance penetration in rural areas in Pakistan still remains limited. Farmer focused models should offer rural-friendly credit solutions and formal insurance to bolster livelihoods and provide cover against increasingly frequent climate disasters. Such business models will improve access to formal insurance and credit/financing options to improve farmer livelihoods and scaling capabilities, making them more climate resilient.

Example: Acumen Pakistan investee, NRSP Microfinance Bank is amongst the leading microfinance operations in Pakistan that focuses primarily on rural, agricultural markets across the country. The Bank offers rural communities services such as crop and livestock loans, savings and insurance products, and working capital at financing rates up to three times cheaper than those available in the informal sector. NRSP Microfinance Bank has 133 branches and has reached 500,000 borrowers including poor farmers and unbanked rural communities without access to essential financial services

2) Smart farming models focus on on-farm productivity and climate-resilient practices. It is critical that these solutions also may utilize renewable energy to power the solutions to improve the overall resilience of the sector. Three key areas that will improve climate resilience are:

- **Farm mechanization and optimization:** Business models that provide equipment solutions to enhance production processes and develop agricultural land through utilization of a variety of tools, coupled with technologies enabling better monitoring and management of crops and livestock to boost yields.

- **Alternative farming solutions:** Innovative methods optimizing land usage and providing alternative income streams, such as aquaculture and agroforestry. These models can primarily operate in areas where soil degradation, salinity and climate change (among other factors) have caused land to become less arable and lose productivity.

- **Regenerative agriculture:** Business models promoting practices like soil fertility, carbon sequestration, and sustainability through minimal tillage and organic matter use.

Example: Acumen India investee Kheyti offers a low-cost Greenhouse-in-a-Box for smallholder farmers to help mitigate drought conditions. Kheyti's greenhouses lower temperatures by 10° F (-12° C), cost 60 percent less than conventional greenhouses and require 90 percent less water. Kheyti delivers and installs customers' greenhouses along with a drip irrigation system. The team also connects farmers to affordable loans to purchase the greenhouses, offers startup fertilizer and seeds, and helps farmers sell their crops to large grocery retailers.

3) Post-harvest storage and logistics aim to minimize food loss, enhance quality, and improve safety and traceability. Some solutions integrate renewable energy like solar drying units. Such enterprises commonly undertake tasks such as handling, sorting, storage, processing, treatment, conversion, and transportation of the produce to preserve its value.

- **End-to-end value chains:** Business models that facilitate smallholder access to high-value markets while empowering rural communities through skill development and employability.

- **Farm gate storage and logistics:** Cold storage systems and warehousing models that cut out middlemen, reduce food wastage, and increase income while connecting farmers directly to end markets.

- **Post-harvest value addition:** Innovative processing methods that boost farmer incomes via value addition. These models aid in export readiness and alignment with quality standards.

Example: Acumen West Africa investee CropBank constructs the last-mile infrastructure needed to tackle food waste, improve farmer fortunes, and transform agriculture in Nigeria and beyond. The company builds storage and processing facilities at farmgate in dozens of locations throughout Enugu, Benue, and Cross River states in Nigeria. These storage facilities make it more efficient, accessible, and transparent for farmers – 60% of whom are under the age of 35 – to manage, store, and monetize their produce.

Pakistan can only adapt to climate change in the long run by supporting the growth of companies developing scalable, local solutions that help farmers adapt to climate change while building resilient supply chains and ecosystems. While solutions are emerging across the value chain building climate resilience in the sector, there are several barriers to scaling their operations, thereby enabling them to earn higher revenues, optimize costs and develop a more resilient supply chain.

4.3. Barriers to scaling adaptation action

Despite the emergence of innovative agribusinesses offering promising solutions,efforts to scale these initiatives to build a climate-resilient agricultural sector in Pakistan face significant hurdles.

Barrier 1: Agribusinesses unable to access patient equity financing

Risk-averse institutional lenders often deprioritize businesses operating in the agriculture sector as they are seen to require a higher risk threshold and more patient capital. In Pakistan, most agribusinesses have a high level of informality and remain undocumented to avoid legal and regulatory compliance requirements - reducing administrative burdens and costs. For instance, operating informally gives agribusinesses

greater flexibility to avoid paying taxes. Such businesses incur many disadvantages such as limited access to government support including government assistance programs, grants, and subsidies. This makes it even more difficult for these entities to access formal credit. Even when agribusinesses are formally structured, the high costs of commercial credit, combined with stringent collateral requirements, dissuade businesses from accessing credit through formal financial institutions. This keeps agribusinesses small and underinvested in growth – particularly growth robust enough to navigate climate threats that are a core business risk and opportunity.

Both international and domestic investors face supply-side challenges when considering climate-related investments in Pakistan. International private investors are deterred by the barriers to returns on investment in Pakistan. The current ROI hurdle rate of approximately 20% annual returns on existing debt instruments prices out many viable projects. Additionally, the Pakistani PKR's estimated 30% annual depreciation during the last two year introduces significant currency risk, limiting investment options. Perceived political instability further exacerbates the situation, raising minimum return thresholds for international investors. Domestic investors also encounter obstacles, primarily related to credit risk and the long-term nature of climate projects. The relatively high returns currently offered by money market debt instruments make climate projects appear riskier due to the preparatory and logistical efforts required for implementation. Furthermore, the long-term nature of these projects does not align with the business models of most banks, thereby hindering private sector participation.

Private sector credit as a percentage of GDP is under 15% in Pakistan - which is the second lowest in South Asia.[80] The situation is even worse for the agriculture sector, where there is a critical need for growth capital on flexible terms, sensitive to the cyclical nature of the sector. Credit to the agriculture sector as a percentage of total credit is only 4.94%, whereas for regional agrarian countries such as India and Sri Lanka, it stands at 11.92% and 7.59% respectively.[81] Furthermore, commercial lending to growth stage businesses in Pakistan has remained, on average, between six-nine percent of total private sector financing and is characterized by some of the highest interest rates charged in the region.[82] The banking sector, which is the largest player in the financial sector, primarily lends to the government. This tendency is particularly pronounced during high-rate environments, where there is an even greater incentive to park all liquidity in government securities to earn high, risk-free returns.

Structural gaps in the enabling environment for agribusinesses pose significant barriers to growth. Agri-businesses, while possessing high growth potential, face constraints in accessing appropriate financing. There is a dire need for patient, longer-term, and flexible equity financing options, which are currently lacking in the market. The venture capital (VC) industry in Pakistan is nascent, as is the private equity (PE) industry. As of April 2023, there were 10 licensed PE and VC funds registered with the SECP (Securities Exchange Commission of Pakistan) with total assets under management (AUM) of USD 29.3 million. Both types of entities have barely touched the agriculture sector given its high perceived risks.

Barrier 2: Businesses lack expertise in successfully scaling ventures

Businesses in Pakistan face several macro level and company-specific challenges and opportunities, preventing them from scaling successfully. They are often family-run, have informal financial management practices and experience some limits on talent acquisition and operational maturity. Given the informal nature of the sector, businesses often have limited incentive to formalize and develop best practices. They require a robust support ecosystem for scaling viably, including financial institutions willing to invest, research and development centers, and extension services. These deficiencies stifle the growth of local technologies and solutions essential for building climate resilience. Without a conducive environment for research, development, and collaboration, local innovators struggle to access the resources and support needed to scale their solutions, leaving the sector ill-prepared to face the challenges posed by climate change.

Learnings from Acumen's global portfolio and our work with agriculture and climate sector businesses in Pakistan have provided insight into their challenges. Early-stage businesses are often testing out the right product-market fit, have volatile revenue streams, lack a stable customer base, and frequently pivot, making it challenging to pin down their eventual business model. They often lack teams with extensive industry experience and are still in the process of enhancing their capabilities, hindering swift progress and scalable growth.

Barrier 3: Regulatory context must be supportive

The regulatory landscape in Pakistan presents significant challenges for agribusinesses seeking to scale and grow. The absence of substantial tax incentives for investment in agriculture, coupled with limited government support for the private sector, has fostered a challenging environment for agribusinesses. An intricate web of overlapping regulations, often with conflicting provisions, creates a complex and burdensome environment for businesses to navigate. The multiplicity of rules and regulations increases operational costs, delays decision-making, and discourages investment. Regulations often fail to keep pace with the evolving dynamics of the sector, while frequent changes in regulations and policies introduce uncertainty and hinder long-term planning. For instance, sudden changes in export duties or import tariffs can disrupt supply chains and affect business profitability.

The overall investment climate in Pakistan adds another layer of complexity. Foreign direct investment (FDI) plummeted to 0.2% of GDP in FY23, the lowest in three decades. This decline is attributed to difficulties in repatriating profits, inconsistent economic policies, and frequent currency fluctuations. Pakistan's inconsistent policies and restrictions on capital flow significantly diminish its appeal to foreign investors, particularly in sectors like agriculture. As a result, climate-focused agribusinesses are often overlooked in favor of more lucrative alternatives. The devaluation of the Pakistani PKR can directly trigger a significant increase in the cost of doing business for companies that are import-dependent within their supply chains or for meeting capital expenditure needs. As a result, the devaluation leads to an increase in operational expenses (such as energy costs) for companies.

A more agile and responsive regulatory framework that is developed to support prioritized investment areas is crucial and necessary to support the growth and development of agribusinesses in Pakistan.

Efforts to scale climate solutions face many hurdles, but this report focuses on three key areas where targeted interventions can unlock significant progress. These recommendations focus on overcoming barriers related to access to financing, expertise, and regulatory support.

5. Recommendations

Recommendation: Develop and support high quality, "bankable" projects that can attract investment and leverage climate finance efficiently

Securing funding that aligns with the long-term nature of climate projects is essential. Pakistan needs to develop a multi stakeholder approach with private and public sector engagement for:

1. **Catalytic investment:** Mobilize capital for early-stage, high-risk climate innovations, acting as a catalyst for further private sector engagement and unlocking the potential for transformative solutions.

2. **Improving business development:** Support growth-stage agribusinesses that are implementing climate-smart practices and technologies, creating market anchors that attract additional investment and demonstrate the commercial viability of resilience building approaches.

3. **Ecosystem building:** Foster a vibrant ecosystem by connecting early-stage innovators with established players, facilitating knowledge sharing, collaboration, and mentorship to drive innovation and scale impactful solutions.

4. **Financial innovation:** Utilize blended finance models and other innovative financial mechanisms to de-risk investments, attract private capital to higher-risk but impactful projects, and expand access to finance for smallholder farmers and early-stage innovators.

5. **Impact measurement:** Develop standardized metrics and reporting frameworks to showcase the impact and financial viability of climate-smart agriculture investments, building investor confidence and attracting further capital flows.

Recommendation: Engage experienced climate investors, corporates and experts to provide technical support and enable technology transfer to local climate solutions

Developing and attracting specialized knowledge in climate finance, technology, and policy is crucial. Providing comprehensive training and technical assistance to public sector stakeholders on climate finance, project development, and implementation strategies will ensure that they can effectively support the design, management, and monitoring of climate adaptation projects. Additionally, offering technical assistance to help public institutions integrate climate risk considerations into development planning and policy-making will enhance the ability of government agencies to develop robust, climate-resilient projects that meet international funding standards for grant based loans and concessional financing. Other developing countries like Bangladesh and Chile (refer to Annex B) that are highly vulnerable to climate change have developed regulatory roadmaps and mechanisms for building capacity for national climate resilient development. Technical support for the public sector will be key in facilitating private sector climate solutions.

In addition, a robust, locally-adapted action plan that mainstreams adaptation across the public and private sectors which is deeply connected to national priorities will be critical in facilitating clear short- and long-term actions. Efforts to address climate adaptation in Pakistan involve a wide range of stakeholders, including government agencies, non-governmental organizations (NGOs), international donors, research institutions, and local communities. Despite their shared goals, these stakeholders often operate in silos, leading to fragmented and uncoordinated efforts. Without a clear and comprehensive plan, resources are often misallocated, and efforts are duplicated, leading to inefficiencies and suboptimal outcomes.

Recommendation: Develop supportive regulatory context to build and scale high priority climate solutions

Strengthening regulatory support structures is essential to effectively connect adaptation projects with private investment in Pakistan. This involves creating clear, transparent, and investor-friendly regulations that encourage private sector participation in climate adaptation initiatives. Establishing regulatory frameworks that provide incentives such as tax breaks, subsidies, and fast-tracked project approvals can attract private investments. The regulatory framework for FDI (Foreign Direct Investment) in particular needs to be strengthened, at the national and subnational level to attract green investments. Additionally, developing robust public-private partnership (PPP) models and offering guarantees to mitigate investment risks will further enhance investor confidence. Domestic financial resources can also be mobilized through innovative financing mechanisms that can be used to attract new sources of private capital. This includes introducing carbon taxation, implementing green/blue bonds, developing carbon markets etc.

Some key areas that Pakistan can strengthen are:

1. **Private sector participation:** Provide tax incentives, subsidies and other financial incentives to encourage private sector investment in climate-resilient agricultural practices.

2. **Public-private partnerships:** Foster collaborations between government bodies and private companies to pool resources, share expertise, and implement scalable climate adaptation projects.

3. **Centralized climate finance body:** Climate stakeholders often operate in silos, leading to fragmented and uncoordinated efforts. It is critical to streamline focus and create a high-powered central body that can convene relevant stakeholders swiftly and efficiently.

4. **Capacity building programs:** Develop training programs and workshops to enhance the skills and knowledge of private sector stakeholders in climate-smart agriculture and sustainable practices.

5. **Streamlined regulations:** Simplify regulatory processes to facilitate easier access to climate finance and reduce bureaucratic hurdles for private investors.

6. **Access to global expertise:** Create platforms for knowledge exchange, enabling local enterprises to learn from international experts and adopt best practices in climate resilience and agricultural innovation. Participate in global agricultural research initiatives and networks to stay updated on cutting-edge advancements and innovations with regional experts in China, East Asia, the Middle East, etc.


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6. Conclusion

Pakistan is projected to be one of the world's most populous countries by 2050, with a population expected to reach 310 million. This demographic shift, coupled with the intensifying impacts of climate change, presents unprecedented challenges for the sector. The agricultural sector stands at a critical juncture, simultaneously grappling with significant systemic challenges and the fallout from increasingly frequent climate disasters. The evidence presented in this report underscores the severe and far-reaching consequences of climate variability on crop yields, farmer livelihoods, and overall food security. From extreme weather events to shifting rainfall patterns, the challenges are multifaceted and complex.

However, these challenges also present opportunities for transformation. The emergence of local climate-resilient solutions demonstrates the potential for innovation and adaptation. Given the massive scale of the climate crisis and its potential to multiply challenges in every sector of the economy, a coordinated, multipronged approach is necessary to effectively counter climate threats. This requires a concerted effort from policymakers, researchers, farmers, and the private sector to work collaboratively and build a sustainable agricultural future. Enhancing its capacity to tap into global climate funds and develop innovative financial instruments and building institutional expertise to support at the farmer, business and ecosystem levels is crucial for effective adaptation and mitigation strategies. By investing in agribusinesses, enhancing value chains, bolstering research and development, and promoting sustainable agricultural practices, Pakistan can enhance the climate resilience of the sector and food security for the nation.

While the road ahead is fraught with challenges, a concerted effort to address these issues is essential to ensure food security and sustainable livelihoods for future generations. By capitalizing on opportunities and fostering strategic partnerships, Pakistan can build a resilient agricultural sector that ensures food security and economic prosperity for its growing population.

The agricultural sector stands at a critical juncture, simultaneously grappling with significant systemic challenges and the fallout from increasingly frequent climate disasters.

7. Annexes

Annex A: Spotlight on 2022 floods

Pakistan's record floods in 2022 affected 33M people, displacing approximately eight million and taking the lives of more than 1,700.[83] In the summer of 2022, the country experienced its wettest August since 1961. Sindh and Balochistan provinces were subject to unprecedented rainfall, surpassing average monthly totals by six and seven times, respectively. Climate attribution studies (which research the link between human-caused climate change impacts on severe weather events) of these two provinces have found that extreme rainfall events are now much more intense due to climate change. In just five days, the amount of rainfall was a staggering 75% greater than it would have been if the planet hadn't warmed by 1.2°C.

The destruction from the floods was made even worse by a chain reaction of extreme weather. An unusual monsoon season brought exceptionally heavy rain, while melting glaciers added to the water levels after a record-breaking heatwave. This intense heat wave had already caused a major drought, with temperatures soaring above 45°C for days on end. This series of devastating events has left the region reeling, with total damages and economic losses estimated at a staggering USD 33 billion.

The floods, accelerated glacial melt, and resulting landslides devastated millions of homes and key infrastructure, submerging entire villages, and destroying livelihoods. Estimates suggest that, as a direct consequence of the floods, the national poverty rate increased by 3.7 to four percent, pushing between 8.4 and 9.1 million people into poverty. Post-disaster, 94 districts were declared as "calamity hit," accounting for more than half of all districts in the country. However, most of the districts impacted were in the provinces of Balochistan, Sindh, and Khyber Pakhtunkhwa (KP). Out of the 25 poorest districts in the country, 19 were calamity-affected.

The scale of the flooding was unprecedented. It was the world's deadliest flood since the 2017 South Asian floods and described as the worst in Pakistan's history. The flood waters were slow to recede, forcing an estimated five million people to live in flooded areas and an estimated 14.6 million people to require emergency food assistance between December 2022 and March 2023. Agriculture sector (food, livestock, fisheries) losses amount to USD 3.7B, with the floods sweeping away USD 1.3B (rice, cotton, sugarcane, fruits and vegetables) in Sindh province alone. The floods have also severely impacted the planting of wheat - Pakistan's staple crop and the backbone of nutrition for the majority of the country. Approximately 50,000 head of livestock (a regular and stable source of income in rural areas) were killed in Sindh alone. Dependent on the agriculture sector for the majority of its export goods, Pakistan's economic growth projections for the 2022-23 fiscal year were also slashed in half.

Annex B: Bridging the adaptation finance gap: lessons from Chile and Bangladesh

Pakistan's overall adaptation financing needs stand at approximately USD 152 billion for the period 2023-2030. However, attracting this level of investment is proving difficult. Historical data reveals an average annual inflow of only USD 1.3 billion from multilateral development banks between 2015 and 2022. In comparison, during the same period, neighboring countries such as India and China which aren't as vulnerable to the effects of global warming raised approximately USD 3.3 billion and 2.1 billion in climate finance per year. Pakistan can draw valuable lessons from countries that have successfully attracted and built systems to leverage climate finance towards bridging their adaptation gaps and building climate resilience.

Chile has implemented a comprehensive climate strategy, including green bonds and a framework law that fosters private investment in adaptation and mitigation projects. Chile's strategy has been bolstered by its successful green financial

issuances, such as green and ESG bonds under its Green Bond Framework of 2019 and subsequently the Sustainable Bond Framework (2020) and SLB Framework (2022). It became the first country in Latin America to issue green bonds in 2019, and in the same year announced the decommissioning of coal-fired power plants by 2040.[84]

Bangladesh has successfully attracted both domestic and international climate finance, integrated climate considerations into national budgeting, and established a dedicated trust fund to support vulnerable communities. Bangladesh has been one of the largest recipients of climate finance in South Asia, from both domestic and international sources. The Bangladesh Climate Change Trust Fund (BCCTF), for example, supported 789 projects with an investment of USD 443 million to implement strategic actions under the Bangladesh Climate Change Strategy and Action Plan (BCCSAP).

These examples highlight the importance of:

- **Strong national climate strategies:** Clearly outlining goals, policies, and financing mechanisms for both mitigation and adaptation.
- **Institutional capacity building:** Enhancing coordination between stakeholders and developing expertise in climate finance.
- **Innovative financing mechanisms:** Utilizing tools like green bonds, carbon markets, and dedicated trust funds to mobilize resources.
- **Mainstreaming climate considerations:** Integrating climate risks into sectoral policies and budgeting processes.

By learning from these successful models, Pakistan can enhance its ability to attract and utilize climate finance, thereby bridging the adaptation gap and building resilience in its vulnerable agricultural sector.

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