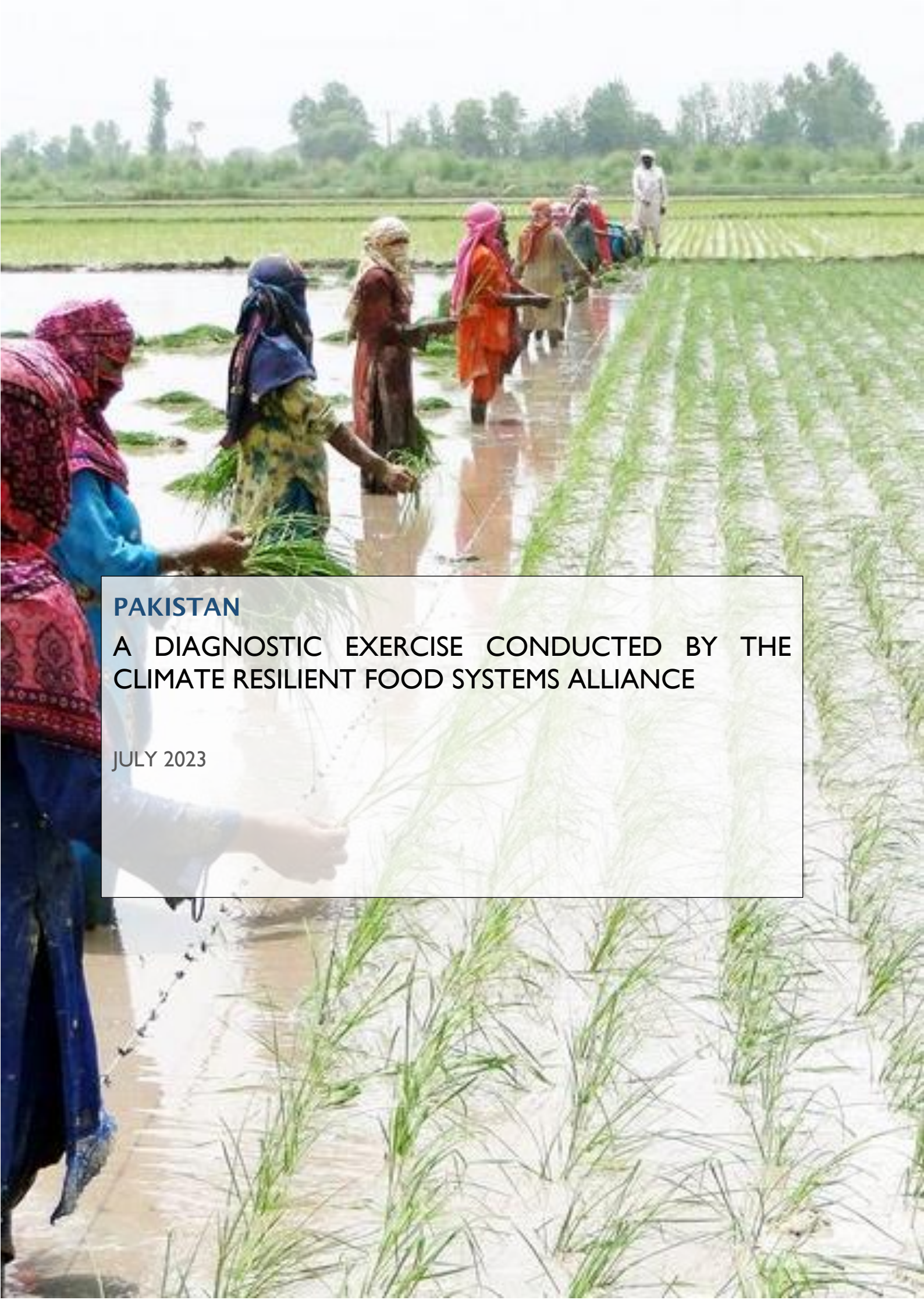

PAKISTAN

A DIAGNOSTIC EXERCISE CONDUCTED BY THE CLIMATE RESILIENT FOOD SYSTEMS ALLIANCE

JULY 2023

1 National circumstances

Overall population: 229.22 million (estimation of 2022)

Area: 79.6 billion hectares

GPD: $353 Billion USD (2022)

Food insecurity: 36.9% (2018) [1]

CO_2 emissions (annual): 229.5 million tons (2021)

People affected by Weather-related events: +30 million since 2010 [1](2021)

Losses related to weather-related events: 9.1 percent of GDP/ annual average (2022)

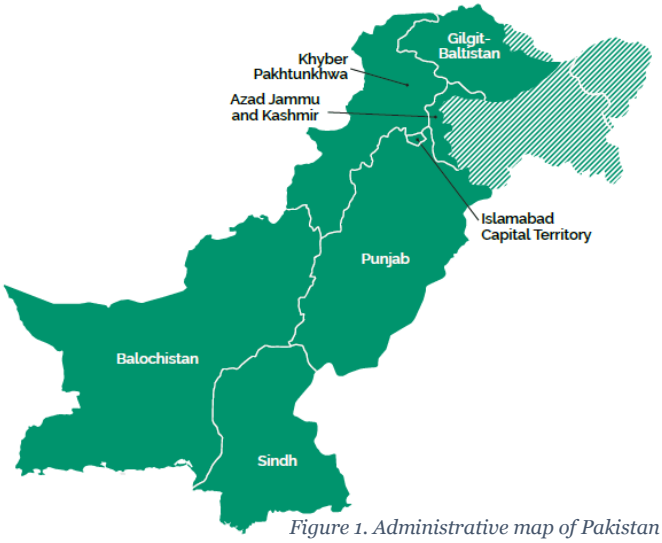

Figure 1. Administrative map of Pakistan

1.1 Country overview

Pakistan is a lower middle-income country located in South Asia, sharing borders with the People's Republic of China, Afghanistan, India, and Iran and the Arabian Sea in the south. The country covers an area of 79.6 billion hectares, including the area of territory in dispute.

The administrative structure of Pakistan presently comprises four provinces at the first-order level: Balochistan, Khyber Pakhtunkhwa, Punjab and Sindh plus the Islamabad Capital Territory. Additionally, there are two parts of Pakistan-administered Kashmir: Azad Jammu and Kashmir and Gilgit-Baltistan (Figure 1[1]). The total population exceeds 229 million people, being the fifth most populous country in the world. Most of the population resides in rural areas, being Punjab and Sindh home to more than three-quarters of the total (Figure 2).

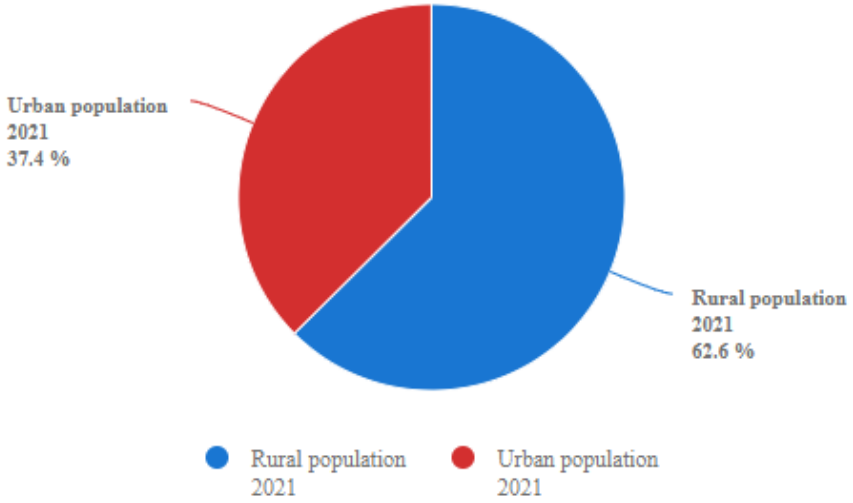

Figure 2 Urban and rural population

[1] This map is for illustrative purposes. It is not to be taken as necessarily representing the view of the CRFS Alliance on boundaries or political status.

Source: FAOSTAT 2021

1.1.1 Geography

Pakistan has a semi-arid monsoonal climate, although physiographic diversity gives rise to very different climates. Four major climate zones can be identified: glacial, humid, arid, and extremely arid regions.

The northern part is mainly covered with glaciers at a mean altitude of 4158 m.a.s.l. The humid region consists of the Himalaya, Karakoram, and Hindukush ranges, which receive mean rainfall of 825 mm per year at a mean elevation of 1286 m.a.s.l. The central arid region is characterized by low plains and has the main agricultural areas, with average rainfall and altitude of 322 mm per year and 633 m.a.s.l, respectively. The southern zones along the Arabian Sea, particularly the Western Dry Plateau and the Indus delta, are extremely arid; the region gets 133 mm mean rainfall per year, with a bare soil region at an average altitude of 444 m.a.s.l (Dilawar *et al.*, 2021).

The Indus River flows down from the Himalayas, through the length of Pakistan, before emptying into the Arabian Sea near the city of Karachi. 90% of Pakistan's people resides in the Indus basin, more than 80% of the arable land is irrigated by its waters and more than three-quarters of its economy is based on its resources (Michel, 2020). The Indus significantly depends on snow and ice melt, particularly during the dry months that bracket the summer monsoon rains (Young.W.J *et al.*, 2019).

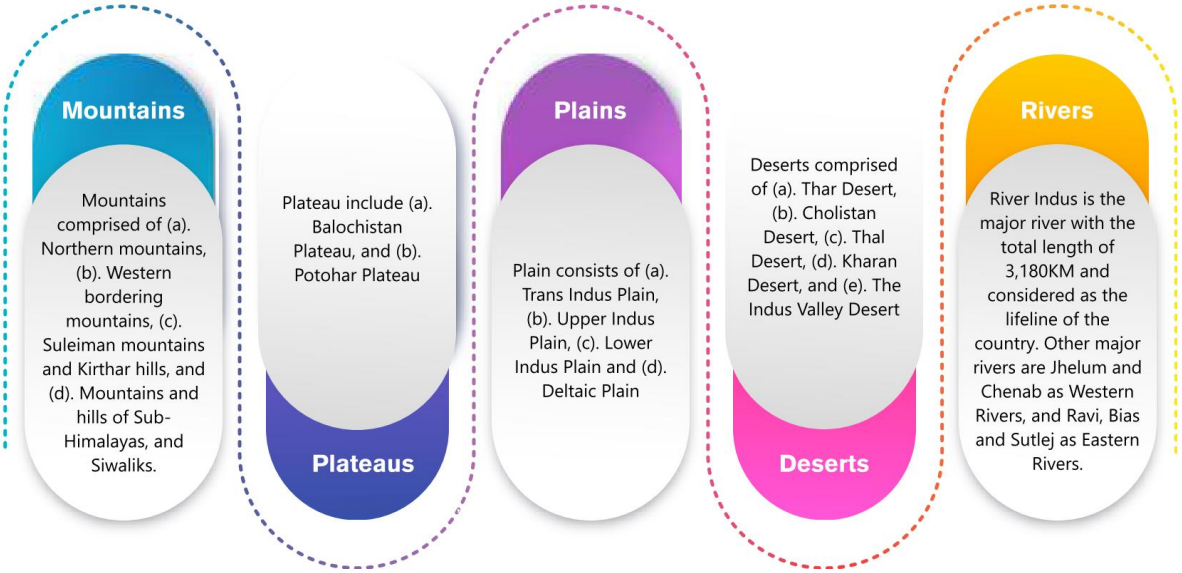

Figure 3 Main elements of the physical geography of Pakistan

Source: (National Disaster Management Authority, 2023)

1.1.2 Economy

Pakistan's economic landscape underwent substantial changes from 1960 to 1990. The relative contribution from agriculture to GDP fell from 45 percent to around 25 percent. This trend persisted, albeit gradually, with agriculture and industry each contributing approximately 20%, while the services sector surged to nearly 60%. Within agriculture, cropping has had much slower productivity growth compared to that of livestock, such that Pakistan's major crops now contribute less than 5 percent of GDP (Young.W.J *et al.*, 2019).

This slower structural transformation led Pakistan to experience two decades of steady economic growth, in part influenced by the increase in investment from China in the China–Pakistan Economic Corridor projects.

In 2021, Pakistan ranked as the 40th largest economy globally in terms of GDP, 66th in total exports, and 47th in total imports. The top exports of Pakistan are textile products and rice (Observatory of Economic Complexity, 2021).

This growth delivered significant reductions in poverty. However, strong pressures on domestic prices, external and fiscal sectors and the exchange rate also decreased. These imbalances were exacerbated by the flooding in 2022, surging world commodity prices, tightening global financing conditions, and domestic political uncertainty (The World Bank, 2023).

2 Food systems overview

The Pakistan's food systems are predominantly anchored in agriculture and livestock, which has the potential to become a robust engine of inclusive growth and poverty reduction.

2.1 Production

Pakistan is a highly diverse country, having 10 agro-ecological zones Figure 4, where more than 35 types of crop and livestock mixed farming systems are practiced (Table 1) (Ministry of National Food Security and Research, 2016). However, Three- fourths of the country receives less than 250 mm of rainfall annually, leading to 8 million ha of land in Pakistan is idle and unutilized due to unfavourable climatic conditions. Supplemental water is used for profitable agricultural production (CIAT and World Bank, 2017).

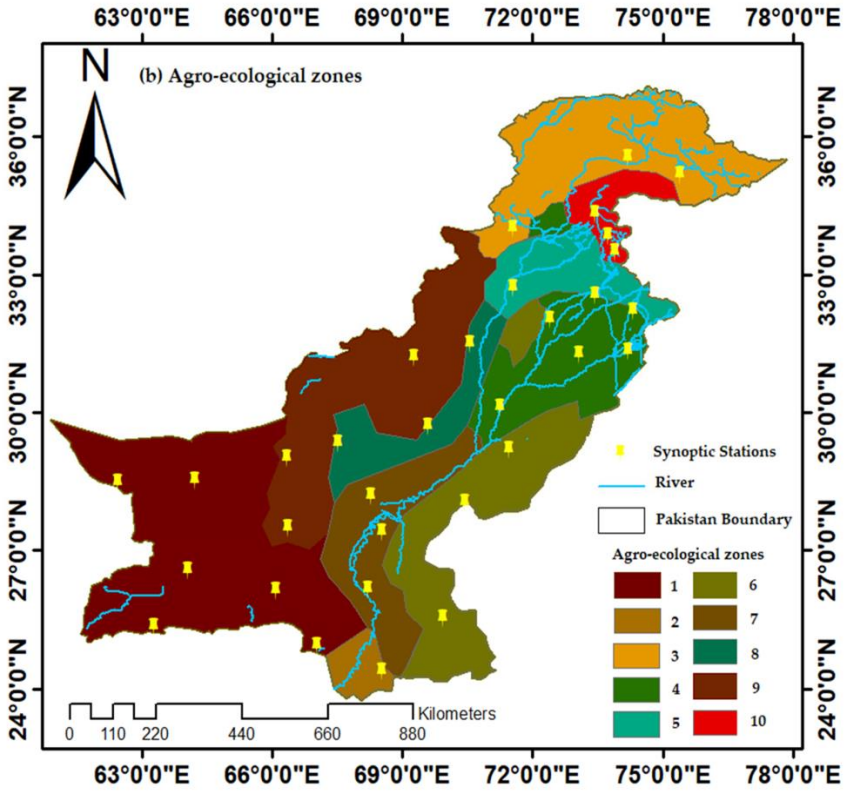

Figure 4 Agro-ecological zones of Pakistan

Source: (Dilawar *et al.*, 2021)

Table 1 Characteristics of agro-ecological zones of Pakistan

Zones	Rainfall (mm/day)	T_{max} (°C/day)	T_{min} (°C/day)	Climate	Crops
1. Dry Western Plateau[1]	1.3 mm	32 °C	18 °C	Arid tropical marine	Wild olives, small trees, grasses
2. Indus delta[2]	1.4 mm	33 °C	21 °C	Arid tropical marine	Sugarcane, cotton, wheat
3. Northern dry mountains[3]	4.0 mm	24 °C	10 °C	Sub humid	Grazing pattern
4. Northern irrigated	4.6 mm	32 °C	17 °C	Semi-arid	Wheat, cotton, millet, rice, mangoes, citrus
5. Rainfall	9.8 mm	30 °C	16 °C	Sub humid	Rice, wheat, maize, mustard, and barley
6. Sandy desert	2.4 mm	33 °C	18 °C	Arid	Shrubs, grasses

Zones	Rainfall (mm/day)	T_{max} (°C/day)	T_{min} (°C/day)	Climate	Crops
7. Southern irrigated	1.4 mm	35 °C	19 °C	Arid subtropical	Cotton, wheat, berseem, and sorghum
8. Suleiman Piedmont	2.4 mm	33 °C	18 °C	Arid subtropical	Millet, wheat
9. Western Dry Mountains	5.4 mm	25 °C	10 °C	Semi-arid	Apple, peach, apricot, grapes, plum
10. Wetmountain	16.7 mm	26 °C	13 °C	Humid	Wheat, maize

Source: (Dilawar *et al.*, 2021)

Agriculture

The agriculture contributes to about 20% of the whole country's GDP (Gross Domestic Product), engaging almost 65% of the country's labour force in agricultural value chains (30.2 % men and 67.2% women). The average farm size in Pakistan is 2.6 hectares (ha), with approximately 43% of the farmers with holdings less than one ha (CIAT and World Bank, 2017). The agriculture sector is the major contributor in the overall export earnings of Pakistan. The share of the food group for 2021-22 stood at 17.5% (Ministry of National Food Security and Research, 2023).

The diverse agro-ecological zones allows the production of nearly 100 field and horticultural crops: 5 major & 25 minor crops, 30 vegetables, nearly 30 fruits, 5 condiments and numerous medicinal herbs (Ministry of National Food Security and Research, 2021). A total area of 21.2 Mha is cultivated. Wheat, cotton, rice and sugarcane, are among the major crops (Figure 5), contributing around 4.9% to the total GDP. The agricultural activity is concentrated in the Indus plains with Punjab contributing 76% to agricultural production, followed by Sindh with 15% (Ministry of National Food Security and Research, 2023).

Pakistan experienced more than 65 percent land extension during 1947-80. Beyond this period, cropping area did not exhibit any significant expansion, which indicates that any improvement in production will not be related to the expansion of agricultural land, but to the implementation of better practices and innovation (State bank of Pakistan, 2019).

There are two main cropping seasons in Pakistan. The Kharif season, in which crops are sown at the beginning of the rainy season. Rice, sugarcane and Maize are part of this group. The Rabi Season, on the other hand, is when crops are sown at the end of the monsoon and the beginning of winter. Wheat, gram and potatoes are part of this group.

The country has the world's largest contiguous irrigation system with almost 80 percent of the cultivated area irrigated (FAO, 2021; Shah *et al.*, 2021). More than 100 small dams, 19 barrages and 57.000 km of canals are part of the infrastructure that allows the agricultural production (Ministry of National Food Security and Research, 2021). However, erratic monsoons patterns, increased glacial melt, low water storage capacity and on-going cross boarder water disputes add uncertainty to the availability

of water and affect production capacity. Additionally, inefficient water management under both irrigated and rainfed production systems is one of the main constrains for the sustainability of the agricultural sector (CIAT and World Bank, 2017).

Water harvesting and efficient use in dry rainfed regions is a promising proposition but has not been adequately developed. Resultantly, economic disparities among irrigated and non-irrigated regions had created conflicts and security problems (Ministry of Industries and Production, 2021).

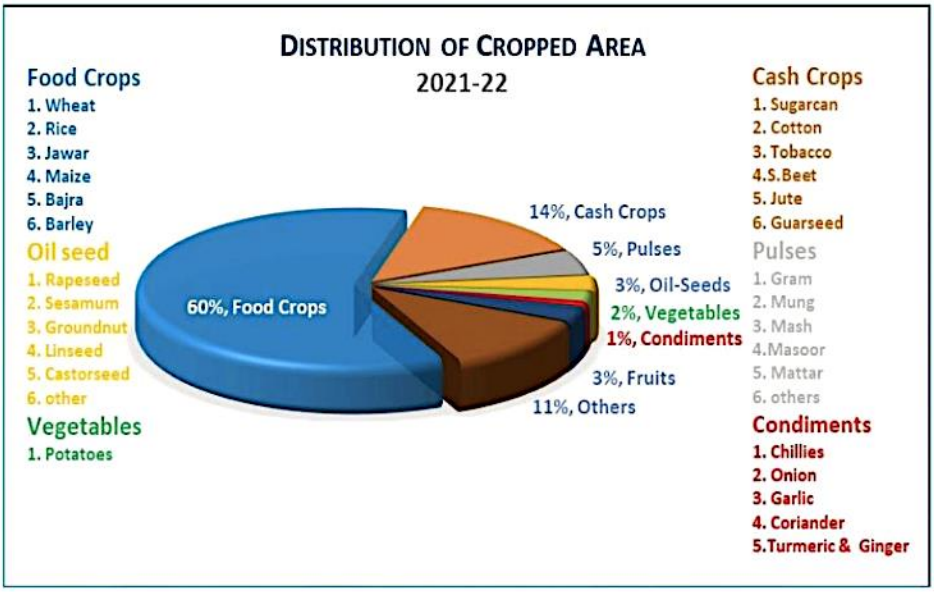

Figure 5 Distribution of cropped area 2021-2022

Source: (Ministry of National Food Security and Research, 2023)

The agriculture sector is highly dependent on ecosystem services. However, key ecosystems for water and climate regulation, such as forests, including conifer, broad leaved, riparian, scrub and mangrove forest, account to less than 5% of the area (Aziz, 2021). Furthermore, the available agriculture land has been facing degradation caused by water and wind erosion, depletion of soil fertility, deforestation, unsustainable livestock grazing and water logging practices (State bank of Pakistan, 2019).

Finally, gender inequality and discrimination persist in the agricultural sector. Women are less likely to own income-generating assets such as land, machinery or equipment, nor do they have equal power in financial or economic decision making. The lack of access to technologies, weak extension support, and high illiteracy among rural women creates further challenges for them in the agriculture sector (Samee *et al.*, 2015).

Livestock sub-sector

Livestock is rapidly growing in Pakistan (Table 2), contributing a 62.7% to the agricultural GDP and 14.36% to the total GDP. This sub-sector is a central livelihood for the rural population, generating daily cash income for 8.5 million small farmers and landless families (Ministry of National Food Security and Research, 2023).

Pakistan is one of the leading producers of milk with an estimated production of 52.6 million tons, supplying 6% of milk consumed worldwide. Despite the high production, the country imports dry milk and other dairy products due to seasonality. Ninety percent of the total milk produced enters the marketing channels from subsistence farmers and five percent is processed as dairy pack products.

Pakistan currently has the world's fifth largest beef herd (World Bank Group, 2022). The country also produces about 3.9 million ton of meat, including beef, mutton and poultry meat. The organized large and small fattening units are few; however, commercial dairy and feedlot fattening operations are emerging in the country.

The development of this subsector is constrained with: a) The high price of seeds and agriculture inputs; b) Lack of federal and provincial capacity; c) low capacity to control infectious animal diseases; d) Inadequate compliance to national and international standards for quality and hygiene; and e) Low quality and contaminated feed (Ministry of National Food Security and Research, 2016).

Table 2 Livestock population from 1986 to 2022

Province	1986	1996	2006	2018-19	2019-20	2020-21	2021-22
Pakistan							
Cattle	17541	20424	29559	47821	49624	51494	53436
Buffaloes	15705	20272	27336	40002	41191	42416	43679
Sheep	22655	23544	26488	30859	31225	31595	31981
Goats	28647	41166	53787	76143	78207	80326	82508
Camels	958	816	921	1090	1104	1118	1134
Horses	388	334	344	371	373	375	378
Asses	2998	3559	4269	5417	5517	5620	5725
Mules	69	132	176	196	199	203	208
Poultry	57503	63198	73648	88494	89840	901220	92616

Poultry is also a dynamic sub-sector contributing 1.3 percent to national GDP and 6.3 percent to agriculture, making Pakistan the 11th largest poultry producer in the world producing more than 92.000 poultry birds and around 16 billion eggs annually (National Food Security policy, 2016).

Fisheries sector

With a coastline of 1120 km, the Fishery sub-sector is one of the most important economic activities supporting livelihoods of a large group of the population. It plays a significant role in the national economy and food security, contributing 1.39% to the agriculture GDP and 0.32% to the total GDP (Government of Pakistan, 2023). About 740 thousand metric tons of fish is produced in the country, with exports worth US$ 349 million. Lakes, rivers and natural ponds are used for breeding trout for recreational fishing. However, inland aquaculture is not a developed industry in the country yet (Ministry of National Food Security and Research, 2016).

2.2 Processing and manufacture

Food products is considered Pakistan's largest industry, accounts for 27% of its value-added production and 16% of the manufacturing sector employment. Approximately 80,000 small businesses and more than 2 million micro-enterprises contribute to this industry. Many of these are in rural areas and fall into the category of food processors, depending heavily on agricultural raw materials and poorly skilled non-farm labour. For example, about 40% of these small businesses are in the milling subsector of staple food products like wheat and rice.

The foremost issue faced by Pakistan's agro food industry is the limited application of technology and innovations and poor management of the supply chain. The industry is highly labour intensive but the employment provided pays low wages. About 75% of the rural-based food manufacturers are in the informal sector. This informal economy finds difficulty in accessing essential raw materials, capacity building and financial products.

Marketing and quality standards are specially lacking thus affecting the overall sales and access to international markets. Companies report that commercial banks often fail to understand their risks associated to the natural environment, so they cannot offer appropriate credit services.

A reasonable work has been done in Pakistan on secondary processing of agricultural produce, however, the area of primary processing of agriculture produce is not yet developed, therefore, tremendous potential exists in developing value added products (Table 3) (Ministry of Industries and Production, 2021).

Table 3 Value added products.

Commodity	Value Added Products
Cereals	Biscuits, Starch, Glucose etc.
Fruits & Vegetables	Jams, Squashes, Syrups etc.
Oil Seeds & Vegetable Oils	Specialty Fats, Shortenings, Margarines etc.
Sugarcane	White Sugar, Brown Sugar, Refined Sugar, Chip Board & Paper
Milk & Dairy	Whole Milk Powder, Skimmed Milk Powder, Condensed Milk, Ice Cream, Butter & Ghee
Meat & Poultry	Gelatine & Sausages etc.

Source: (Ministry of Industries and Production, 2021).

Key low-cost technologies needed for the development of the food processing industry include seed/grain drying, extrusion technology, efficient dal (pulses) processing technology, and modified atmosphere technology for fruits and vegetables.

2.3 Distribution

A vast global network connects the numerous parts of the value chain. These include suppliers, manufacturers, warehouse owners, retailers, exporters and the end consumers. Wholesale markets for fresh food products are still an important hub for the distribution of agricultural produce, connecting multiple actors, as well as traditional markets (bazaars). However, they have tended to decline in importance in urban areas as a result of the growth of supermarkets, which procure directly from farmers or through preferred suppliers and maintain continuous, year-round supply.

Retail sales of processed foods is expanding by 10% per year and currently are estimated at about US$1.4 billion, of which imported products account for US$325 million (Ministry of Industries and Production, 2021).

2.4 Consumption

Pakistan's food sector is changing significantly with an inclined shift in lifestyles and traditional eating habits. On average, a consumer allocates 42% of their income to food expenditures (Ministry of Industries and Production, 2021).

At national level, nearly 70 million tons of cooked/prepared food is annually needed to feed current population. This demand shall rise to 130 million tons by 2050. In commodity form, the total required agricultural production is about 160 million tons; which shall increase to nearly 296 million tons by 2050.

Pakistan heavily relies on imported edible oil, dry milk, pulses, and other processed food products, with the food import bill reaching around US$ 4 billion. Notably, imports of edible oil alone constitute US$ 2.7 billion, accounting for 67% of the total import bill for food items (Ministry of National Food Security and Research, 2016).

According to Pakistan's latest National Nutrition Survey (2018), 36.9 percent of the households in Pakistan labelled are food insecure. 40% of children aged below five years are stunted, 17.7% are wasted, 28.9% are underweight and 9.5% are overweight (Figure 6). The stunting, wasting and underweight prevalence is relatively higher in rural areas than the urban.

Considering women between 15-49 years, 14.5% are underweight, 24.2% are overweight and 13.9% are obese. Sindh, Baluchistan and AJK have more undernourished women while overweight and obesity are more pronounced in ICT, KP and KP-NMD (UNICEF, 2018).

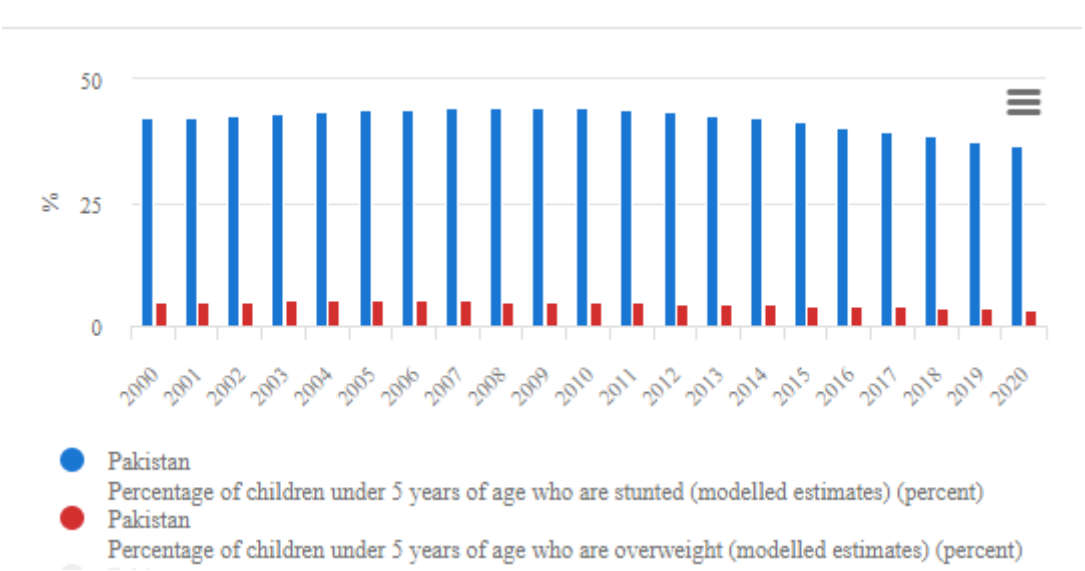

Figure 6 Percentage of child malnutrition

Source: FAOSTAT 2021

There are also significant figures of prevalence of micro-nutrient deficiencies like vitamin-D, vitamin-A, iron, folic acid, calcium, vitamin-B12 and Zinc due in part to low diversity in the diets.

The causal factors to malnutrition in Pakistan are varied. However, the major underlying factors include both limitations in households' access and affordability to healthy and nutritious foods, the food habits and preferences, urbanization and globalization influence in food consumption patterns, which collective shape the food

purchasing and preparation practices (Ministry of National Food Security and Research, 2021).

Regarding accessibility, limited attention has been paid to the local production of minor crops and livestock produce, such as pulses, fruits, vegetables, nuts and oilseeds, which not only contribute around 50 percent of dietary energy, but also significantly contribute to the nutritional food security. In contrast, a large infrastructure of government-run commodity operations works in the country to ensure the availability of major food crops (especially wheat) (State bank of Pakistan, 2019).

It is also well recognised that the impacts of climate-related events such as flooding and droughts have significantly affected food prices and availability, which worsen food insecurity.

In relation to affordability, a part of this can be explained by the prevalence of poverty in the country. Almost a quarter of Pakistan's total population lives below the poverty line. This means that around 50 million people in the country are unable to meet basic needs given their incomes. Most of these people dwell in rural areas (State bank of Pakistan, 2019).

2.5 Losses and wastage

Food quality loss or waste refers to the decrease of a quality attributes of food (nutrition, aspect, etc.), linked to the degradation of the product, at all stages of the food chain from harvest to consumption.

In Pakistan, post-harvest losses in food grains are 15-18% and in fruits and vegetables they are accounted as 20-40%. The losses happened at harvest, threshing, storage and transportation stages (Ministry of Industries and Production, 2021).

The main causes of food losses are imbalanced use of inputs, faulty irrigation systems, diseases, insect and fungi damages, inappropriate harvesting practices, excessive supplies, poor grading and packaging, poor handling during transportation, lack of storage facilities, frequent failure and or interruption of power supply.

Effectively reducing losses and wastage requires the active engagement of both public and private sectors (Ministry of National Food Security and Research, 2016).

3 Climate risks and food systems

Pakistan is ranked among the top ten most climate vulnerable countries in the world in the Global Climate Risk Index (Thow *et al.*, 2022). Climate change can negatively impact food value chains by inhibiting production, constraining processing and transportation, increasing trade deficits, lowering export prices and, thus, limiting the participation of food system actors. Through a domino effect, food and nutrition security of the population might decrease while having a detrimental effect on their resilience.

3.1 Climate risks and vulnerability overview

3.1.1 Current climate and key trends

The country has a diversified geography and climate, ranging from the Himalayas to coastal regions (CIAT and World Bank, 2017), with four well- marked seasons: winter (December to March), pre- monsoon (April to May), summer or monsoon (June to September) and post- monsoon (October to November) (Sheikh et al., 2009). Summer season is extremely hot and the humidity ranges between 25% to 50%. Daytime temperature ranges around 40°C in plain regions and 15°C in northern areas. The average winter temperature ranges around 4°C to 20°C in the plain areas. Whereas, in northern mountainous region, temperature sometimes falls as low as -50°C (CIAT and World Bank, 2017).

In summer, Pakistan receives rainfall from south Asian monsoon whereas in winter, rainfall is the result of western disturbances. Most of the country receives rainfall of less than 250 mm annually, except in the southern slopes of Himalaya and the sub mountainous regions in the northern segment of the country, where annual rainfall ranges from 760 mm to 2,000 mm (Government of Pakistan, 2018).

Temperature

Warming in Pakistan was estimated at 0.57°C over the 20th century, slightly less than the average for the South Asia region of 0.75°C. Warming is strongly biased towards the winter and post-monsoon months (November–February) and more pronounced in the southern region, with Punjab, Sindh, and Balochistan experiencing winter warming of 0.91°C–1.12°C over the same period, and Khyber Pakhtunkhwa in the north experiencing only 0.52°C. The rise in average daily maximum temperatures (0.87°C between 1961–2007) has been slightly stronger than the rise in average temperatures. A concurrent increase in the frequency of heat wave days has been documented, particularly in Sindh Province (World Bank, 2021).

Projected temperature increases in Pakistan are significantly higher than the global average. The model ensemble projects an average increase of 5.3°C in the highest emissions pathway scenario (RCP8.5). Uncertainty clouds projections on the seasonality of future changes, but the broad trend matches the historic pattern seen, showing stronger increases in Oct–Dec than Jun–Aug (World Bank, 2021).

Precipitation

Pakistan has a complex historical precipitation profile. While early 20th-century trends showed a decline, since 1960, there's been a slight increase. This overall trend hides considerable sub-national variation. Mean rainfall in the arid plains of Pakistan and the coastal belt has decreased by 10%–15% since 1960, contributing to the ongoing degradation of the country's wetlands and mangrove ecosystems. Most other regions have experienced a slight increase in the monsoon and dry seasons. The number of heavy rainfall events has increased since 1960, and the nine heaviest rains recorded in 24 hours were recorded in 2010 (World Bank, 2021). Glaciers in most of the Himalayas are retreating, exept in the Karakoram region, where glaciers are either advancing or stable (Parry, 2016).

Great uncertainty surrounds projections of future precipitation rates in Pakistan and changes on an annual basis for the model ensemble are not statistically significant. However, the increase in average annual precipitation under the highest emissions pathway (RCP8.5) by the end of the century is supported by multiple models.

Additionally, a study suggests that precipitation may increase in the Upper Indus basin, and decrease in the Lower Indus basin (Rajbhandari *et al.*, 2015).

Scientific research also highlights the risk of increased frequency and intensity of flood and drought events due to changes in the seasonality, regularity, and extremes of precipitation (Amin *et al.*, 2017; World Bank, 2021).

The inconsistent performance of climate models in projecting precipitation trends in Pakistan is in part associated to the challenges to simulate changes in the South Asian monsoon as well as the dynamics of El Niño Southern Oscillation (Parry, 2016; World Bank, 2021)

Sea level rise

Since 1900, the sea level rise has greatly accelerated. During the period 2006-2018, it has been rising at a rate of 3.7 mm/year – nearly three times as fast as during 1901-1971 (IPCC, 2022b). Along the coast of Pakistan, sea levels have risen by about 1.2 mm per year in recent decades, which is below the global average. However, combined with delta flooding, this process has already adversely affected water availability and livelihoods (Parry, 2016).

The largest area of vulnerability is the Indus Delta, around 4,750 km2 of which sits below 2 m above sea-level. The city of Karachi could witness sea level rise of up to 15 cm in the next 20 years, affecting millions of people. Saline intrusion continues to be a major challenge in the coastal zone, degrading land quality and agricultural yields. These issues are likely to intensify, affecting many marginal and deprived communities (World Bank, 2021).

3.1.2 Main climate hazards

Table 4 Main climate hazards in Pakistan

Climate hazard	Relevance in the country
Increased variability in river flows	In Pakistan, where inter- annual variation in precipitation is already very high, variability of river flows will further increase due to increase in the variability of monsoon and winter rains and decrease of natural reservoirs in the form of glaciers and perennial snow (Government of Pakistan, 2018).
Glacier's retreat in the HKH	Most glaciers in the eastern Himalayas, suffered intense mass losses as the result of exceptionally warm and dry conditions in 2021 (World Meteorological Organization, 2021). The changes in Indus River System (IRS) flows are linked with the response of the Karakoram glaciers to climate change. However, the projection of this response has been subject of debate. Some studies emphasize that longer-term temperature rises will result in glacial loss, and reductions in the runoff and river flows of the Indus, as well as changes to its seasonal profile. Other studies suggest glaciers could expand in size due to increased winter rainfall (Government of Pakistan, 2018; World Bank, 2021). The domino effect of these melting glaciers could include landslides, dam bursts, heavy flooding, soil erosion, and long-term water scarcity.
Glacial Lake Outburst Floods (GLOFs)	Pakistan's mountain regions also hold vulnerability to glacial lake outburst floods, triggered when ice melt and moraine failure releases large volumes of water trapped at high altitudes (Government of Pakistan, 2018; World Bank, 2021). It is estimated that 7.1 million people are at risk from GLOFs. For example, a heatwave triggered an extreme GLOF in northern Pakistan in 2022. (Zachariah *et al.*, 2023).

Floods	Extreme rainfall events have impacted the country in the recent decades and are projected to increase in frequency and severity. For example, the flood of 2010 resulted in about 2000 deaths and over 20 million people affected. In 2022, one-third of the country was under water, 1,700 people died, 33 million people were affected, and nearly 8 million people were displaced. (Government of Pakistan, 2022). While the underlying drivers of the impacts are not limited to climate change, the scale of the flooding emphasised the nation's vulnerability to this risk. The uncertainty around issues such as glacial melt, average precipitation, and extreme precipitation projections is a major concern (World Bank, 2021). Deforestation and inappropriate design or maintenance of canals are major issues that amplify flood risk.
Droughts	The probability of meteorological drought is projected to strongly increase under all emissions pathways. Drought frequency is increasing in already arid and semi-arid areas, but will also be more frequent in Pakistan's wetter northern areas. In 1999 and 2000, a major drought caused crop failure, killed 2 million livestock heads and caused a mass famine in Pakistan. The understanding of climate change interactions with El Niño phenomenon is key to mitigate this risk (World Bank, 2021).
Landslides	Northern Pakistan is particularly prone to landslides and with climate change projected to increase rainfall intensity this is likely to become worse in the future (Shahzad, Ding and Abbas, 2022). Expansion of crop areas can impact natural ecosystems, reduce flood water drainage and destabilise slopes, making landslides more likely (World Bank, 2021). Landslides can block water sources and roadways affecting food production and transportation.
Sea level rise and salinization.	17 mouths of the Indus River have now decreased to two active creeks and there has a been reduction of 92% of the active delta from 1.3 million ha in 1833 to 100,000 ha in 2017. 42,607 ha of land are degraded. Sea intrusion of up to 225 kms is indicated. With changes in the flows of the Indus river and the projection of sea-level rise, this issues will be likely to intensify, affecting many vulnerable communities (World Bank, 2021). Additionally, sea level rise could significantly contribute to losses of coastal wetlands and mangroves by increasing salinity in the coastal areas (Government of Pakistan, 2022).
Heatwaves	In June 2015, Karachi city was hit by a severe heatwave, causing the death of over 1,200 people and 50,000 reporting illness (Government of Pakistan, 2022). In Pakistan, mean annual temperature, and heatwave are projected to increase resulting in a greater number of people at risk of heat- related medical conditions (World Bank, 2021).
Tropical cyclones	The coastline is prone to tropical cyclones and tsunamis increased by higher sea surface temperatures (Ministry of Climate Change, 2021). The ocean shows an overall surface warming trend at rates of more than 0.04 °C per year in the area of the Arabian Sea, which is about three times faster than the global surface ocean warming rate (World Meteorological Organization, 2021). Yemyin Cyclone (2007) affected 2.3M people costing USD322M in damages. Other lesser cyclone events have occurred in 2010, 2022, 1999 and 1997.

3.1.3 Impacts on and vulnerability of food systems.

Ideally, a systems approach should be used to assess how climate change affect the food sector in Pakistan, emphasising the interactions within the components of the

system, including its enabling socioeconomic and biophysical environment. However, most of the research on climate change impacts on food systems is only focused on production. A significant knowledge gap exists around the complex ways in which climate change impacts food processing, storage, distribution and consumption (IPCC, 2022b).

Agriculture-based food systems

Agriculture in Pakistan is significantly affected by short- term climate variability and longer-term climate change. Severe droughts followed by devastating floods have contributed to low crop yields, loss of livestock, damage to irrigation infrastructure and food shortages.

The extra heat leads to early grain formation which stunts wheat and corn grains size, reducing yields. For example, in March and April of 2022, in conjunction with fertilizer shortages and lack of irrigation water, extreme temperatures affected wheat crop yields in the Rabi season (Food Security Information Network and Global Network Against Food Crises, 2023).

Later in the year, a devastating flood event caused economic losses associated to the agriculture, food, livestock, and fisheries amounted to US$9,244 million and damages were calculated in US$3,725 million. Around 4,410 million acres of agricultural land were damaged (Ministry of Planning Development & Special Initiatives, 2022).

Temperature increases have also been shown to reduce fruit trees productivity. In the Indus Delta, the early end of the winter season is causing heat stress problems for banana crops and limiting pollination. This is resulting a reduction in quantity and quality (Environment Climate Change and Coastal Development Department - Government of Sindh, 2021). Additionally, increases in temperature can result in decreased protein, zinc, iron, and quality of protein in crops, contributing to malnutrition and stunting (Government of Pakistan, 2021)

The destruction of crops has resulted in the deterioration of livelihoods, employment and agriculture related income, spilling over on the industry and services sectors, as well as decline of exports of important crops such as rice and sugar cane.

Droughts are expected to increase in winter, while increase in precipitation in the summer season may cause floods. Despite extensive irrigation infrastructure, there are gaps in water management that result in leaving the country in a water-stressed situation for a large part of the year.

Studies suggest that temperature rises of 0.5°C–2°C could lead to around an 8%–10% loss in yield of crops such as wheat, sugarcane, maize, rice and fruit crops (Dehlavi, Groom and Gorst, 2015; CIAT and World Bank, 2017; World Bank, 2021) (Figure 7). Moreover, climate change impacts on water resources needed for agriculture are unclear due to the uncertain behaviour of the northern glaciers.

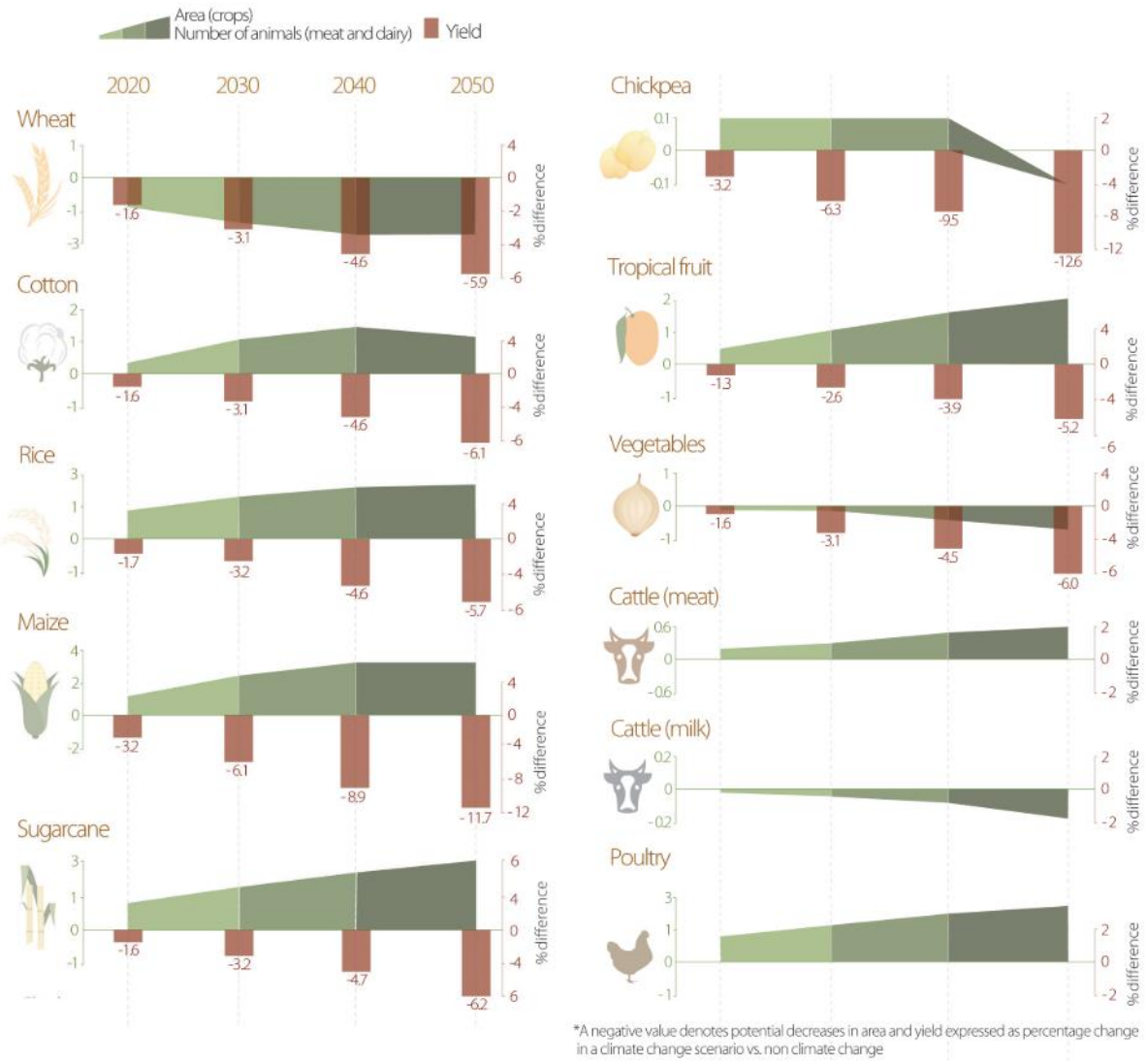

Figure 7 Climate change impacts on yield, crop area and livestock numbers in Pakistan (IMPACT model)

Source: (Robinson *et al.*, 2015; CIAT and World Bank, 2017)

Model Used: International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)

Apart from the decrease in yields, other cascading impacts have been observed. Crops grown in Sindh's desert regions are particularly vulnerable to agricultural pests and disease outbreaks following flooding and erratic rainfall. This is projected to become more severe with an increase in wet and very wet days (Zhu *et al.*, 2013). For example, in 2019-2020, Pakistan experienced a locust infestation after unprecedented heavy rains and cyclones in the Arabian Peninsula. With losses totalling nearly US$ 2.5 billion and a declaration of national emergency (UNDP, 2021).

A further influence of climate change on agricultural production is through its impact on the health and productivity of the labour force, which is expected to drop as a result of warming (World Bank, 2021). Additionally, climate induced migration could increase having implications for food security in both urban and rural populations. For example, 80% of the population in the Indus Delta has now been displaced, many moving to Karachi. Floods and coastal intrusion have been key drivers of this dynamic (Idris, 2021)

Livestock-based food systems

An analysis involving 148 countries in terms of the potential vulnerability of their livestock sector to climate and population change shows that South Asia is the most vulnerable region. However, there is scarcity of information on the projected impacts and adaptation aspects of livestock production both at the global and national level (IPCC, 2022a).

In terms of direct impacts, climate-change-induced heat stress and reduced water availability are likely to have negative effects on livestock (IPCC, 2022a). Most domestic livestock have comfort zones in the range 10–30°C, depending on species and breed (Nardone *et al.*, 2006). At higher temperatures, animals eat 3–5% less per additional degree of temperature, reducing their productivity and reproductive performance. For instance, a severe heatwave in 2015, primarily focused on Sindh Province, affected livestock productivity significantly.

Additionally, heat stress suppresses the immune and endocrine system, enhancing susceptibility of the animal to disease (Das *et al.*, 2016). For instance, Droughts in the Sindh and Baluchistan provinces killed two million animals from 1999 to 2002 (World Bank, 2021).

Flooding and landslides events also have direct impact on livestock. In the devastating flood of 2022, around 0.8 million livestock were estimated to have perished, which meant the loss of livelihoods for many families (Ministry of Planning Development & Special Initiatives, 2022).

Regarding the indirect impacts, changing seasonality, increasing frequency of drought and rising temperatures are affecting pastoral systems, decreasing fodder availability, and increasing incidence of vector borne diseases, and parasites, resulting in decreasing productivity (Stanimirova *et al.*, 2019). Additionally, climate change has induced severe impacts on livestock through degradation of rangelands, pastures and forests in the Hindu Kush Himalaya region (IPCC, 2022a).

Fishery- based food systems

Climate change is predicted to decrease total productive fisheries potential in South and Southeast Asia, driven by a temperature increase of approximately 2°C by 2050 (IPCC, 2022a).

Sea level rise, changes in precipitation and an increase in temperature have drastic effects on Pakistani fisheries and aquaculture, including the local communities depending on them for livelihoods (FAO, 2018)

Increased water temperature, acidification and reduced dissolved oxygen can lead to spawning time changing, which then means that fish are more susceptible to parasites and that their feed conversion ratio is reduced (Environment Climate Change and Coastal Development Department - Government of Sindh, 2021). Likewise, water salinisation brought about by sea level rise is expected to impact the availability of freshwater fish (Dasgupta *et al.*, 2017).

About 69% of the commercially important species were found to be impacted by climate change and other anthropogenic factors. A regional study of South Asia forecast large decreases in potential catch of two key commercial fish species (hilsa shad and Bombay duck) which form a major fishery and food source for coastal communities (Dineshbabu *et al.*, 2020).

In Sindh, 65% of the population depend on catching and drying fish, but as fish species decrease due to increased temperatures and the removal of mangroves for charcoal

production, fishermen have to go further out and rely on more dangerous deep sea fishing opportunities (Saqlain and Fullwood-Thomas, 2017).

The post-harvest supply chain

Climate change impacts along the value chain alter availability, access and stability of food security. For the cases of extreme climate events, it is projected that inflation could increase further as food prices rise in response to crop damage, loss of livestock, and the disruption of transport infrastructure critical for supplying agriculture output to markets.

Essential food commodities such as wheat, rice, chicken, meat, eggs, milk, and fresh vegetables make up 18.4 percent of the total urban basic food basket and 26.9 percent in the rural areas. Increase in the prices of these items due to their direct link to the domestic production will ultimately affect the affordability of food (Ministry of Planning Development & Special Initiatives, 2022). Projections show that by 2050, under RCP8.5, there will be 9.32 climate related deaths per million linked to lack of food availability, however this does not include potential climate-related changes to the nutritional content of food (Asian Development Bank and World Bank, 2021).

Despite there is a gap of scientific information on the post-harvest supply chain in Pakistan, many of the impacts identified for other locations are applicable, especially for nutrition-dense foods, which tend to be more perishable and are thus more vulnerable to the impacts of climate change. Among the impacts included in the Sixth IPCC report, the most applicable for Pakistan's food system are listed below:

- Climate-change-related damage to food in storage (e.g., loss of cold storage) and transportation infrastructure (e.g., extreme weather events damaging roads and other infrastructure) could significantly decrease availability and affordability of fruits, vegetables, fish, meat and dairy.
- Higher temperatures and humidity can increase post-harvest loss from pests and diseases, increase occurrence of food-borne diseases and contamination, and raise the cost of refrigeration and other forms of preservation.
- Post-harvest food loss from climate change can occur from microorganisms, insects, rodents or birds.
- Food waste caused by climate change may occur at both retail units and homes because fresh ingredients and prepared foods are vulnerable to quality reduction from exposure to higher temperatures and humidity.
- Rising air temperature, ocean warming, and high CO2 conditions increase risk of food poisoning and pollutant contamination of food through increased prevalence of pathogens, and increased contaminant bioaccumulation and threaten human health.
- The impact of the floods is likely to exacerbate already existing gender inequalities, revealing serious differences in safety, education, decision-making, and employment.

The water–energy–food (WEF) nexus in Pakistan

90% of food production in Pakistan come from irrigated agriculture (Akhtar, Mushtaq and Hashmi, 2020). However, the productivity of agricultural water is 37% per cubic metre, which puts Pakistan into the bottom 10% globally (World Bank Group, 2022).

Intensified rainfall and flood events result in highly damaged irrigation systems. This adversely affects crop production in the coming production seasons. For example, after the floods event of 2022, US$711 million were estimated in damages to water

supply and irrigation systems, which means that, if unaddressed, low food production is anticipated in the coming years, leading to food shortages and high food commodity prices (Ministry of Planning Development & Special Initiatives, 2022).

At the same time, water security is also at risk due to longer dry periods, with a 6% decrease in rain leading to a 29% increase in irrigation needs across the country (Ali and Erenstein, 2017).

Regarding the energy sector, hydropower accounts for 31% of total generation. Reduced water supplies caused by unreliable or variable rainfall and rising temperatures (and subsequent evaporation), particularly during the summer when cooling demand is highest, have resulted in ongoing power outages and crippled the economy, with an estimated annual loss of 2% of GDP. It is anticipated that this will be further exacerbated in the future with power outages having a negative impact on post-harvesting activities leading to increased food waste and loss (WWF, 2022).

Additionally, a prolonged dispute among Pakistan's four provinces centres on the proposed Kalabagh Dam, supported solely by Punjab. Opponents argue that the dam would favour Punjab with additional water and hydroelectricity, but it raises concerns about water storing pools leading to agricultural land loss and water diversion in other provinces (Imran, 2021).

The competition among sectors will necessitate inter-sectoral trade-offs that will likely be made at the expense of water for agriculture. It is projected that, in the next three decades, about 10 percent of all irrigation water will need to be repurposed to meet non-agricultural demand (Davies and Young, 2021).

3.2 Other factors and stressors leading to non-resilient food systems

Non-climatic stressors aggravate climate risks in food systems in Pakistan. For example, climate change interacts with multi-dimensional vulnerability factors like access to public services and education. In Pakistan, nearly 29.5% of the total population is living below the poverty line, more than 50% of household are using motorized or manual pumping as main source of drinking water and 52% of the population do not have a primary level of education (Pakistan Bureau of Statistics, 2021).

In regard to the natural environment, high pressure on natural resources with widespread ecosystems degradation, accelerated desertification and increased pollution is eroding the country's productive lands. Key factors include:

- The dysfunctional drainage system exacerbates flood impacts, with the Indus Basin's natural waterways obstructed by irrigation infrastructure and flood protection bunds. There have also been questions about the ethics behind the current flood control systems, which divert water to rural areas to protect cities (L Otto *et al.*, 2022).
- Intensive irrigation systems of water-intensive crops such as sugar and poor drainage practices have caused waterlogging and soil salinity throughout Pakistan. Large volumes of water from the Indus have been diverted upstream to the Punjab province for agriculture. Downstream in the Sindh, the Indus has shrunk to a canal and in some areas runs dry. Fishermen are now forced to buy water from trucks.
- Large-scale farming contributes to soil erosion, causing ≅ 200 M tonnes/ year of sediment to reach water sources, carrying pesticides and fertilizers (Government of Pakistan, 2018).

- Soil erosion has reduced storage capacity of dams. For example, 30% of the capacity of Tarbela Dam has been lost since the 1970s (Government of Pakistan, 2018).
- Excessive withdrawals of surface water and agrochemical contaminants have affected soil quality and river ecology.
- The degradation of wetlands and marine-coastal ecosystems negatively impacts the delta marine fisheries and mangrove forests. For example, The China-Pakistan Economic Corridor (CPEC) Port Qasim Power Project along the Arabian Sea coastline is reported to have affected livelihoods by damaging fragile coastal ecosystems (Idris, 2021).
- Water availability per capita is 1,000 m3 /capita/annum and falling. Agriculture accounts for 95% of total withdrawals and water demand from the sector is projected to increase with population growth. Marginal or non-agricultural land have been brought into arable use through water diversion schemes.
- Water pricing is a concern as the irrigation water tariff (abiana) levied per unit of cultivated area hardly covers even routine maintenance of the Indus irrigation system.
- There are no regulations on groundwater extraction in Pakistan and roughly 50% of all water for the irrigation system is extracted from the ground with no charge (Cornforth *et al.*, 2023). There are over 600,000 private and about 16,000 public tube wells in Pakistan. In several cities, water table has dropped more than ten meters and quality is affected by pollution (Government of Pakistan, 2018).

Among social-economic dynamics that intersect with resilience in food systems, the following are highlighted:

- The overall literacy rate in Pakistan is 58%, which makes a huge proportion of the population vulnerable to climate change, through a lack of education (World Food Programme, 2018). 44% of all school age children are not in school, the majority of these being girls (World Bank Group, 2022).
- Strong domestic demand, coupled with global commodity price hikes due to COVID-19 disruptions and the war in Ukraine, resulted in the largest current account deficit in four years by June 2022. Currency depreciation and inflation further strained economic stability (WB, October 2022). By December 2022, the price of a basket of basic food items was 36 percent higher year-on-year (WFP, January 2023).
- Smallholder farmers have limited access to education, finance, inputs, services, infrastructure and technology, which constrains productivity in agriculture and allied sectors. Geographic and social isolation is another type of social vulnerability, rural communities often have poor transport networks, limited access to markets or information and fewer livelihood alternatives, and are less able to be informed of risks or be assisted in the event of extreme climate events (IPCC, 2022b).
- A legacy of political instability, weak public institutions and the limited capacity of the public administration influence the fragility of the country. In addition, challenges include the tension from sectarian and religious conflicts, marginalization, youth unemployment, and gender-based inequities in participation in decision-making and access to land ownership and essential services (CIAT and World Bank, 2017).

In this context a combination of long-term structural vulnerabilities and short-term economic shocks is exacerbating food insecurity and vulnerability in Pakistan.

4 Climate, agriculture and food systems policies and practices

4.1 Visions, goals and objectives

Pakistan Vision 2025 recognizes that sufficient, reliable, clean and cost-effective availability of energy, water and food – for now and the future – is indispensable to ensure sustainable economic growth and development. There is a need to fill the enormous gaps in these areas, while simultaneously making efforts to respond to the looming threat of climate change. There is a renewed national consensus to commit major new resources through public and private sector collaboration in these areas and ensure required production and storage capacities. At the same time, efforts will be made towards conservation, efficient distribution and usage of resources, and preventing contamination and environmental degradation (Ministry of Planning Development and Reform, 2015).

4.2 National policies, plans, strategies and commitments

4.2.1 National Adaptation Plan (NAP)

The National Adaptation Plan of Pakistan is currently under development through a Readiness project financed by the GCF and implemented by UNEP. The NAP process will:

- Strengthen the capacity to coordinate and promote climate change adaptation (CCA) at systemic, institutional and individual levels, and help poor and climate vulnerable communities to adapt to climate change impact;
- Integrate CCA into policies, strategies, legislation, regulations, and programs;
- Strengthen a system to generate and share knowledge, experience, and lessons learned at national and sub-national levels to advance CCA; and
- Develop a strategy to implement, monitor, and communicate adaptation benefits at different levels, and scale up government efforts in adaptation efforts, and process of regularly updating NAP.

4.2.2 Nationally Determined Contributions (NDC) (2021)

Pakistan NDC 2021 indicates an adaptation cost of US$7-14 billion of urgent support needed for mainstreaming, institutional strengthening and integrated framework for adaptation and mitigation for enhanced social, economic and ecosystem resilience. Key contributions in the adaptation aspect include:

- To build resilience through nature-based solutions and protection of ecosystems and biodiversity.
- Mitigate impacts of extreme events through preparedness and capacity building.
- Incorporate health and environment in climate and disaster risk reduction related policies and vice versa.
- Improve climate resilience of communities through improved development outcomes in WASH sector.

4.2.3 Other instruments

National Climate Change Policy (2021):

This policy provides a framework for addressing climate change across various sectors, including agriculture. The updated Policy document has been designed in accordance with the requirements of Paris Agreement on climate change, Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction. Hence, appropriate measures relating to disaster preparedness, capacity building, institutional strengthening; technology transfer and international cooperation have also been incorporated as important components of the policy. Refer to Annex 1 for priority actions related to building climate resilience in food systems.

National food security policy (2018)

This policy has the mission to ensure a modern and efficient food production and distribution system that can best contribute towards food security and nutrition, in terms of availability, access, utilization and stability. The instrument includes as a goal making agriculture more productive, profitable, climate resilient and competitive. The strategic framework considers, among other priorities:

- The efficient use of natural resources such as water, land, rangelands, pasture and forests;
- Safe food production for better environment and climate change compatibility
- Equity including how to empower women and vulnerable groups such as sharecroppers, tenants, the landless, trans-humants, and marginalized communities from highly fragile areas such as mountains and deserts.
- Diversifying the food systems for better diets and nutrition through developing innovations targeting household food diversity specially focusing on implementing zero hunger program.
- Improving market support for achieving the goals of fair prices to both consumers and producers, and value chain development for better food availability and access.

National Food Pathways (2021):

The Strategic National Pathway Document highlights that managing future food security in Pakistan is more challenging than before in view of quantity and quality of natural resource base and climate change and other vulnerabilities, shocks and stresses. Priority actions under 5 tracks were proposed.

- Action track 1: Pakistan has adopted a strategy to increase the level of production of diversified safe food that allow supply to overtake the projected increase in demand.
- Action Track 2: Sustainable consumption patterns might be promoted by mass marketing of dietary guidelines, adopting calorie and environmental labelling for food items, food governance & regulatory monitoring and consumer awareness campaigns.
- Action Track 3: Incentivize regenerative and organic agriculture, promoting use of resource conservation technologies and green-manuring, promoting use of bio-chemicals in crop production & protection.
- Action Track 4: Advance equitable livelihoods by increasing the bargaining power of the farmers while providing competitive marketing options. The initiatives include entrepreneurial skill development and financial services for micro, small and medium sized enterprises (MSMEs).
- Action Track 5: Introduce agriculture parametric insurance products leading to the establishment of “Agriculture Index Insurance Pool”. Further focus will be

on climate resilient technologies development and conservative use of natural resources.

National Disaster Mitigation Plan- Pakistan Remodelled NDMP-II (2023):

This plan is a successor document of National Disaster Management Plan-I 2012-2022. The NDMP-II shall serve as a comprehensive plan that outlines the strategies and interventions to prepare for and respond to emergencies in a coordinated manner. It identifies the roles and responsibilities of various stakeholders and outlines the necessary actions to be taken at each level to manage disasters. The plan focuses on building existing coping capacities and emphasizes the need for community involvement.

The following strategies would directly aim to minimize, advert and address loss and damage in the food systems:

- Functionalize the disaster management system at district levels
- Developing multi-hazard vulnerability and risk assessment profile at national levels
- Developing disaster risk management plans at various levels
- Climate change adaptation
- Promoting climate smart and disaster resilient sustainable development
- Strengthening of multi-hazard early warning system
- Building capacities through training and research
- Community involvement in reducing disaster risk at local level
- Preparedness for effective emergency response
- Post disaster recovery

Action Plan on Sustainable Consumption and Production (SCP) for Pakistan's Sustainable Food System:

The plan emphasizes on the shift towards more sustainable food system all along the food value chain. The Plan has the following objectives:

- Create a modern, efficient and diversified agriculture by adopting Sustainable agriculture practices, technologies for sustainable production system and to meet food security;
- Reduce food waste and crop loss;
- Increase and ensure protection and preservation of prime agricultural land and combat Desertification and Drought; and,
- Adoption of climate resilient techniques and measures for ensuring food security and sustainable agriculture.

Resilient Recovery, Rehabilitation, and Reconstruction Framework (4RF)

In response to the 2022 floods, the Resilient Recovery, Rehabilitation, and Reconstruction Framework (4RF) is the Government of Pakistan's strategic policy and prioritization document which will guide the recovery, rehabilitation and reconstruction of the country. The framework draws from the findings of the Post Disaster Needs Assessment (PDNA) and presents sequenced priorities around four Strategic Recovery Objectives (SRO), a policy framework, a financing strategy, and implementation and monitoring arrangements.

Strategic Recovery Objectives (SRO):

- Enhance governance and the capacities of the state institutions to restore lives and livelihoods of the affected people, especially the most vulnerable
- Restore livelihoods and economic opportunities
- Ensure social inclusion and participation
- Restore and improve basic services and physical infrastructure in a resilient and sustainable manner (Government of Pakistan, 2022)

Technology Needs Assessment for Climate change Adaptation

The technology needs relevant to the food systems are:

Agriculture

- High-efficiency irrigation systems for irrigated and rain-fed areas
- Drought-tolerant crop varieties
- Climate monitoring and forecasting – early warning system

Water

- Surface rainwater harvesting
- Groundwater recharge
- Urban storm-water management

Provincial agriculture policies:

Four provinces have agriculture policies and all of them include actions aiming to build climate resilience. However, their implementation is limited. Refer to Annex 2 for a summary of the resilience approach of each provincial policy.

Other relevant policies or instruments include:

- Framework for Implementation of National Climate Change Policy
- Second National Communication to UNFCCC
- First Biannual Update Report 2022
- Prime Minister Agriculture Emergency Program
- Sustainable Development Policy
- National Zero Hunger Program
- GB Agriculture Policy
- Multisectoral Nutrition Strategy 2018-25
- Pakistan Adolescent Nutrition Strategy 2020-25
- Climate change gender action plan (ccGAP) – GCF

5 Institutional arrangements and coordination.

In Pakistan, institutional arrangements and coordination related to food systems and climate change involve various government departments, agencies, and stakeholders at different levels. Here's an overview of the key institutional arrangements and coordination mechanisms in Pakistan:

Ministry of Climate Change and Environmental Coordination: The MoCC is the primary governmental entity responsible for formulating and implementing policies, plans, and strategies related to climate change. It plays a crucial role in coordinating climate change-related initiatives across different sectors, including agriculture and food systems.

Ministry of National Food Security and Research: The MNFS&R is responsible for formulating policies and plans related to food security, agriculture, and livestock.

It plays a significant role in coordinating efforts to enhance climate resilience in the agriculture sector and address climate change impacts on food systems.

Provincial Departments and Agencies: Pakistan has four provinces, each with its own departments and agencies responsible for agriculture, food security, and climate change. These departments, such as the Agriculture Departments, Irrigation Departments, and Environmental Protection Agencies, work on implementing climate adaptation and mitigation measures at the provincial level and coordinate with the federal government.

National and Provincial Climate Change Cells: National and provincial climate change cells serve as focal points for coordinating climate change activities and programs within their respective jurisdictions. They facilitate coordination among different stakeholders, monitor progress, and support the implementation of climate-related initiatives.

Climate Change Policy Implementation Committees: These committees are established at the federal and provincial levels to oversee the implementation of climate change policies and strategies. They bring together representatives from relevant ministries, departments, and civil society organizations to ensure effective coordination and collaboration.

Research and Academic Institutions: Various research and academic institutions in Pakistan contribute to knowledge generation, research, and capacity-building efforts related to climate change and food systems. They provide technical expertise, conduct studies, and collaborate with government entities to inform policy development and implementation.

International Cooperation: Pakistan collaborates with international organizations, bilateral partners, and donor agencies to address climate change and food system challenges. These collaborations involve coordination mechanisms and partnerships to access financial resources, technical expertise, and knowledge sharing.

It is important to note that coordination and institutional arrangements can vary in their effectiveness and may face challenges such as limited resources, coordination gaps, and overlapping mandates. To ensure efficient coordination and effective implementation, ongoing efforts are required to strengthen institutional capacities, streamline coordination mechanisms, improve data sharing, and enhance collaboration among relevant stakeholders at all levels.

6 Priority actions for resilient food systems

Priority 1: Technology transfer for water management and climate resilient agriculture:

Efficient water management and climate-resilient agriculture are critical components of ensuring food security in Pakistan. Priority actions include the adoption of technologies such as rainwater harvesting systems, groundwater recharge, high efficiency irrigation systems, drought tolerant crop varieties, climate monitoring and forecasting and early warning system. The progress in technology transfer must be accompanied by the conformation of a knowledge exchange network on water management and climate resilient agriculture. Additionally, this priority includes the enhancement of the research capacity of various relevant organizations to address knowledge gaps on climate risks and adaptation strategies in the food systems.

Priority 2: Climate Change Adaptation through Nature-based solutions in the Indus River Watershed

Nature-based Solutions have the potential to put Pakistan on a more climate-resilient and nature-positive pathway. NbS can meet many of society's adaptation needs and priorities, while also conserving and restoring the ecosystems on which food systems depend. It can also help the country make progress in multiple objectives including not only climate change adaptation, but also climate change mitigation, biodiversity conservation and sustainable development more broadly. This priority emphasizes the need to accelerate and scale up NbS implementation, supported by robust policies, regulations, and financial resources. Restoration of ecosystem services, land degradation control, biodiversity conservation, and sustainable management of resources like rangelands and agroforestry are integral components of NbS strategies.

Priority 3: Promotion of climate-resilient livelihoods and creation of agri-food, livestock, and fisheries value chains, leveraging opportunities for youth and women

This priority includes the improvement of agriculture, livestock and fisheries resilience and productivity by promoting climate-smart measures. This will be articulated with the development of processing clusters of high value products and the reduction of post-harvest losses. Value addition and innovation must be central, as well as gender-responsive climate-resilient strategies and youth access to tools to enhance their livelihoods. Linkages with markets and access to credit or other financing sources will be promoted. Diversification of food will be fostered at the production and consumption tiers of the value chains.

Priority 4: Comprehensive risk management system for food security

This priority encompasses three components of risk management that can be built on the framework of the National Disaster Management Plan (2023): (i) National Level Food Security Information and Early Warning System (FSIEWS) and develop the harmonized framework of governance; (ii) support and strengthen adaptation and response capacity at district, provincial and national levels; and, (iii) prevent and respond to disasters and food crises. This priority requires the interinstitutional work of the National Disaster Management Authority and the multiple sectors involved in food systems. Actions under this priority include strategies to deal with climate induced loss and damage through policies and actions for recovery, rehabilitation and reconstruction.

Setting up a Climate Development and Knowledge Network is essential to prepare all stakeholders for potential future hazards, reducing vulnerability and preventing loss and damage within food systems.

Priority 5: Developing an enabling environment for climate resilient food systems

This priority highlights the need to review and develop key policies, legislation, and institutions; mainstream climate resilience into national development planning and implementation; and initiate and/or develop coherent systems and strategies for climate finance, capacity development and research, climate services, and a national system for monitoring, evaluation, and research of climate resilience. This process could include the revision of water management policies and the integration of climate change adaptation for food security in such instruments.

This priority must be based on updated and reliable climate risk assessment and promote the development of capacities at national and subnational levels to make decisions towards a more resilient food system.

Priority	Instrument	Barriers
Priority 1: Technology transfer for water management and climate resilient agriculture	• National Climate Change Policy (2021) • Adaptation Technology Needs Assessment (2017) • Food Security Policy (2016) • 4R framework (2022) • Updated NDC (2021) • Updated NDC (2021)	• Insufficient cooperation for technology transfer, and knowledge sharing and co-production.
Priority 2: Climate Change Adaptation through Nature-based solutions in the Indus River Watershed	• 4R framework (2022) • Food Security Policy (2016) • National Climate Change Policy (2021) • Updated NDC (2021) • National Disasters Mitigation Plan (2023)	• Technocratic approaches to water management focusing exclusively on engineering measures. • Limited awareness and understanding of NbS among national and local policymakers, preventing its inclusion in policies, regulations and budgets. • Limited awareness and understanding of NbS among private sector actors, hindering its integration in risk management strategies and investments. • Lack of transboundary approaches for NbS at the basin level. • Uncertainty about the biophysical limits to ecosystems in a changing climate
Priority 3: Promotion of climate-resilient agri-food, livestock, and fisheries value chains, leveraging opportunities for youth and women	• Food Security Policy (2016) • 4R framework (2022) • National Climate Change Policy (2021) • Updated NDC (2021)	• Limited finance for adaptation. • Lack of an enabling environment for cold chain development to reduce food loss and waste. • Insufficient access to Agricultural Risk Insurance for resilience building. • Lack of Incentives to producers to adopt and invest in climate-smart technologies and practices. • Marginal women's and youth participation across resource governance, agri-business development, and digital innovations
Priority 4: Integrated risk management system for food security	• National Food pathways • Food Security Policy (2016) • 4R framework (2022) • National Disasters Mitigation Plan (2023)	• Limited monitoring of food crisis risks does not allow to take early and preventative action to protect vulnerable populations in contexts affected by natural resource scarcity, and exposure to climate shocks. • Lack of an integrated approach that addresses the challenges of climate change by combining social assistance and disaster risk reduction strategies.

Priority 5: Developing an enabling environment for climate resilience in Pakistan	• Food Security Policy (2016) • 4R framework (2022) • National Climate Change Policy (2021) • Updated NDC (2021) • National Disasters Mitigation Plan (2023)	• Knowledge gaps on climate risks, impacts on food systems and adaptation options. • Outdated or disarticulated policies at national and provincial levels. • Insufficient enforcement and investment for the implementation of the policies. • Insufficient investment in research and innovation to transform the agri-food systems through improved resilience. • Limited policy packages that shift consumption towards sustainable healthy diets and make them affordable for all. • Existing counterproductive incentives in agricultural, trade, and investment policies prevent the mobilization of public and private finance for climate-positive food systems transformation.

7 Relevant projects, programmes and initiatives contributing to the implementation of the priority actions.

Drawing from the desk revision, previous and current projects were reviewed and linked to the main priority action to which they have mainly contributed. In some cases, one project contributed to two or more priority actions. Complemented with the desk revision of the policy framework, this exercise will help identify progress and gaps in the implementation of the priority actions for food resilient systems.

Priority 1: Technology transfer for water management and climate resilient agriculture

- Agricultural Innovation Program (AIP) (Link)
- Agri-hub Project

Priority 2: Climate Change Adaptation through Nature-based solutions in the Indus River Watershed

- The Living Indus initiative (LII) (Link)
- The Living Indus: managing climate change through ecological restoration (at concept note stage led by UNEP)
- Ten Billion Trees Tsunami Programme (Link)
- Indus Ecoregion Conservation Project (Link)
- Recharge Pakistan: Building Pakistan's Resilience to Climate Change through Ecosystem-Based Adaptation for Integrated Flood Risk Management- GCF (Link).
- Blue Carbon Project Pakistan (Link)
- Scaling-up of Glacial Lake Outburst Flood (GLOF I and II) risk reduction in Northern Pakistan – GCF and (Link)
- Transforming the Indus Basin with Climate Resilient Agriculture and Water Management – GCF (Link)
- Pakistan's Ecosystem Restoration Fund (Link)

Priority 3: Promotion of climate-resilient agri-food, livestock, and fisheries value chains, leveraging opportunities for youth and women

- Climate Resilient Urban Human Settlements Unit (Link)
- Punjab Irrigated Agriculture Productivity Improvement Project (Link)
- Sindh Resilience Project (Link)

Priority 4: Integrated risk management system for food security

- Khyber Pakhtunkhwa Food Security Support Project (Link)
- The Strategic Strengthening of Flood Warning and Management Capacity of Pakistan (Link)
- Disaster and Climate Resilience Improvement Program (Link)
- Hydromet and Disaster Risk Management Services Project (Link)
- Strengthening food security post COVID-19 and locust attacks (Link)

Priority 5: Developing an enabling environment for climate resilience in Pakistan

- Building capacity to advance National Adaptation Plan Process in Pakistan (NAP project) (Link)

8 Needs and gaps for implementation.

There are several institutional and policy challenges to the implementation of actions towards climate resilient food systems, including longstanding tensions between federal and provincial governments, low implementation capacity of government, shortage of financing and the lack of mainstreaming of adaptation into sectoral strategies.

The 18th amendment (Article 140A) to the Constitution of the Government of Pakistan in 2010 marked a significant shift in the country's institutional and governance structure. This amendment devolved legislative power over environmental issues to the provinces, giving them the responsibility to implement agricultural policies and actions based on priorities determined by sub-district authorities. However, the successful implementation of this devolution has been hindered by several critical gaps:

Implementation Challenges: Effective implementation of policies and plans remains a challenge. Limited institutional capacity, coordination issues among different government departments, and inadequate resources hinder the successful execution of climate and agriculture-related strategies.

Technology Adoption: The adoption of climate-smart agricultural technologies and practices by smallholder farmers remains relatively low. Limited access to improved seeds, modern irrigation systems, and machinery hampers the resilience-building efforts in the agriculture sector.

Research and Development: There is a need for increased investment in agricultural research to develop climate-resilient crop varieties, sustainable farming practices, and innovative solutions for climate change adaptation and mitigation.

Access to sustainable finance: Smallholder farmers and the entire market often face challenges in accessing credit and financial services to invest in climate-resilient agriculture. There is a need for improved access to affordable credit, insurance, and other financial instruments to support farmers' adaptation and resilience-building efforts.

Data and Information Systems: Insufficient data, limited monitoring systems, and inadequate climate and agricultural information networks pose challenges in

understanding climate risks, planning interventions, and implementing evidence-based policies.

Gender Mainstreaming: There is a need for greater attention to gender mainstreaming in climate and agriculture policies. Women farmers, who play a significant role in agriculture, face specific challenges and should be empowered through targeted interventions and inclusive decision-making processes.

9 Entry points for the work of the CRFS Alliance and its core partners

The review of policy framework and complementary instruments related to climate change and food systems in Pakistan shows that despite the complexity of both issues, the country is working on the integration of different agendas in order to have a more systemic approach to climate resilience in food systems.

The Climate-Resilient Food Systems (CRFS) alliance provides a framework for food systems transitions that deliver resilience to climate, shocks and stresses, protect biodiversity and ecosystems' services, reduce poverty and enhance social, gender, equity and North-South & inter-generational justice.

The table below outlines the entry points in relation to the Country Priority Actions, and how the CRFS alliance can mobilize its expertise to advance progress in the specific areas.

Priority	Entry points
Priority 1: Technology transfer for water management and climate resilient agriculture	**Support south-south and north-south cooperation and collaboration for the development/transfer of adaptation technologies for resilient food systems.** The CRFS Alliance can call for state and non-state actors to support adaptation technology transfer and help channel the implementation of the technologies through the work of the member organisations that are already implementing projects that involve climate-resilient technologies in the country. Thus, reducing time and financial resources in the process of capacity building and appropriation of the technologies by smallholder farmers and other actors in the value chain. Additionally, The CRFS Alliance can facilitate knowledge exchange and collaboration between national and international stakeholders, including researchers, policymakers, and practitioners. This can involve sharing best practices, lessons learned, and innovative technologies for irrigation, water re-use, rainwater harvesting and biotechnology for crops and livestock.
Priority 2: Climate Change Adaptation through Nature-based solutions in the Indus River Watershed	**Promote cross-sectoral and transboundary coordination for up-scaling EbA to the Indus River basin.** Key members of the CRFS Alliance have supported or are currently supporting NbS projects in the country (WWF, UNEP). The CRFS Alliance could bring multiple actors to a discussion on the lessons learned and opportunities for synergies to make the case for positioning NbS as a cost-effective strategy at the transnational level. The work of CRFS Alliance members supporting policy/law development and capacity building of national and local entities can contribute to the adoption of 'Ecosystem-based Adaptation' as part of an overall adaptation strategy in the country. For example, a focus on NbS for food security could be included in the National Adaptation Plan, some pilot drought and flood

	management plans could be developed or a Indus River protection Law could be promoted. The CRFS Alliance can contribute to monitoring and evaluating the effectiveness of NbS interventions or policy instruments related to building resilient food systems. This can involve developing indicators, data collection frameworks, and impact assessments to track progress, identify gaps, and inform adaptive management approaches.
Priority 3: Promotion of climate-resilient agri-food, livestock, and fisheries value chains, leveraging opportunities for youth and women	**Facilitate access to sustainable finance and technical assistance for climate resilient value chains.** The CRFS Alliance could increase the effectiveness of projected initiatives of UN partners such as the Living Indus Initiative, particularly about the design and establishment of the Pakistan Ecosystems Restoration Fund. Another entry point to address the adaptation financing gap would be the support that the CRFS Alliance and partners could provide in identifying and catalyzing opportunities to engage the financial sector in the work of the National Rural Support Program (NRSP) in order to channel funds to build climate resilient value chains. Additionally, the CRFS Alliance can play a role in capacity building by providing training programs, workshops, and technical assistance to strengthen the knowledge and skills of policymakers, researchers, extension workers, SMEs, NGOs and farmers. Capacity building initiatives can focus on climate-smart agriculture, sustainable farming practices, water management, and other areas relevant to building resilient food systems.
Priority 4: Integrated risk management system for food security	**The CRFS Alliance can foster partnerships** (i.e, with Insu-Resilience, REAP and FAO) to advance towards integrated risk management systems, with early or anticipatory action and climate risk insurance to strengthen the preparedness, food security and financial resilience of the most vulnerable communities. Through these partnerships, the Alliance can leverage collaborations among diverse stakeholders and mobilize support, raise awareness, and promote the integration of multiple agendas that could contribute to an integrated risk management for food security.
Priority 5: Developing an enabling environment for climate resilience in Pakistan	**Collect lessons learned and identify opportunities and barriers that stakeholders are facing to build climate resilient agri-food livelihoods and inform the NAP Process.** The CRFS Alliance can collect lessons learned, identify opportunities, and assess barriers faced by diverse actors in building climate-resilient agri-food livelihoods. This information can inform the National Adaptation Plan (NAP) Process and other planning instruments, providing insights into the enabler conditions necessary for effective, long-term, and gender-responsive promotion of resilient food systems. The CRFS alliance can help build the bridge between local action and national planning by promoting inter-sectors and interinstitutional dialogues and supporting participatory processes. The CRFS Alliance can support research initiatives focused on understanding the complex dynamics of food systems and climate risks in Pakistan. This includes studying the impacts of climate change, identifying vulnerabilities, and assessing the effectiveness of interventions aimed at enhancing resilience. The alliance can also promote interdisciplinary research to address knowledge gaps and provide evidence-based recommendations on integrating climate change adaptation, sustainable agriculture, and food security into national and sub-national policies.

10 Bibliography

Akhtar, T., Mushtaq, H. and Hashmi, M.Z.-R. (2020) 'Drought monitoring and prediction in climate vulnerable Pakistan: Integrating hydrologic and meteorologic perspectives', *Hydrology and Earth System Sciences Discussions*, (October), pp. 1–29.

Ali, A. and Erenstein, O. (2017) 'Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan', *Climate Risk Management*, 16, pp. 183–194. Available at: https://doi.org/10.1016/j.crm.2016.12.001.

Amin, A. *et al.* (2017) 'Comparison of future and base precipitation anomalies by SimCLIM statistical projection through ensemble approach in Pakistan', *Atmospheric Research*, 194, pp. 214–225. Available at: https://doi.org/10.1016/j.atmosres.2017.05.002.

Asian Development Bank and World Bank (2021) 'Climate risk country profile - Pakistan', p. 32.

Aziz, T. (2021) 'Changes in land use and ecosystem services values in Pakistan, 1950–2050', *Environmental Development*, 37. Available at: https://doi.org/10.1016/j.envdev.2020.100576.

CIAT and World Bank (2017) *Climate-Smart Agriculture in Pakistan*, *CSA Country Profiles for Pakistan*. International Center for Tropical Agriculture (CIAT). Available at: https://ccafs.cgiar.org/publications/climate-smart-agriculture-peru#.WW1A-YTyvm4.

Cornforth, R. *et al.* (2023) 'Pakistan climate change impact storylines based on existing vulnerability literature', *Walker Institute* [Preprint].

Das, R. *et al.* (2016) 'Impact of heat stress on health and performance of dairy animals: A review', *Veterinary World*, 9(3), pp. 260–268. Available at: https://doi.org/10.14202/vetworld.2016.260-268.

Dasgupta, S. *et al.* (2017) 'The Impact of Aquatic Salinization on Fish Habitats and Poor Communities in a Changing Climate: Evidence from Southwest Coastal Bangladesh', *Ecological Economics*, 139, pp. 128–139. Available at: https://doi.org/10.1016/j.ecolecon.2017.04.009.

Davies, S. and Young, W. (2021) 'Unlocking Economic Growth Under a Changing Climate: Agricultural Water Reforms in Pakistan BT - Water Resources of Pakistan: Issues and Impacts', in M.A. Watto, M. Mitchell, and S. Bashir (eds). Cham: Springer International Publishing, pp. 109–131. Available at: https://doi.org/10.1007/978-3-030-65679-9_7.

Dehlavi, A., Groom, B. and Gorst, A. (2015) 'Climate change adaptation in the indus ecoregion: a microeconometric study of the determinants, impacts, and cost effectiveness of adaptation strategies', *World Wide Fund for Nature (WWF) Pakistan, Islamabad* [Preprint]. Available at: https://wwfasia.awsassets.panda.org/downloads/110215_idrcstudy_1.pdf.

Dilawar, A. *et al.* (2021) 'Towards understanding variability in droughts in response to extreme climate conditions over the different agro-ecological zones of Pakistan', *Sustainability (Switzerland)*, 13(12). Available at: https://doi.org/10.3390/su13126910.

Dineshbabu, A.P. *et al.* (2020) 'Assessment of stock vulnerability of Indian marine fishes to past changes in climate and options for adaptation', *Climate Research*, 79, pp. 175–192. Available at: https://doi.org/10.3354/cr01586.

Environment Climate Change and Coastal Development Department - Government of Sindh (2021) 'Sindh Climate Change Action Policy'.

FAO (2018) *Impacts of climate change on fisheries and aquaculture*, *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options*.

FAO (2021) 'Pakistan at a Glance'.

Food Security Information Network and Global Network Against Food Crises (2023) 'Global Report on Food Crises 2023', *Food Security Information Network and Global Network Against Food Crises*, pp. 1–50.

Global Carbon Project (2021) 'Carbon budget and trends'. Available at: https://www.globalcarbonproject.org/carbonbudget/index.htm.

Government of Khyber Pakhtunkhwa (2015) 'Agriculture Policy Khyber Pakhtunkhwa', p. 80. Available at: http://extwprlegs1.fao.org/docs/pdf/pak173417.pdf.

Government of Pakistan (2018) 'Pakistan's second national communication on climate change to UNFCCC)', *Pakistan's second national communication on climate change to United Nations Framework Convention on Climate Change (UNFCCC)*, pp. 1–238. Available at: http://www.gcisc.org.pk/SNC_Pakistan.pdf.

Government of Pakistan (2021) 'Pakistan Updated NDC 2021', p. 76. Available at: https://unfccc.int/sites/default/files/NDC/2022-06/Pakistan Updated NDC 2021.pdf.

Government of Pakistan (2022) 'Resilient Recovery, Rehabilitation, and Reconstruction Framework Pakistan (4Rf)', *Ministry of Planning, Development and Special Initiatives*, pp. 1–156. Available at: https://www.pc.gov.pk/uploads/downloads/Final_4RF.pdf.

Government of Pakistan (2023) 'Pakistan Economic Survey 2022-23', *Economic Adviser's Wing, Finance Division*, 3(1), pp. 1–46. Available at: https://medium.com/@arifwicaksanaa/pengertian-use-case-a7e576e1b6bf.

Government of Sindh (2018) 'Sindh Agriculture Policy (2018-2030)', p. 38. Available at: http://www.wsip.com.pk.

Hafeez, A. (2014) 'Azad Jammu And Kashmir Agriculture Policy: A Ten Years Perspective', (April), pp. 1–4.

Idris, I. (2021) 'Areas and population groups in Pakistan most exposed to combined effects of climate change , food insecurity and COVID-19', *GSDRC, University of Birmingham* [Preprint].

Imran, K. (2021) 'Water Sharing Issues in Pakistan: Impacts on Inter-Provincial Relations Khadeeja Imran', *Journal of Development and Social*, 2(Iv), pp. 947–959. Available at: http://doi.org/10.47205/jdss.2021.

IPCC (2022a) *Asia. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Available at: https://doi.org/10.1093/oso/9780197616192.003.0010.

IPCC (2022b) *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge. Edited by S.L. H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig and B.R. S. Löschke, V. Möller, A. Okem. Cambridge, UK and New York.

L Otto, F.E. *et al.* (2022) 'Climate change likely increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan', *World Weather Attribution*, 10(11), p. 12.

Michel, D. (2020) *Water Conflict Pathways and Peacebuilding strategies*, *Peace Works*.

Ministry of Climate Change (2021) *National Climate Policy*, *National Climate Policy*. Edited by Government of Pakistan. Available at: https://doi.org/10.4324/9781315769059.

Ministry of Industries and Production (2021) *Food Processing Sector in Pakistan*.

Ministry of National Food Security and Research (2016) 'National Food Security Policy Government', *Ministry of National Food Security and Research*, pp. 1–25.

Ministry of National Food Security and Research (2021) 'National Pathways for Food Systems Transformation in Pakistan', 2, pp. 3–8.

Ministry of National Food Security and Research (2023) 'Agricultural Statistics of Pakistan 2021-2022', *Government of Pakistan*, p. 128.

Ministry of Planning Development & Special Initiatives (2022) 'Pakistan Floods 2022: Post-Disaster'.

Ministry of Planning Development and Reform (2015) 'Pakistan Vision 2025'. Available at: https://fics.seecs.edu.pk/Vision/Vision-2025/Pakistan-Vision-2025.pdf.

Nardone, A. *et al.* (2006) 'Climatic effects on productive traits in livestock', *Veterinary Research Communications*, 30(SUPPL. 1), pp. 75–81. Available at: https://doi.org/10.1007/s11259-006-0016-x.

National Disaster Management Authority (2023) 'National Disaster Mitigation Plan - Pakistan Remodeled Ndmp-Ii 2023'.

Observatory of Economic Complexity (2021) 'Contry profile: Pakistan'. Available at: https://oec.world/en/profile/country/pak.

Pakistan Bureau of Statistics (2017) 'Census 2017'. Available at: https://www.pbs.gov.pk/content/population-census.

Pakistan Bureau of Statistics (2021) 'Pakistan Social and Living Standards Measurement Survey (2019-20)', *Ministry of Planning, Development and Special Initiatives*, p. 645. Available at: https://www.pbs.gov.pk/sites/default/files//pslm/publications/pslm_district_2019-20/PSLM_2019_20_District_Level.pdf.

Parry, J.-E. (2016) *Review of Current and Planned Adaptation Action in Pakistan*.

Rajbhandari, R. *et al.* (2015) 'Projected changes in climate over the Indus river basin using a high resolution regional climate model (PRECIS)', *Climate Dynamics*, 44(1–2), pp. 339–357. Available at: https://doi.org/10.1007/s00382-014-2183-8.

Rana, A.W. *et al.* (2021) 'Proposed Balochistan agriculture policy 2021', (April).

Available at: https://pdf.usaid.gov/pdf_docs/PA00Z3HK.pdf.

Robinson, S. *et al.* (2015) 'The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT): Model description for version 3', *International Food Policy Research Institute* [Preprint].

Samee, M.D. *et al.* (2015) *Women in Agriculture in Pakistan*, *Australasian Plant Disease Notes*. Edited by FAO.

Saqlain, A. and Fullwood-Thomas, J. (2017) 'Enhancing the evidence base for Vulnerability and Risk Assessment in Badin , Pakistan', (May).

Shah, S.M. *et al.* (2021) 'Sustainability assessment of agriculture production systems in Pakistan: A provincial-scale energy-based evaluation', *Ecological Modelling*, 455. Available at: https://doi.org/10.1016/j.ecolmodel.2021.109654.

Shahzad, N., Ding, X. and Abbas, S. (2022) 'A Comparative Assessment of Machine Learning Models for Landslide Susceptibility Mapping in the Rugged Terrain of Northern Pakistan', *Applied Sciences (Switzerland)*, 12(5). Available at: https://doi.org/10.3390/app12052280.

Stanimirova, R. *et al.* (2019) 'Sensitivity of Global Pasturelands to Climate Variation', *Earth's Future*, 7(12), pp. 1353–1366. Available at: https://doi.org/10.1029/2019EF001316.

State bank of Pakistan (2019) 'Special Section 2: The State of Food Security in Pakistan'. Available at: https://www.sbp.org.pk/reports/quarterly/fy19/Third/Special-Section-2.pdf.

State Bank of Pakistan (2022) 'Annual Report 2021-2022 - The State of Pakistan's Economy - Chapter 2 Economic Growth'.

The World Bank (2023) 'The World Bank In Pakistan'.

Thow, A. *et al.* (2022) 'INFORM Climate Change Quantifying the impacts of climate and socio-economic trends on the risk of future humanitarian crises and disasters', (October). Available at: https://doi.org/10.2760/383939.

UN ESCAP (2022) 'Pathways to adaptation and resilience in South and South-West Asia: subregional report'. Available at: https://repository.unescap.org/handle/20.500.12870/4611.

UNICEF (2018) 'National Nutrition Survey 2018: Key Finding Report', *Government of Pakistan & UNICEF*, pp. 1–48. Available at: https://www.straitstimes.com/sites/default/files/attachments/2018/11/20/st_20181120_vnd_4427153.pdf.

World Bank (2021) 'Climate Risk Country Profile: Pakistan'.

World Bank Group (2022) *Country climate and development report: Pakistan*. Available at: https://doi.org/10.46883/onc.2022.3611.

World Food Programme (2018) 'Climate Risks and Food Security Analysis: A Special Report for Pakistan', (December), p. 112. Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/Climate_Risks_and_Food_Security_Analysis_December_2018.pdf.

World Meteorological Organization (2021) *State of the Climate in Asia*.

WWF (2022) 'Recharge Pakistan: Building Pakistan's resilience to climate change through Ecosystem-based Adaptation (EbA) and Green Infrastructure for integrated

flood risk management', pp. 1–50. Available at: https://www.greenclimate.fund/documents/20182/574760/Funding_Proposal_-_SAP003_-_UNEP_-_Bahrain.pdf/511d87fe-50c5-8be8-9ade-f6236ccf46c2.

Young.W.J *et al.* (2019) 'Pakistan: Getting More from Water', *The World Bank*, p. 163. Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/251191548275645649/pakistan-getting-more-from-water.

Zachariah, M. *et al.* (2023) 'Attribution of 2022 early-spring heatwave in India and Pakistan to climate change: lessons in assessing vulnerability and preparedness in reducing impacts', *Environmental Research: Climate*, 2(4), p. 045005. Available at: https://doi.org/10.1088/2752-5295/acf4b6.

Zhu, T. *et al.* (2013) 'Climate change impacts and adaptation options for water and food in Pakistan: scenario analysis using an integrated global water and food projections model', *Water International*, 38(5), pp. 651–669. Available at: https://doi.org/10.1080/02508060.2013.830682.

Annexes

Annex 1. Priority actions closely related to building climate resilience in the food systems included in the National Climate Change Policy (2021)

Dimension	Priority Actions
Policy	Develop appropriate digital simulation models for assessment of climate change impacts on the agricultural production systems.
	Promote targeted research on adoption of sustainable land management practices
Technology	Promote appropriate technologies for irrigation, water re-use, and rainwater harvesting.
	Promote biotechnology in crops and improved breeds of livestock that are less vulnerable to climate change and variability.
Management	Ensure an enabling financial environment for farmers to invest in and adopt the relevant technologies to overcome climate related stresses;
	Improve post-harvest capacity, such as storage and processing facilities and infrastructure, preferably at farm level.
Risk management	Allocate adequate financial and other resources to implement "National Disaster Risk Management Framework"
	Develop a proper risk management system including crop insurance to safeguard against crop failures due to extreme events
	Improve the extension system and enhance use of the media to allow communication of climatic predictions and corresponding advice to farming communities.
	Undertake risk mapping and set mechanisms to monitor possible avalanches, floods and landslides and take precautionary measures.
	Undertake hydrological modeling and flood plain mapping/zoning of the Indus River system against climate change scenarios.

Ecosystems	Carry out detailed studies to identify the most fragile and resilient ecosystems in all ecological zones
	Adopt 'Ecosystem-based Adaptation 'as part of an overall adaptation strategy.
	Encourage involvement of local communities in conservation and sustainable use of biodiversity and ensure the expansion of current protected area coverage.
Socio-economic	Improve access of poor communities to appropriate technologies for crop production and credit facilities for agricultural development;
	Diversify livelihood opportunities for vulnerable communities to advance socio-economic stability and cater for climate-induced migrations.
Gender and youth	Develop and implement climate change vulnerability-reduction measures that focus particularly on women's needs and empower women's groups and networks.
	Provide enabling opportunities for youth to play a role in climate action.
Institutional mechanisms	Establish Climate Change Cells in sectoral federal and provincial ministries.
	Ensure that agriculture, water, forest, energy, health, biodiversity, and DRR related vulnerabilities induced by climate change get duly integrated and addressed in the relevant national policy documents.
Capacity Building	Strengthen national climate change science related institutions in terms of necessary financial and technical support;
	Provide training and support, at national and international levels, to the concerned officials and experts of line ministries and departments to further enhance their knowledge and capacities on climate change issues
Awareness raising	Develop a national climate change awareness program involving communities, as well as climate change relevant ministries and departments;
International and regional cooperation	Work with countries like Nepal, Bhutan, Kyrgyzstan and other mountainous countries to take initiatives on mountain ecosystems, particularly glaciers and their contribution to sustainable development and livelihoods, and to high light the region's vulnerability to climate change;
	Help establish institutional linkages among national institutions in the South Asian region to facilitate sharing of knowledge, information and capacity building programs in climate change related areas and jointly tackling the trans boundary water, air quality and pandemic concerns (locust, Covid etc.);
Finance	Ensure the access and effective use of opportunities available internationally for adaptation and mitigation efforts
	Establish a "Pakistan Climate Change Fund" for financing climate change related projects;
	Explore the innovative private finance schemes, such as green bonds, blue bonds, nature bonds etc.;

Annex 2. Summary table of the resilience approach of each provincial agriculture policy

Policy	Key actions	Resilience approach
Punjab agriculture policy (2018)	Expansion in agriculture produce markets:	• Reforms in Agriculture Marketing Laws and Regulations • Storage Expansion to Ensure Competitive Prices for Farmers • Build Value-Chains and Incentivize SMEs in Agro-Processing • Market Intelligence and Information Dissemination
	Improve access and quality of agriculture inputs:	• Optimize Subsidy Programs • Easy Credit for Farmers • Strengthen Agriculture Innovation and Research • Reforms in Seed Sector Law and Regulations • Improve Farmers' Access to Information and Advisory Services • Empowering Rural Women for Inclusive Growth
	Climate smart and regenerative agriculture	• Encourage change in crop-mix • Safety Net for Small Farmers Through Area Yield Index Insurance
Sindh Agriculture Policy (2018)	Raise overall growth rate in the sector to 4-5 percent.	• Restructure the sector and create a regulatory framework to encourage the banks and private sector to enhance investments and finance into agriculture. • Facilitate and promote technological improvement such as cold chain storage along the full value chain.
	Reduce rural poverty to half current levels, along with food insecurity and malnutrition.	• Enhance the productive assets of the rural poor, such as small sharecroppers, cattle farmers, the landless, transhumant, small-scale fishers, and women headed households. • Provide inputs and services to the poor and those living in remote and resource poor areas. • Encourage nutrition sensitive agriculture production and household level consumption.
	Make efficient and sustainable use of natural resources and minimize negative environmental impacts, make all efforts to preserve the agro-ecological resource base.	• Promote better on-farm water management. • Regulate and control groundwater resources, coastal lands and water, and grazing areas. • Enhance effective controls on pollutants, including fertilizer, pesticides and effluent runoff. • Promote Forestry, especially agro forestry.
	Enhance resilience and climate change adaptability.	• Promote suitable agriculture practices, including new livestock breeds and seeds, along with modified cultivation and animal husbandry practices which reduce emissions and are suitable for the emerging weather conditions. • Upgrade or build suitable infrastructure, particularly at farm level, to deal with higher, but more variable rainfall; and floods and droughts.

		• Improve dissemination of up-to-date weather information and early warning of disasters. • Launch agriculture and livestock insurance programs to reduce income variability for farmers. • Prepare strong contingency plans and set aside funds in case of unforeseen disasters. • Introduce latest crop storage and preservation techniques.
Khyber Pakhtunkhwa Agriculture Policy (2015-2025)	Enhancing and Strengthening the Commodity Chain for Key Commodities. Strengthening Systems for Technology Generation, Assessment, and Dissemination Agriculture Zoning for Development Capacity Development and Registration of NGO/CSO Service Providers Specific Actions for Promoting Private Sector Investment Rangeland Development. Disaster Risk Preparedness.	• Promote efficiency and value addition in commodity chains. • Facilitate technology generation and dissemination. • Develop specialized zones for production and processing according to the agroclimatic zones. • Strengthen capacity of NGO/CSO service providers and promote inclusiveness. • Encourage private sector investment and entrepreneurship. • Develop and manage rangelands for sustainable livestock production. • Implement disaster risk preparedness and management programs
Proposed Baluchistan Agriculture Policy (2021)	Agriculture Zoning Crop Diversification Potential for Horticulture and High Value Agriculture Promoting Agricultural Business Enhancing Yield and Clusters Development Post-Harvest Management Agriculture Research and Extension	• Agriculture planning must be based on agro-climatic conditions. • Higher allocation for High Value Agriculture (HVA) and improve knowledge of farmers about horticulture and crop diversification. • Support to farmers for developing farming systems which would be more in harmony with the natural resource base. • Foster post-harvest management by developing cold storage facilities, and packaging, processing, and transport. • Estimation of water demand and preparation of contingency plans. • Conservation of surface and underground water • Promote the use of water efficient technologies in irrigation. • Take Steps for rain-harvesting and water storages. • Dis-incentivizing water intensive crops. • Better coordination for flood control works and disaster preparedness.

	Promotion of Value Addition through Food Processing Empowering Women in Agriculture Water Resource Management	
AJK Agriculture Policy (2014)	Agricultural Extension and Technology Transfer Integrated Pest Management Exploring Unconventional High Value Agriculture and Value Chain	• E-Agricultural Extension System • Farm Services Centers • Soil and Water Conservation Research and Development Program. • Bioengineering practices for soil conservation • Cultural and mechanical practices that minimize pests and optimize the environment for natural crop defenders. • Exploring Unconventional High Value Agriculture and Value Chain • Introduction of new crops (broccoli, swiss chards, leeks and asparagus) • Promotion of organic vegetables, mushrooms and herbal/medicinal crops. • Vertical Expansion in Food Crops • Reducing Land Degradation • Skill development in post-harvest techniques of fruit and vegetables for local producers • Dissemination of agricultural market information

Source: (Hafeez, 2014; Government of Khyber Pakhtunkhwa, 2015; Government of Sindh, 2018; Rana *et al.*, 2021)

Annex 3. Past relevant projects:

- Building Capacity on Climate Change Adaptation in Coastal Areas of Pakistan
- Building Climate Change Awareness in the South Asian Media
- Building Effective Water Governance in the Asian Highlands
- Building the Capacity of Civil Society Organizations in Africa and Asia
- Climate Change, Agriculture and Food Security in Pakistan: Adaptation options and strategies
- Climate Leadership for Effective Adaptation and Resilience
- Climate Proofing Growth and Development in South Asia
- Conservation and Sustainable Management of Biodiversity in Khyber Pakhtunkhwa
- The Determinants, Impact and Cost Effectiveness of Climate Change Adaptation in Pakistan
- Disaster risk Insurance for Vulnerable Communities in Pakistan
- Gender and Social Vulnerability to Climate Change: A study in disasterprone areas in Sindh
- GLOBE Climate Legislators Initiative
- Groundwater Resilience to Climate Change and Abstraction in the Indo-Gangetic Basin

- Himalayan Adaptation, Water and Resilience
- Himalayan Climate Change Adaptation Programme
- Mainstreaming Climate Change Adaptation through Water Resource Management in Leather Industrial Zone Development
- Managing Climate Risk for Urban Poor
- Pathways to Resilience in SemiArid Economies
- Reducing Risks and Vulnerabilities from Glacier Lake Outburst Floods in Northern Pakistan
- Resilient Cities Program
- Rural Livelihoods and Climate Change Adaptation in the Himalayas
- Scoping a Programme of Work on Climate Compatible Development for Pakistan
- Sheltering from a Gathering Storm
- Sindh Irrigated Agriculture Productivity Enhancement Project
- Strengthening the Resilience of Coastal Communities, Ecosystems, and Economies to Sea Level Rise and Coastal Erosion
- The Vulnerability of Pakistan's Water Sector to the Impacts of Climate Change: Identification of gaps and recommendations for action