

Climate and Health Vulnerability Assessment

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PAKISTAN



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LIST OF ABBREVIATIONS

API	Annual Parasite Incidence
AR6	Assessment Report 6 [of the IPCC]
CCC	Climate Change Council
CCKP	Climate Change Knowledge Portal [of World Bank]
CD	Communicable Disease
CHVA	Climate and Health Vulnerability Assessment
CHEVT	Climate and Health Economic Valuation Tool
CMIP5	Coupled Model Intercomparison Project Phase 5
COVID-19	Coronavirus Disease 2019
CPEC	China-Pakistan Economic Corridor
CRU	Climatic Research Unit [University of East Anglia, UK]
DEWS	Disease Early Warning System
DHIS	District Health Information System
DRM	Disaster Risk Management
EWS	Early Warning Systems
FEWS	Famine Early Warning System
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas [emissions]
GHS	Global Health Security
GLC	Global Landslide Catalogue
GLOF	Glacial Lake Outburst Flood
GoP	Government of Pakistan
HEAT	Heat Emergency Awareness and Treatment
HiAP	Health in All Policies
HIS	Health Information Systems
HRH	Human Resources for Health
HSS	Health System Strengthening
IHR	International Health Regulations
ILO	International Labour Organization
IMR	Infant Mortality Rate
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
JE	Japanese Encephalitis
JEE	Joint External Evaluations (for IHR)
LHW	Lady Health Workers

MMR	Maternal Mortality Ratio
MoNHSRC	Ministry of National Health Services and Regulations and Coordination
MECS	Modern Energy Cooking Solutions
NASA	The National Aeronautics and Space Administration
NCCP	National Climate Change Policy (of Pakistan)
NCD	Noncommunicable Disease(s)
NDC	Nationally Determined Contributions
NDMP	National Disaster Management Plan
NOAA	National Oceanic and Atmospheric Administration
OOP	Out-of-Pocket (spending on health)
PHC	Primary Health Care
PM_{2.5}	Fine Particulate Matter
PPP	Purchasing Power Parity
PPPA	Public Private Partnership Authority
RCP	Representative Concentration Pathway
SLR	Sea-Level Rise
SOPs	Standard Operating Procedures
SPEI	Standardized Precipitation Evapotranspiration Index
ToT	Training-of-Trainers
UHC	Universal Health Coverage
UNFCCC	United Nations Framework Convention on Climate Change
VBD	Vector-Borne Disease
WASH	Water Sanitation and Hygiene
WBD	Waterborne Disease
WHO	World Health Organization



EXECUTIVE SUMMARY

INTRODUCTION

Pakistan is one of the most vulnerable countries in the world to climate change.

Extensive geographical diversity and exposure to a wide range of climate-related hazards, a strong dependency on agriculture and water resources, high rates of multidimensional poverty, as well as a sizable and expanding population, independently and collectively contribute to climate change-related vulnerabilities across the country. Climate change can have profound effects on health outcomes in Pakistan — either by exacerbating the country’s existing health burdens or by creating new health risks.

AIMS OF THE CLIMATE AND HEALTH VULNERABILITY ASSESSMENT (CHVA)

The objective of this Climate and Health Vulnerability Assessment (CHVA) is to assist decision-makers in Pakistan with planning effective adaptation measures to mitigate climate-related health risks. To do so, the characteristics of the climatology of Pakistan are first described, with a focus on the observed and projected climate exposures that are relevant to health, as well as key climate-related hazards. Then climate-related health risks, namely heat-related risks, vector-borne disease (VBD) risks, waterborne disease (WBDs) risks, and risks to nutrition are examined in light of projected climate variability and change, including identifying vulnerable populations most at risk, where possible. The final step assesses the adaptive capacity of the health system in Pakistan to manage current and future climate-related health risks. This assessment is used to inform a series of recommendations that are aimed at reducing climate-related health vulnerability and building climate resilience in Pakistan’s health sector.

OBSERVED AND PROJECTED CLIMATE CHANGE

Over the last half century, there has been remarkable evidence of climate change in Pakistan.

Warming is accelerating, having over a half degree Celsius over the past century, and is strongly skewed toward the winter and post-monsoon months, most notably affecting Sindh, Punjab, and Balochistan. Average annual rainfall in Pakistan has increased over the last half century, albeit with important subregional variations. Pakistan’s precipitation regime is highly complex, due to the significant influence of El Niño cycles and strong variations in interannual and interseasonal rainfall. For example, provinces such as Balochistan and Sindh receive the least amount of average annual rainfall, when comparing with other provinces.

Projected temperatures in Pakistan through the mid-century will redefine the magnitudes of extreme heat exposure and occur alongside likely increases in precipitation. Average monthly temperature increases, under the SSP3-7.0 emissions scenario, will range from 0.73°C to 1.04°C in the 2030s and from 1.33°C to 1.91°C in the 2050s across Pakistan. These increases will make the populations of Punjab and Islamabad especially vulnerable. Based on the SSP3-7.0 scenario, projected daily maximum temperatures by the mid-century are especially alarming: they will range from 46.82°C to 47.7°C in Punjab and 46.44°C to 47.18°C in Islamabad. The historic summer season is projected to lengthen, compounded by rising nighttime temperatures.

Furthermore, an increasing trend in precipitation will be occurring until the mid-century, though this projections are characterized by high levels of uncertainty due to available information. During the 2030s, national annual precipitation is projected to increase by 10 percent, with the largest increases taking place sub-nationally in Punjab and Sindh. By the 2050s precipitation is expected to keep increasing throughout Pakistan. Low-lying coastal areas south of Karachi toward Keti Bander and within the Indus River delta will be at the greatest risk of projected sea-level rises (SLRs).

Extreme heat, flooding, landslides, and droughts can profoundly affect population health in Pakistan, many of which have already demonstrated increases in frequency and intensity. The most common climate-related hazards can be summarized as follows:

- **Extreme heat:** Across most of Pakistan, mean temperatures are already at, or very near, recognized extreme-heat thresholds and increasing. Northern regions are projected to experience the most substantial increases in extreme heat exposure during the 2030s and 2050s.
- **Extreme precipitation:** Increases in total and extreme precipitation, combined with a westward shift of the Asian monsoon, are leading to severe flood risks that are affecting every province in Pakistan, and this is predicted to increase through the 2030 and 2050s.
- **Landslides:** Increases in heavy-precipitation events, combined with populations and land-use factors, may result in the increased risk of landslides causing damage to homes and infrastructure, as well as significant losses of life.
- **Droughts:** High vulnerability to droughts is already occurring and is expected to increase, throughout the country, projected to have a 66 percent probability of severe drought by the end of the century.

Extreme heat, flooding, landslides, and droughts can profoundly affect population health in Pakistan, many of which have already demonstrated increases in frequency and intensity.

CLIMATE-RELATED HEALTH RISKS

The effects of climate change on the health outcomes of the population of Pakistan are considered across four health risk categories in this assessment: heat-related risks, vector-borne disease (VBD) risks, waterborne disease (WBD) risks, and risks to nutrition.



Heat-related health risks are wide-ranging, including the effects on mortality, heat-related injuries, as well as mental health and well-being. Extreme heat is currently a significant climate-related health risk in Pakistan, with most of areas experiencing a high heat index. The 2015 heatwave — one of the deadliest in recent history — provides an illustrative example of the current risk. Excessive heat-related deaths and impacts on labor productivity in Pakistan are likely to increase under the SSP3-7.0 scenario. Increases in the number of hot days (maximum temperature [Tmax] > 35°C) and tropical nights (minimum temperature [Tmin] > 20°C) will expose millions of people to dangerous temperatures, particularly in Sindh, Punjab, and Balochistan regions, as well as urban centers such as Karachi and Lahore.



Vector-borne disease (VBD) risks pose a significant threat to the health of Pakistan's people, as climate continues to change. Dengue is the fastest emerging arboviral threat in Pakistan, with more than 62 million people vulnerable to infection. Ongoing climate and infrastructural changes in Pakistan will alter the geography of dengue transmission risks, with the populations of Punjab and Islamabad at highest risk. Shifting the suitability of malaria vectors in Pakistan will marginally change the subnational geography of malaria transmission risk through 2050, under high-emissions scenarios, with the northern regions experiencing the largest gains in suitable areas for malaria mosquitoes.



Waterborne diseases (WBDs) are likely to increase in response to the impact of climate changes on water quality, via temperature increases, flooding, and droughts, placing an additional 5 million people at risk. Populations residing along the Indus River system will be the most vulnerable to the flood related WBD risk. In addition, temperature increases projected for Sindh and Balochistan may lead to more frequent and / or intense drought events, with consequent increased rates of diarrheal diseases — driven by insufficient water quality and inadequate quantity available for hygiene practices.



Nutrition Risks. Poor nutrition outcomes and food insecurity are likely to be substantially aggravated by climate change, particularly in Balochistan, and lower Sindh. Impacts on wheat and rice production will be especially important to future nutrition outcomes, given their importance as dietary staples throughout Pakistan. Wheat yields are projected to decline by 19 percent during the 2060s in the Punjab province where 80 percent of Pakistan's wheat production takes place. Notably, water scarcity concerns could further limit rice production in favor of less water-intensive crops.

ADAPTIVE CAPACITY OF PAKISTAN'S HEALTH SYSTEM

The extent to which Pakistan's health system is prepared for and has the capacity to respond to climate-related changes is a key modifier of climate-related health risks. In this assessment, Pakistan's adaptive capacity to prevent and manage climate-related health risks is examined according to the World Health Organization's (WHO) six health system building blocks. Gaps in the adaptive capacity of Pakistan's health system include the following:



1. Leadership and Governance: Although Pakistan is committed to meeting the climate challenge through both adaptation and mitigation measures, there are limited coordination mechanisms in place to facilitate cross-sector action on climate change and health.



2. Health Workforce: Pakistan already faces numerous health workforce challenges that climate change is likely to exacerbate. The current health workforce varies significantly across districts, with significant urban-rural disparities across both private and government health sectors. Further, there is the lack of a systematic approach toward capacity development on climate-related health risks, with emergency preparedness and responses a key challenge for Pakistan's health workforce.



3. Health Information and Disease Surveillance: Pakistan's current health information system is fragmented, with insufficient vertical coverage. Further, climate and weather information is not sufficiently integrated into the District Health Information System (DHIS) and early warning systems (EWS) to inform the prevention and management of climate-sensitive health risks as well as the early response to them.



4. Essential Medical Products and Technologies: While Pakistan has a National Essential Medicines List with policy measures and operative guidelines in place for regulating essential medicines and laboratories, gaps exist between policy and practice. Furthermore, there has been no assessment of technologies to ensure that the health equipment is resilient to climate change.



5. Service Delivery: The devolution of federal responsibilities for health and population welfare to the provincial level has led to challenges in health service delivery. There has been no comprehensive review of current health care infrastructure in Pakistan to identify climate change-related vulnerabilities, and minimum standards for climate-sensitive healthcare have not been developed.



6. Financing: Pakistan's historically low public financing on health has led to significant out-of-pocket (OOP) payments, thus increasing poverty, especially in light of ongoing climate-related risks. This is of particular concern when responding to large-scale disasters, such as those related to climate change. Likewise, risk pooling in Pakistan does not account for climate and health risks. Limited experience with strategic purchasing in the Pakistan health sector further precludes climate and health results from being appropriately achieved.

RECOMMENDATIONS TO ENHANCE HEALTH SYSTEM RESILIENCE TO CLIMATE CHANGE

The findings of this assessment are used to inform its recommendations to enhance the resilience of Pakistan's health system to climate change, including health interventions and strategies for adaptation in Pakistan. Recommendations are guided by WHO's operational framework for building climate-resilient health systems. High-level recommendations include the following:

1. Strengthen climate-health policy environment at national and subnational levels. The government of Pakistan (GoP) would be well-advised to ensure that health is featured prominently in the country's national climate change adaptation plans and strategies. To this end, the integration of climate-related health risks into the next iteration of the Pakistan National Health Vision would be a critical step. Moreover, it is recommended that the further development of subnational adaptation plans is adapted to provide specific climate-related health actions, building from examples such as the Karachi Heat Health Action Plan.

2. Enhance coordination mechanisms for climate and health action. This involves the designation of a national climate and health focal point for liaising with stakeholders at different levels. Establishing coordination mechanisms with key actors both inside and outside the health sector — including line ministries of climate change, agriculture, planning and development, and transportation, among others — will be highly beneficial.

3. Develop health workforce capacity to manage climate and health risks. Realizing the intended objectives of the proposed capacity development actions requires two cardinal steps: (a) the introduction of formal pedagogical training on climate change and health as part of medical, paramedical, and nursing curricula at higher-education and vocational institutions; and (b) the development of training and awareness-raising materials tailored for health providers and community health workers on climate change and health risks and adaptation responses. A focus on the management of extreme heat exposure risks — **especially in Sindh, Punjab and Balochistan**— where the most substantial increases in heat exposure are projected, could be a first priority.

4. Develop an intersectoral platform to monitor climate-related health risks and support the establishment of a climate-informed disease early warning and response system. Under the patronage of the Ministry of Climate Change and Environmental Coordination, it is recommended that the surveillance of key climate risks, as they relate to health, be conducted to inform the operationalization of the Ministry of National Health Services and Regulations and Coordination (MoNHSRC) programs. Building on prior efforts to strengthen the disease early warning system (DEWS), it is recommended to further expand the scope of such a system to incorporate climate-sensitive diseases.

5. Climate-proof health infrastructure and technologies. In light of findings stemming from these proposed assessments, the government may wish to revisit building codes to ensure that they are climate-smart and consider the likely impacts of climate-related hazards.

6. Establish a national risk register for climate-health risks in Pakistan, with seasonal climate outlooks to inform health sector programming. The register would provide the likelihood, scale, and extent of such emergencies affecting the population to inform the government's emergency response. In tandem, and feeding into the proposed national risk register, the government would be well-advised to develop seasonal climate outlooks.

7. Pool health funds to cover climate-related health risks and include climate risk considerations in strategic purchasing. A pre-payment mechanism providing this financial protection for climate-related health impacts, through the pooling of resources, could be considered. Moreover, a bold move could be made toward instituting a provider-payment mechanism that incentivizes healthcare providers to focus on climate-related health outcomes. To this effect, a strategic purchasing mechanism that pays for climate results should be designed and implemented across the provinces of Pakistan, particularly those most vulnerable to climate-related health risks.

INTRODUCTION

1.1 COUNTRY CONTEXT

Pakistan is a lower-middle-income country with an economy that has slowly been growing over the last two decades. By 2018, the country's gross domestic product (GDP) had risen to USD314.6 billion, compared with USD82.0 billion in 2000 [1]. The coronavirus disease 2019 (COVID-19) pandemic, as well as both high fiscal and balance of payment deficits, collectively resulted in an economic downturn to USD262.6 billion by 2020 [2]. Pakistan's GDP per capita was USD1,189 in 2020 — part of a downturn over the last two years precipitated by the pandemic; until then, its GDP per capita had been rising steadily, reaching USD1,482 in 2018 [1].

Poverty in Pakistan is widespread, with important distributional inequalities. Over a third (35.7 percent) of the population lives below the extreme poverty threshold of USD3.20 per day, while a little over three-quarters (76.2 percent) lives below the USD5.50 poverty threshold [1].¹ Both of these measures have shown steadily improving trends over recent decades (68.1 percent and 90.8 percent, respectively). Income inequality, as measured by the Gini index for 2018, was 31.6, representing adequate equality; this figure had remained at this level over the past two decades [1].

Pakistan is the fifth-most populous country in the world. In 2020, the population was just over 220 million [1], representing an increase from 142 million in 2000 and is expected to increase to 263 million by 2030 and 338 million by 2050 [1]. Nearly 7 percent of the population is under 5 years old and nearly 35 percent of the population is under the age of 15, while less than 5 percent is over the age of 65. There are significant variations in

population sizes among the regions in Pakistan: they range from 110 million in the Punjab province (more than half of the population) to 2 million in Islamabad [3]. In 2020, nearly two-thirds was living in rural areas (62.8 percent); however, by 2030, it is expected that this figure would drop to 59.3 percent, and by 2050, more than half the population would be expected to reside in urban areas (52.2 percent) [1].

Pakistan is vulnerable to the health impacts of climate change. Coupled with human-induced health stressors, climate change exacerbates existing health burdens and creates new health risks. Changes in temperature and precipitation patterns affect the geographic range and burden of a variety of climate-sensitive health risks, while simultaneously impacting the functioning and capacity of health systems. Compounding these challenges, climate has impacts on health and economic inequalities that are not uniformly distributed — demographic, socioeconomic, geographical, and environmental factors — which can significantly affect population health risks. These vulnerabilities are a result of several factors.

¹ Poverty headcount ratio of USD3.20 and USD5.50, using the 2011 Purchasing Power Parity (PPP) formula.

Geographical diversity, ranging from high altitudes in the northeast to arid coastal plains in the south, renders the population vulnerable to a wide range of extreme climate-related events. Pakistan is also a strongly agrarian country, therefore making it sensitive to climate shocks affecting agricultural productivity and food security. High population density and population growth projections further increase the likelihood of climate-sensitive disease outbreaks.

Pakistan is committed to meeting the climate challenge through both adaptation and mitigation measures. Pakistan ratified the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) on November 10, 2016, which aims to limit the global mean temperature increase to well below 2°C compared with pre-industrial levels. Section IV of this assessment highlights the key steps adopted by the government of Pakistan (GoP) to meet its climate aspirations.

1.2 AIM OF THE ASSESSMENT AND THE CONCEPTUAL FRAMEWORK

The objective of this Climate and Health Vulnerability Assessment (CHVA) is to assist decision-makers with planning effective adaptation measures to deal with climate-related health risks. Where available, these measures are provided at the subnational level to assist regional health planners. The recommendations of this CHVA are primarily aimed at the health sector, as well as related sectors that affect climate-related health risks such as disaster risk management (DRM).

Adaptation priorities need to be implemented alongside fundamental and urgent action to mitigate climate change. It is important to stress how complex the climate challenge is and how hard it is to predict exactly how severe climate exposures facing populations will become.

There are many factors that could slightly slow or significantly speed up rates of change, including positive feedback effects and, most worrying of all, cascading climatological tipping points. For this reason, mitigating existing greenhouse gas emissions (GHGs), as well as developing and implementing measures to protect health from the changing climate, is of paramount importance.

Investment in adaptation strategies to proactively address the effects of climate change on health outcomes is critical. This assessment is concerned with the climate risks to health and health systems, the adaptive capacities that are in place to deal with these risks, and the recommendations for meeting identified gaps. The primary focus of this assessment is, therefore, on climate adaptation and resilience measures. However, as the Assessment Report Six (AR6) of the Intergovernmental Panel on Climate Change (IPCC) makes clear, “Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered” [4]. Mitigation alone is no longer a sufficient strategy, regardless of the pace with which governments and communities around the world act. Adaptation is now as critical a part of climate action as mitigation. This report focuses on adaptation measures, but where possible, it also includes recommendations for reducing GHGs or facilitating the decoupling of emissions from progress toward human health and development goals.

The World Health Organization’s (WHO) operational framework for building climate-resilient health systems [5] is adopted to analyze Pakistan’s adaptive capacity to adequately deal with current and future identified risks. Based on this framework (Figure 1), this assessment is first structured around the six health system strengthening (HSS) building blocks: these six categories encompass the assessment of capacities and gaps — now and into the future. The framework

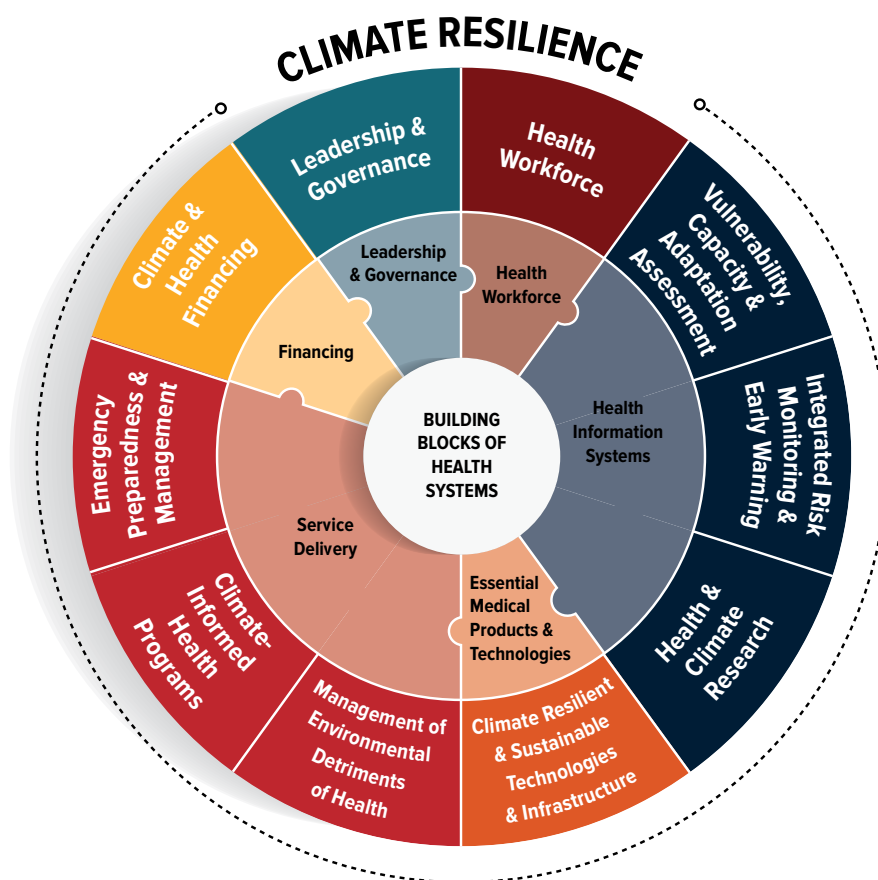
then moves on to consider the 10 components of health system climate resilience.

This assessment follows a stepwise linear approach. The first step characterizes the climatology in Pakistan, highlighting the observed and future climate exposures relevant to health. The second step examines climate-related health risks, including identifying vulnerable populations most at risk. The final step assesses the adaptive capacity of the Pakistan health system, identifying


gaps to manage current and future climate-related health risks. Together, these steps serve to inform a series of recommendations for reducing climate-related health vulnerability in Pakistan. The assessment is based on a review of the published literature, national statistics, and consultations with key counterparts in government: they include the Ministry of Climate Change and Environmental Coordination; the Ministry of National Health Services and Regulations and Coordination (MoNHSRC); and the Directorate of Malaria, Dengue, and other Vector Borne Disease Control.

FIGURE 1.

WHO’s operational framework for building climate-resilient health systems comprising 10 components and their connections to the building blocks of health systems



Source: World Health Organization, 2015, Operational Framework for Building Climate Resilient Health Systems.



This assessment has inherent limitations, due in part to the lack of access to specific data and/or information and availability issues, as well as the inability to conduct mission travel and collect primary data as part of the CHVA process due to the ongoing COVID-19 pandemic at the time of this assessment. Hence, the ability to conduct comprehensive quantitative analyses for specific climate-related health risks, along with in-depth reviews of the resilience of aspects of the health system, was constrained.

The assessment incorporates subnational considerations for health-related climate action. For the purpose of this assessment, the administrative regions of Pakistan are considered as follows: four provinces (Balochistan, Punjab, Khyber Pakhtunkhwa and Sindh); and one federal territory (Islamabad Capital Territory). This assessment uses the term, “regions,” when referring collectively to all of the above administrative “provinces” and “territories.”

CLIMATOLOGY

This section describes observed climatic changes and projected trends, highlighting the priority climate-related hazards in relation to human health risks in Pakistan.

Climate information is taken from the World Bank Group's Climate Change Knowledge Portal (CCKP). Observed changes in mean annual, mean maximum, and mean minimum temperatures and precipitation are presented on CCKP for the period 1901–2021. Climate data in the World Bank Group's CCKP is derived from the Coupled Model Intercomparison Project, Phase 6 (CMIP6), the foundational data used to present global climate change projections in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). CMIP6 relies on the Shared Socioeconomic Pathways (SSPs), which represent possible societal development and policy scenarios, which are used to represent the climate response to different plausible future societal development storylines and associated contrasting emission pathways to outline how future emissions and land use changes translate into responses in the climate system. This assessment explores observed climate conditions for the latest climatology, 1991–2020, and projected climate conditions and changes under SSP3-7.0² for the near (2030s; 2020–2039) and medium term (2050s; 2040–2059).

Pakistan's topography is characterized by high-altitude mountain ranges, significant arid and desert areas, as well as major rivers flowing to its coastline along the Arabian Sea. The country borders India to the east, Iran and Afghanistan to the west, and China to the north. The high-altitude regions, encompassing the Himalayas and Karakorum mountains in the northeast, with several peaks over 8,000 meters (m), collectively cover approximately 11 million hectares (ha) (approximately 14 percent of the total landmass) [6]. These mountains include almost 15,000 square kilometers (km²) of nearly 7,000 glaciers, making Pakistan one

of the most heavily glaciated countries outside the polar regions. Several major desert areas exist across Pakistan, each surrounded by arid regions at various altitudes.

Pakistan's Indus River is the one of the largest rivers in the world: it is fed by a combination of glacial meltwater and seasonal precipitation from the Asian monsoon flowing through the plains of Punjab and Sindh. Due to the country's highly connected hydrological regime, surplus water in the north — due to heavy rainfall, snow, and / or glacier melting — will flow rapidly down to the

² Note: SSP3-7.0 represents a higher emissions scenario and is considered a more realistic worst-case scenario in which warming reaches ~3.5-4 deg C by 2100. When considering 'risk' it is most prudent to use higher scenarios in order to not dangerously under-estimate potential changes and risk conditions.

low elevation plains of Sindh and Punjab, thus flooding cultivated lands, which can potentially destroy crops and infrastructure. Conversely, when the monsoon fails, leading to lower rainfall in the northern regions, the agricultural plains in the south will suffer. This situation is further compounded by intense heat, increased evapotranspiration conditions, and higher water demand.

Finally, Pakistan has a long southern coastline region along the Arabian Sea stretching just under 1,000 km. In the east, this coastline is shallower, leading to increasing coastal flood risks.

2.1 OBSERVED AND PROJECTED CLIMATE CHANGE

The diversity of Pakistan's topography results in substantial climatic differences across the country. Along the coast and the lowland plains of the Indus, it is predominately hot and dry, becoming progressively cooler moving northeast toward the mountains. There have historically been four distinct seasons: (a) the dry, cool winter from December to February; (b) the dry, hot spring from March to May; (c) the southwest monsoon period or the summer rainy season from June to September; and (d) the retreating monsoons from October to November [7].

Average annual temperatures across Pakistan have risen by over half a degree Celsius over the past century. Subnational average annual temperature spiked as high as 27.75°C in the Sindh province, demonstrating profound temperature-related exposures across the country. The northern provinces — such as Khyber Pakhtunkhwa — are vulnerable to lower temperatures, while Punjab, Sindh, and Balochistan are vulnerable to higher temperatures throughout the year. Much of the observed warming has been skewed toward the winter and the post-monsoon months of November

to February, most notably affecting the regions of Punjab, Sindh, and Balochistan [7].

Average annual rainfall in Pakistan has increased over the last half century, albeit with important subregional variations. Besides the northern regions where monsoon rains are often around 200 millimeters (mm) a month from July to September, the remainder of the country receives little precipitation throughout the year [7]. Overall, Balochistan and Sindh receive the least amount of average annual rainfall. Successive patterns of flood and drought events are common in Pakistan: they result from a high degree of interseasonal and interannual variability in rainfall and El Niño cycles [7]. Glacier volumes in the central Karakoram have been stable or increasing over the past two decades due to the rise in the summer and winter precipitation levels.

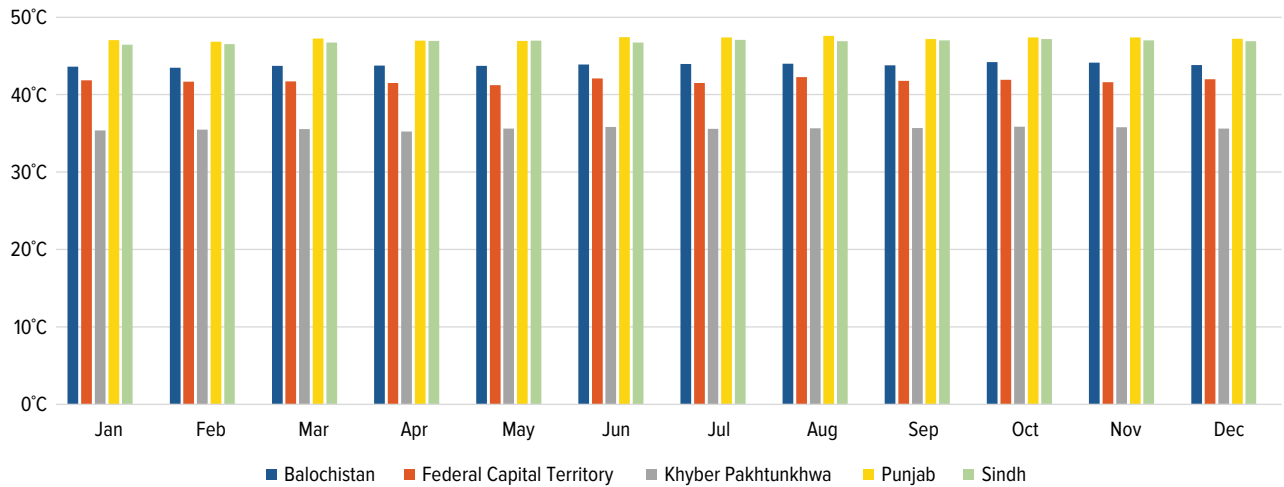
Projected temperature increases in Pakistan will redefine the magnitudes of extreme-heat exposure. Average monthly temperature increases across Pakistan, under the SSP3-7.0 emissions scenarios, will range from 0.73°C to 1.04°C in the 2030s and from 1.33°C to 1.91°C in the 2050s. These increases are similar for both average minimum and maximum daily temperatures.

These increases will make the populations of Punjab and Sindh especially vulnerable. From May to August, average temperatures will range from 34.19°C to 36.28°C in Punjab and 32.88°C to 36.3°C in Sindh during the 2050s. Daily maximum temperatures during the same time period are especially alarming, ranging from 46.82°C to 47.7°C in Punjab and 46.44°C to 47.18°C in Sindh (Figure 2).

The diversity of Pakistan’s topography results in substantial climatic differences across the country.

FIGURE 2.

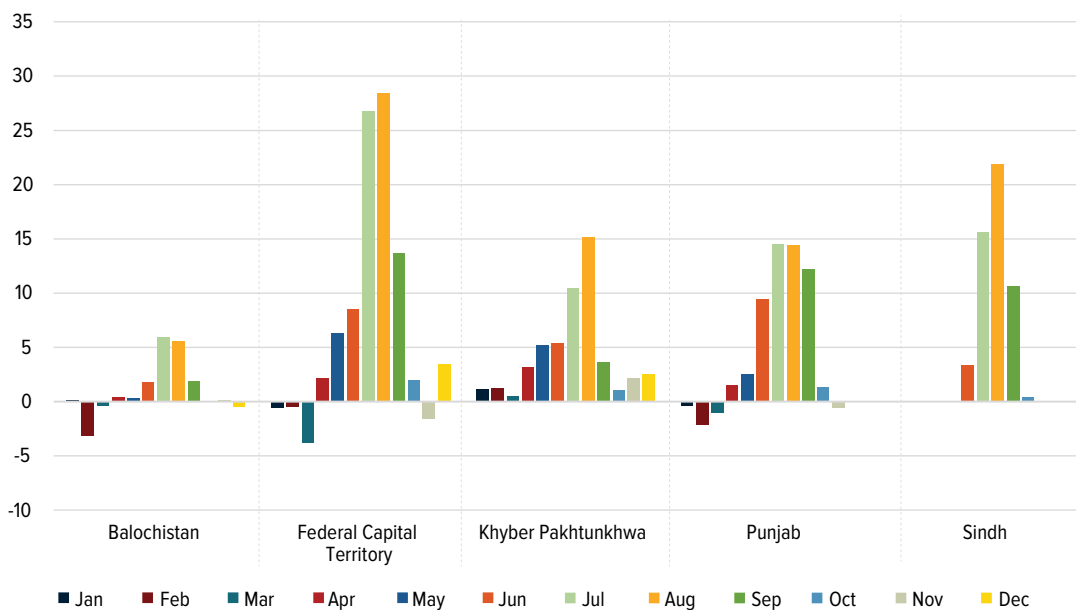
Projected average daily maximum temperature across the provinces of Pakistan in the 2050s



Source: World Bank Climate Change Knowledge Portal

FIGURE 3.

Monthly changes (that is, anomalies) in average precipitation in the 2050s under SSP3-7.0 among the regions of Pakistan



Source: World Bank Climate Change Knowledge Portal

Sea-level rises (SLR) pose significant threats to Pakistan’s physical coastlines and coastal ecosystems.

The largest increases in average monthly temperatures are projected to occur during the spring season (March–May) and in September, signaling a lengthening of the “summer,” that is, warmer temperatures that will be compounded by escalating nighttime temperatures. By the 2050s, the annual number of tropical nights — characterized by nighttime temperatures that do not fall below 20°C — will reach a maximum of 241.28 days in the province of Sindh (Table 1). The result of this is that nighttime temperatures in Sindh will not fall below 20°C from April to October. This is a concern because the human body needs to have the opportunity to cool down adequately after experiencing high daytime temperatures.

A more thorough discussion of the implications of these temperature changes and extreme heat in general is provided in the following section.

Pakistan has a relatively high degree of interannual and interdecadal variability in its precipitation regime. Projections indicate an increasing trend in precipitation for Pakistan toward the mid-century, with significant subnational differences in projected rainfall.³ During the 2030s, Pakistan’s annual precipitation is projected to increase by 10 percent at the country scale. The largest increases are likely to occur in Punjab and Sindh (+12.11 and 11.66 percent each).

3 Information presented in this assessment reflects current scientific understanding and modeling capabilities. There are high levels of uncertainty for future precipitation rates in Pakistan, due to the model’s weak performance in simulating future changes in the South Asian monsoon and the dynamics of the El Niño Southern Oscillation.

By the 2050s, precipitation is expected to keep increasing throughout Pakistan. The projected national rate of increase is 10.30 percent, observing most of this trend in Sindh and Punjab (13.23 and 19.05 respectively).

Sea-level rises (SLR) pose significant threats to Pakistan’s physical coastlines and coastal ecosystems. Without adaptation, studies suggest that over 1 million people may face coastal flooding annually by the end of the century under a high-emissions scenario [48]. Over the past century, the mean sea level has risen by 1.1 mm/year on average for Pakistan, and between 1989 and 2018, the Sindh coastline had seen a mean erosion rate of 15–20 m/year⁴ in the Indus Delta [8]. It is anticipated that global mean SLR will be 0.2–0.6 m by the end of this century, whereas for South Asia (including Pakistan), the figure is projected to be slightly higher at 0.7 m (0.42 – 1.12 m in range) [9].

In terms of regions, Sindh is particularly vulnerable to increases in coastal flood risks, due to its coastal topography, in combination with higher storm surges caused by SLR and predicted changes in storm frequency and severity. Future SLR risks are expected to be the highest in the more eastern low-lying coastal areas south of Karachi toward Keti Bander and within the Indus River delta [10]. Balochistan, though a coastal province, is less vulnerable to the impacts of these events due to its higher coastal topography. Tropical cyclones do make landfalls on Pakistan’s coastline, though these

4 Erosion rates of -14.17 +/- 0.55 m/year and -19.96 +/- 0.65 m/year on the western and eastern sides of the Indus Delta Region, respectively.

have historically been uncommon, as windstorms typically lose much of their intensity before reaching Pakistan [11]. However, it is important to point out that the amplitude of surge events, associated with these types of storms, can be several meters high and the continued rise of global mean sea levels is likely to exacerbate storm-surge effects [10].

2.2 CLIMATE-RELATED HAZARDS

There are several climate-related hazards affecting population health in Pakistan, many of which have already demonstrated increases in frequency and intensity. Pakistan is among the most disaster-prone countries in the world: it is ranked eighth among the 10 most affected countries globally, according to the Climate Vulnerability Index of 2019 [12]. The most common climate-related hazards are extreme heat, floods, landslides, mudslides, and droughts — each of which can profoundly affect population health.

2.2.1 EXTREME HEAT

In some regions of Pakistan, mean temperatures are already at, or very near, recognized extreme heat thresholds and are increasing.⁵ Whereas the previous discussion covers overall historic and projected temperature changes, this section focuses on temperature extremes, using two recognized classification thresholds: (i) very hot days: $\geq 35^{\circ}\text{C}$ and (ii) extremely hot days: $\geq 40^{\circ}\text{C}$. Notably, there are overlaps between these discussions, given how high temperatures across Pakistan are occurring now and into the future.

Observed temperatures from 1995 to 2014 show that Sindh and Punjab are the most vulnerable to temperatures $\geq 35^{\circ}\text{C}$. Mean monthly temperatures in these regions exceed 35°C from May

to August. In addition to the already high daily maximum temperatures, heatwave events⁶ commonly affect both these regions, further exacerbating the situation. The 2015 heatwave event was especially deadly, the health outcomes of which are discussed in the next section.

Water, used for drinking, bathing, and cooling, is an important adaptation resource during periods of intense heat. With Pakistan expected to experience changing precipitation patterns, characterized by increased periods of aridity that are predicted to overlap with the hot seasons, particularly as this gets longer due to climate change, water resources will be limited, and water availability constrained. This will, therefore, have an impact on adaptive capacity, which can be expected to increase vulnerability, especially for the populations of the Sindh and Punjab regions.

Sub nationally, Punjab and Sindh, are projected to experience the most extreme heat exposure during the 2030s and 2050s. The largest percentage increases in the number of days above 35°C and 40°C will occur in the Federal Capital Territory— a 22 percent increase in the number of very hot days and a 64 percent increase in the number of extremely hot days by 2050 (Table 1). Though Sindh, Punjab and Balochistan has historically experienced extreme temperatures, the population in this region and other regions may lack the capacity and the experience to adequately deal with such extreme, sustained temperatures. Across Pakistan, the increase in the number of very hot and extremely hot days will mean that for regions such as Punjab and Sindh, only rarely will there be days where temperatures are below 35°C from May to September.

Populations in the major urban areas of these regions are especially at risk since tempera-

⁵ As defined by temperatures $\geq 35^{\circ}\text{C}$.

⁶ In this instance, a heatwave is defined as five or more consecutive days during which the daily maximum temperature surpasses the average maximum temperature by 5°C (9°F) or more.

tures in cities will exceed those of surrounding rural areas. Urban areas become “heat islands” of higher temperatures than outlying areas, due to the relative lack of greenery, coupled with the high concentration of infrastructural development that re-emits heat more than natural landscapes [13]. Therefore, heatwave events in urban regions will be more severe than surrounding areas. Extreme daytime temperatures will be compounded by a simultaneous rise in the projected number of tropical nights (Table 1), providing inadequate nocturnal recovery from daytime extremes, particularly due to the absence of artificial cooling measures.

2.2.2 FLOODS

Climate-related increases in total and extreme precipitation, combined with the westward shift of the Asian monsoon, are leading to severe flood risks affecting every province in Pakistan.

The 2010 monsoon was particularly significant, leading to some of Pakistan’s most severe floods. This event inundated one-fifth of the country — affecting 20 million people and claiming over 2,000 lives [14]. Since 1991, over 84 severe flood events have occurred, affecting over 65 million people [15]. In addition to riverine floods from extreme precipitation, the high-altitude regions of Pakistan are also vulnerable to glacial lake outburst floods (GLOFs): they are triggered by melting ice, which can release large volumes of water, often down heavily populated mountain valleys. Significant uncertainty exists around predicting GLOFs, since these events are dependent on the future extent of glaciers in the mountainous areas affecting Pakistan. This in turn is heavily dependent on temperature rises and changes in local precipitation levels.

Extreme precipitation magnitudes are projected to increase over the 2030s and 2050s. Projected figures for the largest 1-day precipitation will increase by 2.6 mm (to 30.84 mm) on average

in the 2030s and by 3.49 mm (to 31.65 mm) on average by the 2050s. During the 2030s, these increases will be the most profound in February through April and in September (+5.23mm), particularly in the Sindh province (Table 2). During the 2050s, Sindh will experience the greatest increase (+9.32mm), but the Federal Capital Territory will be experiencing greater average 1-day precipitation with 71.36mm.

A second measure to consider is projections for five-day cumulative rainfalls; these represent a different flood risk where areas can become saturated over a number of days. In this sense, Pakistan will experience an increase of 14.28mm and 22.05mm in the 2030s and 2050s respectively. Sindh will experience the greatest increase (+9.32mm), but the Federal Capital Territory will be experiencing greater average 1-day precipitation with 71.36mm.

2.2.3 LANDSLIDES

Landslides can cause damage to homes and infrastructure, as well as significant losses of life in Pakistan. The relationship between landslides and climate change is complex. While changes in rainfall and temperature may lead to more landslides, increasing droughts and vegetation can decrease the likelihood of these events [16]. Table 3 shows reported landslide events in Pakistan from 1991 to 2020, including the total number affected and mortalities associated with each event. It should be noted that these statistics differ considerably from the National Aeronautics and Space Administration’s (NASA) Global Landslide Catalog (GLC), since they only report the 85 landslides and the mudslides that have taken place since 2007 [17]. Centralized reporting from the Ministry of Climate Change and Environmental Coordination on landslide events, along with associated morbidity and mortality rates in Pakistan, is not available.

TABLE 1.

Annual number and percentage increase of very hot days (>35°C), extremely hot days (>40°C), and tropical nights in the 2030s and 2050s, under SSP3-7.0, throughout the regions of Pakistan

	REF. PERIOD	2030s		2050s	
	# Days	# Days	% Increase	# Days	% Increase
VERY HOT DAYS (>35°C)					
Pakistan	114.09	123.56	8.30%	135.08	9.32%
Balochistan	112.22	124.81	11.22%	138.51	10.98%
Federal Capital Territory	39.2	45.29	15.54%	55.66	22.90%
Khyber Pakhtunkhwa	33.75	39.1	15.85%	45.62	16.68%
Punjab	146.24	154.13	5.40%	166.73	8.17%
Sindh	187.27	198.89	6.20%	212.57	6.88%
EXTREMELY HOT DAYS (>40°C)					
Pakistan	40.38	48.26	19.51%	58.47	21.16%
Balochistan	34.76	44.83	28.97%	56.34	25.67%
Federal Capital Territory	4.66	6.78	45.49%	11.18	64.90%
Khyber Pakhtunkhwa	9.36	11.34	21.15%	14.36	26.63%
Punjab	58.66	66.49	13.35%	78.26	17.70%
Sindh	70.59	81.32	15.20%	96.31	18.43%
TROPICAL NIGHTS (>20°C)					
Pakistan	146.69	156.35	6.59%	166.5	6.49%
Balochistan	144.58	158.08	9.34%	170.91	8.12%
Federal Capital Territory	123.25	133.57	8.37%	144.4	8.11%
Khyber Pakhtunkhwa	72.65	79.4	9.29%	87.09	9.69%
Punjab	185.29	192.84	4.07%	202.5	5.01%
Sindh	220.79	230.6	4.44%	241.28	4.63%

Source: World Bank Climate Change Knowledge Portal.

TABLE 2.

Projected extreme precipitation anomalies for Pakistan for the 2020–2039 and 2040–2059 periods, under SSP3-7.0, from the 1995–2014 reference period

	AVG 1-DAY		5-DAY CUMULATIVE	
	2030S	2050S	2030S	2050S
Pakistan	2.6	3.49	14.28	22.05
Balochistan	1.5	2.86	13.8	17.03
Federal Capital Territory	-0.28	-2.8	12.66	12.89
Khyber Pakhtunkhwa	1.84	1.44	7.95	14.11
Punjab	1.97	2.56	7.93	16.98
Sindh	7.52	9.32	30.88	51.4

TABLE 3.

Landslide events from 1991 to 2020

HAZARD EVENTS	NO. EVENTS	NO. DEATHS	NO. AFFECTED
Avalanche	10	424	4,335
Landslide	9	222	29,707
Mudslide	1	12	12
Total	20	658	34,054

Source: [15].

2.2.4 DROUGHTS

Pakistan is highly vulnerable to droughts due to the erratic monsoon rainfall and rising temperatures; moreover, the likelihood of severe droughts is expected to increase. The duration of drought conditions can be considerable: the worst drought in Pakistan’s history began in 1997 and lasted through 2002. Historically, the southwestern areas of Pakistan, including Balochistan and the coastal belt of Sindh, have been particularly vulnerable to drought conditions [18]. The annual mean probability of severe meteorological droughts

is expected to increase from 17 percent between 2020 and 2039 to 66 percent between 2080 and 2099 [48]. Even as they increase in frequency, droughts are also projected to increase in severity in all the provinces of Pakistan, according to the annual Standardized Precipitation Evapotranspiration Index (SPEI). Currently, Pakistan encounters an annual median likelihood of experiencing severe meteorological drought, estimated at approximately 3%. This classification is based on when SPEI falls below -2^7 .

⁷ The reported SPEI was extracted from the Climate Change Knowledge Portal, using the Coupled Model Intercomparison Project 5 (CMIP5)

2.3 KEY MESSAGES



Historic Observations

- Warming in Pakistan is accelerating and is strongly skewed toward the winter and post-monsoon months, most notably affecting Sindh, Punjab, and Balochistan.
- Average annual rainfall in Pakistan has increased over the last half century, albeit with important subregional variations.



Projected Climate

- Projected temperature increases in Pakistan will redefine the magnitudes of extreme heat exposure. The historic summer season is projected to lengthen, compounded by rising nighttime temperatures.
- An increasing trend in precipitation will be occurring until the mid-century, with projections characterized by high levels of uncertainty. Following this period, however, most regions will experience an increase in precipitation.



Sea-Level Rises (SLR)

- An average increase of 1.1 mm/year had been observed between 1989 and 2018, characterized by erosion impacts for Sindh's coastline and a loss of 15–20 m of land per year in the Indus Delta.
- Future SLRs will have the greatest risk in the low-lying coastal areas south of Karachi toward Ketī Bander and within the Indus River delta.



Climate extremes:

- **Extreme Heat:** Across most of Pakistan, mean temperatures are already at, or very near, recognized extreme-heat thresholds, and rising. Northern regions are projected to experience the most substantial increases in extreme heat exposure during the 2030s and 2050s.
- **Extreme precipitation:** Increases in total and extreme precipitation, combined with a westward shift of the Asian monsoon, are leading to severe flood risks that are affecting every province in Pakistan. This trend is predicted to continue to increase through the 2030 and 2050s.
- **Landslides:** Increases in heavy-precipitation events, combined with populations and land-use factors, may result in increased landslide risks causing damage to homes and infrastructure, as well as significant losses of life in Pakistan.
- **Drought:** Severe droughts already occurs and is expected to increase by 17 percent for the 2030s and by 66 percent by the end of the century.



CLIMATE-RELATED HEALTH RISKS

Pakistan has demonstrated some important improvements in health status over the last two decades, *albeit* with persistent geographic disparities and an increasing burden of noncommunicable diseases (NCDs). Although the maternal mortality ratio (MMR) had halved from 286 deaths in 2000 to 140 per 100,000 live births by 2017, the rate remains high among global and regional comparisons [1]. During the same period, the infant mortality rate (IMR) declined from 84.4 to 58.9 per 1,000 live births, while the under-five mortality rate dropped from 107.5 to 71.6 per 1,000 live births [1]. Life expectancy at birth increased from 62.8 in 2000 to 67.2 in 2019 [19].

Despite these notable achievements, Pakistan is experiencing an epidemiological transition, characterized by a shift from communicable diseases (CDs) to noncommunicable diseases (NCDs). Although NCDs now account for about 60 percent of all deaths, the burden of CDs is still significant [20]. This is important, since many CDs and NCDs are climate-sensitive and will therefore interact with the overall climate-related burden of disease. Other categories of health outcomes, such as mental health, are also important to consider, when looking at the climate-related burden of disease. In Pakistan, nearly 50 million people suffer from some form of mental illness; at the time of the preparation of this assessment, the mental illness situation was also compounded by the impacts of the COVID-19 pandemic [21].

Risks to health from climate change are not evenly distributed in the population: some groups are at greater risk than others. The factors that affect a population's vulnerability to climate change are often similar to those that affect health more broadly [22]. However, climate change may exacerbate health inequalities, especially among certain vulnerable population groups, including

the poor, rural populations, those living in informal urban settlements, women and young children, the elderly, those living with pre-existing conditions and disabilities, as well as displaced populations. Investment in adaptation and mitigation measures must consider who directly benefits from by adopted measures or who may be disadvantaged by them.

Pakistan's CHVA assesses four climate-related health risk categories. These categories include heat-related risks, vector-borne disease (VBD) risks, waterborne disease (WBD) risks, and risks to nutrition. Each category is assessed in terms of current and future risks, with considerations for both national and subnational peculiarities where possible. It is important to note that these risk categories represent only the most pressing health risks to people in Pakistan. Other climate-related health risks have not been included in this assessment: they may incorporate, but are not limited to, air quality and pollution as it relates to respiratory health, the cross-cutting risks of ongoing climate change on mental health, along with direct injuries and mortalities associated with natural hazard events.

In particular, health risks related to poor air quality are recognized as a major environmental health threat, globally and in Pakistan. The South Asia region, including Pakistan, has the worst air quality levels and a high air pollution-associated health burden. In addition to already suffering some of the highest annual average fine particulate matter (PM_{2.5}) exposures in the world, Pakistan is one of the few countries that continue to experience increases in ambient air pollution, with an increase in 3.0 micrograms per cubic meter (ug/m³) between 2010 and 2019. The five most populated cities in Pakistan (Karachi, Lahore-Johor Town, Peshawar, and Rawalpindi) with available air pollution data have annual mean PM_{2.5} levels that are higher than the recommended WHO value of 10 ug/m³. The relationship among air pollution, climate change, and human health impacts is complex, but important. Although a comprehensive quantitative assessment of the health impacts of air pollution in Pakistan is beyond the scope of this CHVA, further investigation into the gaps in evidence is recommended.

3.1 HEAT-RELATED RISKS

The health risks of heat are wide-ranging, including the effects on mortality, heat-related injuries, along with mental health and wellbeing. Health effects caused by heat include the direct effect of heat stress, along with heat rash, cramps, exhaustion, and dehydration, as well as the acute exacerbation of pre-existing conditions including respiratory and cardiovascular diseases. Longer-term mental health risks are also an important effect to consider. In addition to the impacts on individuals, the whole-of-population exposure that occurs with an extreme heat event can lead to significant increases in hospitalizations, thus imposing a strain on health system [23].

Pakistan is known to experience regular heatwaves, with 2015 being one of the deadliest

on record, especially in Karachi. This event has had an important impact on the population and serves as a key reference point for most country-level studies on heat and human health. The 2015 event affected the southern parts of the country in particular, resulting in approximately 1,200 deaths in Karachi [15]. During this event, the heat index rose to around 66°C [24], resulting in a high number of patients, particularly the elderly, being admitted to emergency departments with heatstroke. Residents of Karachi were approximately 17 times more likely to die of a heat-related cause during this event when compared with the previous year (for the same period). Residents with lower monthly incomes and lower education levels were at a significantly higher risk of death [25].

Much of the information on morbidity also came from the 2015 event. A key study found that among cases of heat-related illnesses admitted to the hospital, heat stroke was the most common and present in nearly two-thirds of the cases (64.2 percent), followed by heat exhaustion (35.8 percent), heat syncope (3 percent), and heat cramps (3 percent). Almost half of the patients needed to be placed in high dependency units, with a mean hospital stay of 4 days [26].

Excess heat-related deaths in Pakistan are very likely to increase under a high-emissions scenario. Routine statistics on annual heat-related deaths are not available in Pakistan. However, a recent study demonstrated that all-cause mortality in Pakistan is significantly impacted by high temperatures [27]. Based on the study findings, the relative risk of mortality in Pakistan during the 2000–2019 period increased by 27 percent, when comparing the number of deaths occurring at monthly maximum temperatures of 35–40°C with those at monthly maximum temperatures of 25–30°C (considered to be the base point, as the number of deaths is minimal).

Further, and for the same time period, modeled annual heat-related deaths in South Asia are estimated at approximately 7 per 100,000 (95 percent CI: 4–10) [28], which if extrapolated to Pakistan, would translate to a little over 15,000 heat-related deaths annually. Considering envisaged temperature increases under SSP3-7.0, the implications of a change in the maximum temperature on mortality in Pakistan could lead to excessive deaths well beyond the current estimate. Framed differently, based on climate change projections (see Section II), Pakistan will likely experience increases in the number of hot days (maximum temperature [Tmax] > 35°C) and very hot days (Tmax > 40°C), with the highest increases in Sindh, Punjab, and Balochistan regions, especially during June, July, and August. For example, Sindh, under SSP3-7.0 emissions scenarios, may experience 212.57 hot days (Tmax > 35°C) and 241.28 tropical nights (minimum temperature [Tmin] > 20°C) a year by the 2050s. This may possibly expose nearly 48 million people to potentially life-threatening temperatures, with adverse implications on the health of those populations, particularly vulnerable groups such as pregnant women, children under five years of age, and people over 65 years old.

Future risks of increased temperature are also projected to reduce labor productivity, while increasing the risk of accidents and injury, as well as heat stress in workers. The International Labour Organization (ILO) estimates that Pakistan may lose more than 5.5 percent of working hours in 2030, owing to excessive heat; most of these lost days are in the construction industry and the agriculture sector [29]. The risk of rising temperatures is and will be compounded by poor housing, urban and rural poverty, water insecurity, and an aging population, with the increased prevalence of NCDs.

3.2 VECTOR-BORNE DISEASE (VBD) RISKS

Weather and climate are the critical drivers of spatiotemporal vector-borne disease (VBD) distribution and transmission dynamics. The epidemiology of VBDs is directly influenced by environmental factors that facilitate vector development and survival. Climate variability causes vector and host ranges to expand or contract, shifting disease distribution and seasonality, and/or facilitating the emergence or reemergence of VBDs [30]. Although Pakistan is affected by other major VBDs including chikungunya, leishmaniasis, and Crimean Congo hemorrhagic fever, along with the emerging threats of Zika, yellow fever, and Japanese encephalitis (JE) [31], this assessment focuses on mosquito-borne VBDs — dengue and malaria — given their burden or potential in Pakistan.

Investigating species distribution and seasonality of vectors is valuable to understanding plausible VBD distributions and planning efficient, spatially targeted methods of control. Spatial models were constructed to demonstrate the plausible spatial distributions of the vectors of dengue and malaria to assess the risk propensity of these diseases.

Nonetheless, it is important to recognize that spatial modeling results are limited by the input data's spatial resolutions and dependent on the future extent of glaciers in the mountainous areas. For further information on the modeling methodology and inputs, see Annex III.

3.2.1 DENGUE

Dengue is the fastest-emerging arboviral threat in Pakistan, with an 800-fold increase in cases between 1995–2004 and 2019.⁸ Dengue is transmitted by the bite of infected *Aedes (Ae.) aegypti* and, to a lesser extent, *Ae. albopictus* mosquitoes. These species prefer biting humans over animals and are commonly found in urban and peri-urban environments. Vector feeding and habitat preferences, coupled with other factors including climate and environmental changes, as well as human population dynamics, in Pakistan, have and will continue to influence the patterns of the dengue transmission risk.

More than 62 million people are vulnerable to dengue in Pakistan, with the populations of Punjab and Islamabad at highest risk. Suitability is largely concentrated in the north-central portion of the country and within the Indus Basin. Model results of the historic period show that nearly 54 percent of Punjab is suitable for the dengue vector species — approximately 16 percent of which is populated by more than 31 million people. In Islamabad, nearly 80 percent of the total area is suitable for dengue vectors: of this area, 16 percent is populated by more than 350,000 people. These findings are supported by 2019 statistics of dengue infection in Pakistan: 43 percent of overall cases and 23 percent of dengue-attributable deaths occurred in the cities of Islamabad and Rawalpindi, which are located in the Islamabad and Punjab provinces, respectively [31]. Overall, 36 percent of Pakistan is suitable for dengue vectors.

Ongoing climate change will alter the geography of dengue transmission risk in Pakistan. On the national scale, overall suitability for dengue vectors will largely remain unchanged. In the 2030s and 2050s, the suitable area is expected

to increase to 36 percent and decrease to 35 percent, during the respective time periods having around 61 million population being exposed. Sub nationally, however, differences in population vulnerability will occur, having mountainous regions experiencing an increase in vector suitability, as higher elevated areas will see an increase in temperature. Notably, Khyber Pakhtunkwa will experience the greatest increase of population exposed to dengue vectors (See Table 4). Overall, while the population exposed at national level will remain relatively unchanged, the geographic distribution and vector suitability will be altered due to changes in temperature and precipitation patterns.

Ongoing climate and infrastructural changes in Pakistan could promote the emergence of Zika, yellow fever, and Japanese encephalitis (JE). Vectors of dengue in Pakistan are the same mosquito species that transmit Zika and yellow fever — diseases that are endemic in neighboring China and India. Suitable areas for dengue described above have the potential to become areas at risk for the transmission of Zika and yellow fever. Punjab, and Sindh have sizable populations of the JE mosquito vectors (*Culex tritaeniorhynchus* and *Culex pseudovishnui*) [31]. In addition, the ongoing infrastructural changes, associated with the China-Pakistan Economic Corridor (CPEC), could also facilitate Zika, yellow fever, and JE transmission. Along the eastern route of the CPEC, there is a large swine population — the amplifier host of the JE virus [31]. Transportation via the CPEC from either China or India — endemic countries for JE — poses a significant threat to VBD emergence in Pakistan. While the intention of this analysis aims to support dengue control measures, findings may also be extrapolated to assist in curtailing other VBD threats, including those transmitted by *Ae. aegypti* and *Ae. albopictus* vectors.

⁸ Dengue cases from 1995 to 2004: 699; dengue cases in 2019: 56,000.

TABLE 4.

Area of suitable dengue vector species habitat, by province, in Pakistan (percentage)

	PERCENT AREA									
	POPULATED, SUITABLE			OVERALL SUITABILITY			VULNERABLE POPULATION			
	Historic	2030s	2050s	Historic	2030s	2050s	Historic	2030s	2050s	
Sindh	7.63	7.63	7.63	51.93	51.93	51.88	12,920,689	12,920,689	12,920,689	
Punjab	15.82	15.38	15.29	53.94	53.02	52.08	31,659,749	31,071,289	30,759,303	
Khyber Pakhtunkhwa	8.62	8.75	8.68	43.74	46.56	45.68	11,885,363	12,083,359	12,042,013	
Islamabad	31.97	31.97	31.97	78.94	78.94	78.94	358,759	358,759	358,758	
Balochistan	1.37	1.37	1.37	21.93	21.93	21.93	2,379,293	2,379,293	2,379,293	
							TOTAL	59,203,853	58,813,389	58,460,056

Sources: Temperature (NASA, NEX-GDDP) Land Cover (Copernicus Global Land Service, Proba-V-C3), Water Resources (European Commission's Joint Research Centre, GSW1_0), Flow Accumulation (World Wide Fund for Nature, HydroSHEDS), Population (European Commission's Joint Research Centre, GHSL/P2016/POP_GPW_GLOBE_V

3.2.2 MALARIA

Over 60 million people live in high-risk areas of malaria and nearly 50 million live in areas of low to medium risk [32]. These figures were

estimated in 2018 and show that malaria is an important cause of morbidity and mortality in Pakistan. Historically, Sindh have been among the regions with the highest number of malaria cases across the country. *Plasmodium vivax* is responsible for more than 80 percent of cases, while *Plasmodium falciparum* accounts for the remaining 20 percent [31]. Predominant malaria vectors in Pakistan are *Anopheles (An.) stephensi* and *An. culicifacies*. Notably, the species is also known to colonize irrigated areas [34], and Pakistan boasts the world's largest contiguous irrigation system in the Indus Basin, irrigating over 2.5 million acres [35].

The population living in Punjab is the most vulnerable to malaria, albeit with decreasing vulnerability through 2050. While only 56 percent

of Punjab during the historic period was suitable for the malaria vector species, this area is populated by more than 70 million people — 65 percent of Punjab's total population. More than half of all regions in Pakistan demonstrate a total suitable area of greater than 50 percent for malaria vector species. Model results across all time periods show that 100 percent of the Islamabad Capital Territory is suitable for malaria vectors, 51 percent of which is currently populated by more than 1.4 million people (See Annex III for methodology of model estimation).

Shifting the suitability of malaria vectors in Pakistan will marginally change the subnational geography of malaria transmission risk through 2050 under high-emissions scenarios. Around 37 percent of Pakistan will be suitable for malaria vectors during all the time periods assessed. However, subnational variations and the populations impacted could potentially result in fewer people being at risk. (See Table 5).

Despite the strong correlation between VBD vectors and climate factors, climate is merely one determinant in the VBD transmission risk.

The future risk of these diseases will depend not only on changing climate conditions that define vector suitability, but also environmental, social, and economic conditions. For example, climate change is arguably less of an immediate threat to the emergence of Zika, yellow fever, and JE than the increasing connectivity between Pakistan and endemic countries that is facilitated by the CPEC.

In recent years, Pakistan has made notable progress in reducing malaria morbidity and mortality. For example, Punjab, despite having the largest overall population at risk of malaria in terms of vector suitability, was recently declared malaria-free, along Islamabad [31]. However, without comprehensive vector management strategies that give due consideration to both climate and

environmental conditions, the risk of VBDs could be quite substantial.

3.3 WATERBORNE DISEASE RISKS

The burden of waterborne diseases (WBDs) throughout Pakistan is significant, characterized by high rates of morbidity and mortality; WBDs are especially deadly in the case of children under five years of age. In 2019, diarrheal diseases were the fourth-leading cause of mortality in Pakistan [39]. Current drivers of WBDs throughout the country are attributable to many factors, including sources, quality, and quantity of drinking water; sanitation facilities; and hygiene practices [40, 41] — each of which may be affected by weather and climate change.

TABLE 5.

Area of suitable malaria vector species habitat, by province, in Pakistan (percentage)

	PERCENT AREA								
	POPULATED, SUITABLE			OVERALL SUITABILITY			VULNERABLE POPULATION		
	Historic	2030s	2050s	Historic	2030s	2050s	Historic	2030s	2050s
Sindh	7.95	7.96	7.96	52.26	52.35	52.29	19,030,867	19,032,143	19,032,143
Punjab	16.91	16.81	16.40	55.68	55.96	54.43	71,468,706	71,511,284	67,265,162
Khyber Pakhtunkhwa	10.09	10.26	10.25	52.18	54.64	52.16	22,840,150	23,138,578	22,982,268
Islamabad	50.97	50.97	50.97	100	100	100	1,431,197	1,431,197	1,431,197
Balochistan	1.38	1.38	1.38	21.97	21.88	21.88	2,529,348	2,529,348	2,529,348
						TOTAL	117,300,268	117,642,550	113,240,118

Sources: Temperature (NASA, NEX-GDDP) Land Cover (Copernicus Global Land Service, Proba-V-C3), Water Resources (European Commission’s Joint Research Centre, GSW1_0), Flow Accumulation (World Wide Fund for Nature, HydroSHEDS), Population (European Commission’s Joint Research Centre, GHSL/P2016/POP_GPW_GLOBE_V

Understanding the historic burden and patterns of diarrheal diseases in Pakistan is challenging in the absence of a dedicated surveillance system [42]. However, findings from the Demographic Health Surveys conducted in Pakistan (PDHS) show that overall, the country had seen a downward trend in the prevalence of diarrhea in children under 5 years of age in the two weeks prior to the survey, decreasing from 23 percent in the 2012–2013 PDHS [43] to 19 percent in the 2017–2018 PDHS [44]. Prevalence rates were the same for children in urban and in rural areas (19 percent) in 2018, though children from urban areas were more likely to receive advice or treatment [44]. Notably, regions such as Punjab and Khyber Pakhtunkhwa have a prevalence of diarrhea above 20 percent (See table 6).

Water quality is the most significant driver of waterborne diseases (WBDs) in Pakistan. Only 20 percent of the population has access to safe

drinking water [40] and estimates suggest that 30 percent of all diseases and 40 percent of all mortalities can be attributed to polluted water [41]. The decline in Pakistan’s surface water quality is attributable to contamination from sewage and industrial effluents, in addition to agricultural runoff to the water supply [40].

Climate change can impact water quality through temperature increases, which facilitate the proliferation of waterborne bacteria and algal toxins, and through flood events caused by the increasing intensity of precipitation and glacial melting in some regions of Pakistan. Floods not only damage sanitation infrastructure, but also carry pathogens, dissolved organic pollutants, industrial effluents, and agricultural runoff into surface water and groundwater sources. *Drought conditions* also affect water quality and limited water quantity can force populations to use contaminated water sources for drinking,

TABLE 6.

Two-week prevalence of diarrhea in children under 5 years in Pakistan, 2018

		PERCENTAGE WITH DIARRHEA
Region	Sindh	14.4
	Punjab	20.5
	Khyber Pakhtunkhwa	21.3
	Islamabad	19.7
	Balochistan	18.6
SOURCE OF DRINKING WATER	Improved	19.3
	Unimproved	17.1
TYPE OF TOILET FACILITY	Improved	19.1
	Unimproved sanitation	19.1
	Shared facility	22.4
	Unimproved facility	18.7
	Open defecation	16.5

Source: PDHS 2017–2018 [44]

bathing, and agricultural irrigation. Limited data make quantifying the direct risk of climate on the historic prevalence of WBDs in Pakistan challenging. However, recent extreme weather events highlight the country's vulnerability to WBD risks. In 2010, heavy monsoons rains led to one of the worst flood events in Pakistan's history, with the reported laboratory confirmation of 99 cases of cholera from flood-affected regions [45]. Likewise, floods in Karachi in August 2020 led to reports of cholera, typhoid, and hepatitis, as water supply lines were compromised [46].

Waterborne diseases (WBDs) are likely to increase in Pakistan in the face of a changing climate, with potentially more than 5 million people at risk. Despite the potential for significant health impacts, the research on the relationship between climate change on water quality and WBDs in Pakistan is insufficient to provide precise estimations of future projections of the WBD risk [47]. However, it is recognized that extreme weather events increase WBD risk, such as through floods and droughts. Floods in Pakistan are projected to increase in frequency and intensity, with an additional population of approximately 5 million potentially exposed to extreme riverine floods by 2035–2044 [48]. Likewise, the rate of glacial melting in South Asia has increased, with consequent flood impacts for the population at risk [49]. Districts along the Indus River system will be the most vulnerable to flood related WBD risks.

Taking historic flood events in Pakistan as an indication, the increase in future flood events could result in the breakdown of sanitation infrastructure, thus leading to the contamination of the drinking water supply and in turn increasing the rates of diarrheal diseases including cholera, cryptosporidiosis, rotavirus, typhoid, and paratyphoid. Evidence from the rural areas in regions such as Punjab show that

where sewer drains do exist, they are commonly open, with no treatment of effluents, which can lead to soil and water contamination in normal conditions and present a significant risk to health under flood conditions.

Alongside floods, increased temperatures due to climate change may lead to Sindh and Balochistan experiencing more frequent and / or intense drought events, with the consequent increased rates of diarrheal diseases driven by insufficient water quality and inadequate quantity availability for hygiene practices. This would lead to outbreaks of E. coli and Salmonella from the combination of contaminated food sources and inadequate hygiene facilities. The impact of floods and droughts on WBD risks will be compounded by socioeconomic inequalities including poverty, level of education, access to healthcare, age, and gender [50].

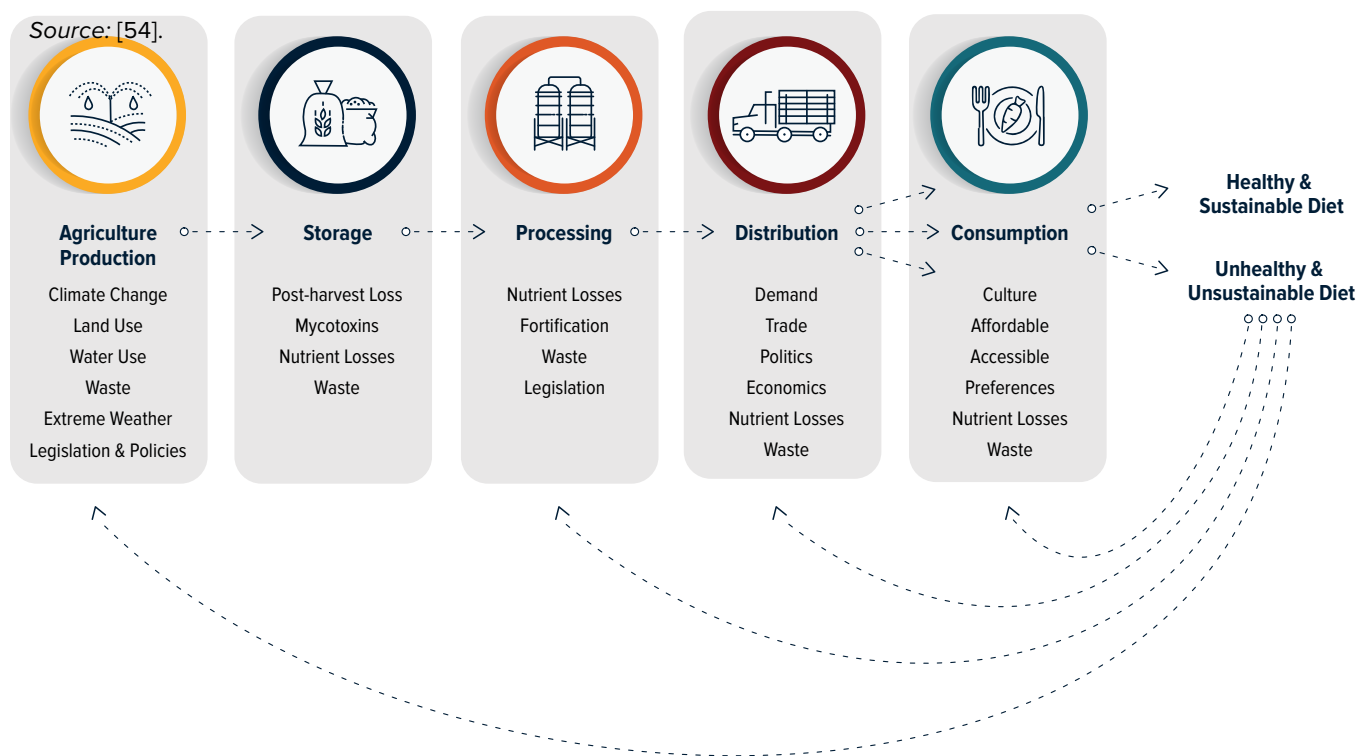
3.4 NUTRITION RISKS

Weather and climate are the foundational drivers of healthy and sustainable diets. The mechanisms by which climate change affects nutrition via the food system are profound, and include acute and chronic effects on agricultural production, storage, processing, distribution, and consumption (Figure 4). Nutritionally secure and stable diets not only depend on agricultural production, but also on the complex interactions of demand, economics, legislation, conflict, food waste, nutrient losses, food safety, and access [51]. Climate variability is already contributing to increases in global hunger and malnutrition [52].

While a comprehensive analysis of climate change's impact on the food system is beyond the scope of this assessment, this CHVA examines climate and nutrition linkages through a food security lens in Pakistan, as they relate to the weather and climate impacts on agricultural

FIGURE 4.

Stages of the food system driving healthy and sustainable diets



productivity. This is highly relevant, as agricultural productivity — a key determinant of food availability — is affected by weather and climate in a multitude of ways, from short-term shocks (for example, natural disasters) to longer-term changes in agroecological conditions, which can drastically reduce yields or redefine spatiotemporal patterns of crop suitability.

Nearly 40 percent of the population in Pakistan is food-insecure, and the prevalence of child malnutrition — among the highest in the world — is increasing. Pakistan’s National Nutrition Survey in 2018 shows that nearly 30 percent of all under-fives were underweight, 40 percent stunted, approximately 20 percent wasted, and more than half of children were anemic [53]. Malnutrition in Pakistan is partially attributable climate change, mainly through extreme weather events,

but also through the interaction of several other factors related to crop production, consumption and access to food, along with health, population growth, sanitation, and care practices [54].

Affordability is a critical determinant of proper nutrition across Pakistan. Food insecurity is strongly correlated with poverty. The average household in Pakistan spends nearly 51 percent of its monthly income on food [55] and more than two-thirds of the households cannot afford a nutritionally adequate diet [56]. Climate shocks (for example, droughts and floods) affect agricultural production and yields, which in turn influence food prices and profit. After the 2010 flood disaster, the prices of wheat and rice increased by more than 80 percent in some region of the country [57]. High food prices, coupled with flood-related losses of food stocks and sources, led to the

severe deterioration of the food security status in flood-affected areas and households, with poor food consumption rising from 13 percent to 76 percent in Sindh and from 10 percent to 45 percent in Punjab [57].

Balochistan and Sindh have the highest rates of food insecurity and malnutrition, with an estimated 3.8 million people at the crisis level.

Of this group, 1 million people are classified under the status of “emergency” [58]. The ongoing COVID-19 pandemic has had severe impacts on food security across the country due to the loss of income-generating opportunities. The Pakistan Bureau of Statistics estimated that from April to July 2020, approximately 40 percent of all households were food insecure, compared with the 16 percent recorded in the 2018/19 Household Integrated Economic Survey [59].

In the absence of adaptation, climate change is likely to substantially aggravate food insecurity and worsen nutrition outcomes. While there is uncertainty on the precise number of people who will be at risk of food insecurity because of climate variability, recent findings suggest that globally, between 2010 and 2050, the population at risk

of hunger could increase by up to 30 percent in response to climate change [60]. The rise in food insecurity spurred by climate change will have profound effects on nutrition outcomes, particularly in Balochistan, and lower Sindh—previously shown to be the areas of Pakistan that are most vulnerable to food insecurity as a consequence of natural hazards [61].





On the national scale, impacts to wheat and rice production will be especially important to future nutrition outcomes.

Wheat, milk, and rice make up approximately 50 percent of the caloric intake for the population [62]. Under RCP8.5, wheat yields are projected to decline by 19 percent during the 2060s in the Punjab province [63], where 80 percent of Pakistan’s wheat production takes place [64]. Projected risks of climate change on rice production are more complicated. Rising mean minimum temperatures have been shown to likely increase rice production in Pakistan [65]; however, increases in precipitation by even 5 percent during the September-October period could adversely affect rice production by nearly 6 percent [66]. Notably, water-scarcity concerns could further limit rice production in favor of less water-intensive crops.

In the absence of adaptation, climate change is likely to substantially aggravate food insecurity and worsen nutrition outcomes.

TABLE 7.

Summary of climate change-related health risks

	CURRENT RISK	PROJECTED RISK
Heat-related Risks 	<ul style="list-style-type: none"> • Extreme heat is currently a significant climate-related health risk in Pakistan, with most areas experiencing a high heat index. • The 2015 heatwave was one of the deadliest in recent history and provides an illustrative example of the current risk. 	<ul style="list-style-type: none"> • Excess heat-related deaths and impacts on labor productivity in Pakistan are likely to increase under both high- and low-emissions scenarios. • Increases in the number of hot days (Tmax > 35°C) and tropical nights (Tmin > 20°C) will expose millions of people to dangerous temperatures, particularly in the Sindh, Punjab, and Balochistan regions, as well as urban centers such as Karachi and Lahore.
Vector-borne Disease 	<ul style="list-style-type: none"> • Dengue is the fastest-emerging arboviral threat in Pakistan, with an 800-fold increase in cases between 1995–2004 to 2019. • More than 62 million people are vulnerable to dengue in Pakistan, with the populations of Punjab and Islamabad at highest risk. 	<ul style="list-style-type: none"> • Increasing temperatures in Islamabad, Punjab, and Sindh are likely to limit mosquito populations to only the areas that are most favorable for their survival. • Ongoing climate and infrastructural changes in Pakistan could promote the emergence of Zika, yellow fever, and Japanese encephalitis (JE). • The population of Punjab is the most vulnerable to malaria, albeit with decreasing vulnerability through 2050.
Waterborne and Water-related Diseases 	<ul style="list-style-type: none"> • Water quality is the most significant driver of waterborne diseases (WBDs) in Pakistan, with low baseline levels of access to safe water and sanitation (that is, roughly 20 percent of the population has access to safe drinking water). 	<ul style="list-style-type: none"> • Climate change-related extreme weather events, notably floods, are likely to drive increases in WBDs in Pakistan due to associated water contamination. • Floods are projected to increase in frequency and intensity in Pakistan, with an additional population of approximately 5 million at risk of extreme riverine floods by the 2040s.
Food Security and Nutrition Deficiencies 	<ul style="list-style-type: none"> • Pakistan's National Nutrition Survey in 2018 estimates that 33 percent of all children were underweight, 44 percent stunted, 15 percent wasted, and 50 percent anemic. • Balochistan and Sindh have the highest rates of food insecurity and malnutrition, with an estimated 3.8 million people at a crisis level. 	<ul style="list-style-type: none"> • In the absence of adaptation, climate change is likely to substantially reduce agricultural yields, aggravate food insecurity, and worsen poor nutrition outcomes. • Wheat yields are projected to decline by 19 percent during the 2060s in the Punjab province, where 80 percent of Pakistan's wheat production takes place.



ADAPTIVE CAPACITY OF PAKISTAN'S HEALTH SYSTEM

4.1 HEALTH SYSTEM OVERVIEW

Pakistan's health sector is decentralized — a mixed system that is legally and administratively managed by provincial and local governments, involving public, private, civil society, and parastatal actors [67]. At the federal level, the Ministry of National Health Services and Regulations and Coordination (MoNHSRC) performs the national stewardship, regulation, and coordination functions. MNHSRC provides the overarching national health strategy that coordinates federal, provincial, and cross-sectoral actions through the Pakistan National Health Vision (2016–2025). With the 2010 devolution of power, the planning of healthcare delivery structures, programs, and services has become the responsibility of provincial health care authorities [67].

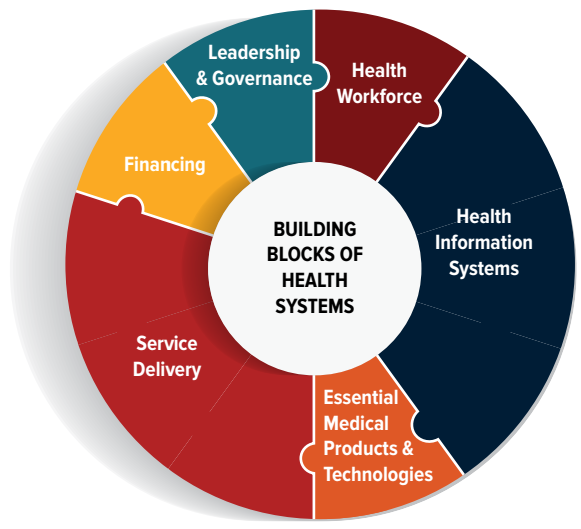
Pakistan suffers from several barriers impeding access to health services that may be further exacerbated by climate change. Despite government efforts to expand primary healthcare services, capacity is limited, leading to an overreliance on higher levels of care and on the private sector, particularly in urban areas. This situation, combined with almost no risk pooling in public health financing, has resulted in high levels of out-of-pocket (OOP) expenditures in Pakistan. Moreover, access is further compromised during and in the aftermath of extreme climate-related events. For example, the damage and loss of critical infrastructure after the 2010 flood affected the population's ability to seek and access adequate health care for multiple years [68]. In particular, the lack of access to health facilities and information

has been shown to increase household vulnerability to health risks in flood-prone areas of Pakistan [69].

COVID-19 has had a significant impact on the adaptive capacities of health systems. The emergence of the COVID-19 pandemic has brought with it a focus on the preparedness and capacities of health systems to manage emerging public health risks of a large scale, including climate and global pandemics. Climate change, in combination with COVID-19, has the potential to disrupt and overwhelm health systems, including healthcare facilities and staff. Meeting the dual crises of COVID-19 and climate change will be an important challenge for Pakistan's health system.

The extent to which Pakistan’s health system is prepared for and has the capacity to respond to climate-related changes holds the key to modifying climate-related health risks. In this assessment, Pakistan’s adaptive capacity⁹ to prevent and manage climate-related health risks is examined according to WHO’s six health system building blocks (Figure 5) [5]. Nevertheless, there are both data / information and methodology limitations that impede the ability of this assessment to comprehensively review the resilience and adaptive capacity of each aspect of the health system. The remainder of this section further elaborates on the health system blocks in as much detail as possible, given these limitations. See also the Annex V for a summarized *Adaptive Capacity and Climate Change-Related Health Risks Gap Analysis*.

FIGURE 5.
WHO’s health system building blocks



Source: [5]

⁹ *Adaptive capacity* is defined by IPCC as follows: “the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.” The related term, *resilience*, is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. People and communities with strong adaptive capacity have great resilience. This assessment makes use of the term adaptation and adaptive capacity to encompass both terms.

4.2 LEADERSHIP AND GOVERNANCE

Pakistan is committed to meeting the climate challenge through both adaptation and mitigation measures, which are coordinated and implemented by the Ministry of Climate Change and Environmental Coordination. Over the last decade, GoP has demonstrated its political commitment and action to address climate change challenges through several global and country-level agreements and protocols — some of which are relevant to health. Nevertheless, the prioritization of climate change and health risks, along with the adaptation options, in national policies and plans (with a focus on both health and climate change) remains mixed (see Annex IV for the summary table).

The evolution of the policy environment in Pakistan to address climate change challenges over the last decade (2012–2021) has included several key policies and action plans. These include, but are not limited to the following:

2012

- **The National Climate Change Policy (NCCP)**
The NCCP informs climate policy in Pakistan to mainstream climate change actions across the entire economy through national and provincial implementation committees that include representatives from the health sector. However, coordination mechanisms are seemingly unclear.
- **National Disaster Management Plan (NDMP)**
The NDMP is a comprehensive plan that identifies macro-level hazards and includes risk assessments. It forms the basis for the development of the multihazard early warning system and identifies the roles and responsibilities of stakeholders involved in disaster management. The plan encompasses components related to human resource development, community-based responses, and multihazard early warning systems.

- **National Monsoon Contingency Plan (July – September 2012) – updated in 2023**

The National Monsoon Contingency Plan provides [70] critical information on monsoon hazards, vulnerabilities, and resource mapping, as well as offers gap analyses of provinces across Pakistan.

2013

- **Framework for Implementation of Climate Change Policy (2014–2030)**

Produced as a follow-up of the NCCP, the Framework for Implementation of Climate Change Policy serves as a catalyst for mainstreaming climate change concerns into decision-making to create enabling conditions for integrated climate-compatible development processes. Although the framework highlights the need to enhance institutional capacity at provincial levels, progress on developing specific policies has been limited and actions have been ad hoc, mostly due to the lack of resources and capacity to deliver policy solutions (Parry 2016; Chaudhry 2017).

- **National Disaster Risk Reduction Policy (2013)**

The National Disaster Risk Reduction Policy aims to build resilience through a multihazard, community-focused approach of reducing exposure to hazards. Specifically, the policy calls for the integration of national capacity to identify and monitor climate change-related vulnerability and hazard trends, as well as development planning that addresses disaster risks alongside environmental and climate-related concerns.

2016

- **Pakistan National Health Vision (2016–2025)**

The National Health Vision aims to increase the health system resilience to disasters through the implementation of mitigation responses and the continued provision of services during

acute crises or health emergencies. Although there are no specific actions to address climate change in the Vision document, there are several key activities that would support adaptation and reduce the health risks of climate change. These are strengthening environmental health protections; improving health information systems (HIS); as well as developing the core capacities to implement International Health Regulations (IHR) and the Global Health Security (GHS) agenda.

- **1st Nationally Determined Contributions (NDCs)**

Pakistan's first NDC outlines the country's climate actions; however, climate-related health risks or the health sector's adaptation actions were not presented.

2017

- **Climate Change Act**

The Climate Change Act supports a “whole-of-government” response to climate change, leading to the establishment of the Climate Change Council (CCC). CCC, headed by the Prime Minister, consists of several line ministries; however, to date, it does not include health.

- **National Action Plan for the Implementation of Bangkok Principles on Health Aspects of the Sendai Framework for Disaster Risk Reduction**

This is a 10-year action plan and roadmap guided by seven relevant principles that work to strengthen the health component of disaster management from relevant provincial perspectives.

- **Karachi Heatwave Management Plan: A Guide to Planning and Response**

The Karachi Heatwave Management Plan outlines strategies for government and non-government agencies to execute prior to,

during, and after heatwave events to prevent heat-related illness and deaths in Karachi.

2018

- **Joint External Evaluation (JEE) – updated in 2023**

A JEE assesses Pakistan's capacity to prevent, detect, and rapidly respond to public health risks and identify critical gaps to enhance preparedness and response. Through this process, the development of the National Action Plan for Health Security was executed. However, actions for reducing the health risks of climate change, including potential security threats, were not explicitly included in this plan.

2021

- **2nd Nationally Determined Contributions (NDC)**

Pakistan's second NDC lays out a comprehensive set of health sector-specific adaptive measures, including the following:

- Enhancing research on the impacts of climate change on health;
- Increasing monitoring and forecasting systems for pandemic and disease outbreaks;
- Collating health co-benefit data to inform policy;
- Adopting the One Health approach;
- Conducting a geospatial analysis to identify hot spots and inform the implementation of adaptive climate-related measures for health;
- Developing standardized emergency procedures;
- Moving toward a system of stockpiling essential medicines; and
- Adopting a Health in All Policies (HiAP) approach.

In addition to the above, the NDC proposes adaptation actions in other sectors that are likely to positively impact health, including agriculture, water resources, disaster preparedness, and water sanitation and hygiene (WASH).

- **National Climate Change Policy (NCCP) 2021**

Pakistan's updated climate change policy, keeps prioritizing health as a key sector for climate-related policy measures, including the following:

- Assess the health vulnerabilities at community level;
- Ensure integration of climate-related measures in national health plans;
- Capacity building for health personnel about climate and health issues;
- Ensure preventive measures for essential medical products and resources availability during extreme weather events;
- Upgrade and extend disease outbreak monitoring and forecasting systems;
- Improve data recording, reporting and analysis of climate-sensitive diseases;
- Assess the impacts of climate change on vector/water borne and nutritional diseases;
- Identification of technology and infrastructure options for WASH resilience;
- Explore public-private partnerships to resolve the issue of financial access for WASH services; and
- Adopt water and sanitation safety plans for rural and urban areas.

2023

- **National Adaptation Plan (NAP)**

Pakistan's NAP includes health within the human capital sector as a priority for adaptation to climate change. The NAP highlights direct health impacts from extreme weather events,

heat stress, VBDs, WBDs, Nutrition, WASH, and reproductive health as key health risks being affected by climate change. In this sense they focus on 3 main objectives for addressing the climate-related health risks:

1. Mainstreaming climate adaptation in health policies by assessing climate change impact on public health, improving data collection and analysis, upgrading disease outbreak monitoring and forecasting, and integration adaptation measures in national and sub national health policies.
2. Enhancing climate resilience through Disaster Emergency Preparedness and Response. This includes activities such as: develop a communication and dissemination strategy, issue timely alerts and advisories on climate-related hazards, capacity building for government officials at federal, provincial and district level, ensure family planning services available amid extreme weather events, expand climate-resilient infrastructure for WASH services.
3. Build workforce capacities to address climate risks. Activities include: developing a climate change curricula at secondary schools and offer specialized courses in colleges and universities; and develop occupation and vocational training; among others.

Limited coordination mechanisms exist to facilitate cross-sector action on climate change and health. There is no climate change and health working group within the government to bring together the multiple sectors involved in strengthening the adaptive capacity to respond to climate change-related health risks and prevent them. As of 2015, the Ministry of National Health Services and Regulations and Coordination (MoNHSRC) has identified a designated climate change and

health focal point to support actions to build climate resilience; however, at the time of this assessment, it is unclear if this position still exists, or if further adequate resources have been provided to support the effective implementation of identified climate change and health activities.

4.3 HEALTH WORKFORCE

Climate change influences workforce capacity, putting additional strains on the overall health system performance. First, climate-related changes in population health needs increase demands on the health system, thus altering the number of staff required. Similarly, climate-related health burdens influence the case mix, thus altering the skill requirements of the health workforce. Finally, climate-related extreme events may impact the health of those working in the sector themselves, therefore affecting their levels of productivity.

As one of the 57 Human Resources for Health (HRH) crisis countries,¹⁰ [71] Pakistan is already facing numerous health workforce challenges.

There are an estimated 1.4 skilled health professionals per 1,000 population, well below WHO's minimum threshold for achieving universal health coverage (UHC) — 4.45 per 1,000 [72]. There is also a shortage of allied health professionals. Projected climate-related health burdens can be expected to further increase demands on the number of skilled health professionals required. Moreover, Pakistan faces several notable challenges with respect to its HRH capacity, particularly pertaining to the lack of a proper skill mix, the quality of education, standards and accreditation, poor absorption capacity, immigration — both internal and external, and career structure challenges.

¹⁰ The 2006 World Health Report [85] identified the countries facing critical health workforce shortages (for example, less than 22.8 skilled health workers per 10,000 population).

The health workforce varies significantly across districts, with particular concentrations observed in urban areas, across both private and government health sectors. These urban-rural discrepancies are particularly high for doctors, with 14.5 physicians per 10,000 population in urban areas, compared with 7.6 in rural areas [73]. In the case of midwives, the distribution between urban and rural areas is less pronounced, though it still skews toward urban centers, with 3.6 midwives to 10,000 population in the urban areas compared with 2.9 in rural areas [73]. The availability of skilled health personnel varies across province and district levels, leading to gaps in health promotion and protection activities.

Despite its critical importance, the coverage of the Lady Health Worker (LHW) program does not seem to be meeting its expected target populations. LHWs are female outreach professionals who have been recognized as government health workers to bridge gaps between health facilities and community members, especially in rural and remote areas. The role of LHWs is important, particularly in the face of climate change and health threats, where remote and rural populations are at particular risk. Despite the success of the LHW program, the number of LHWs is declining, total LHW coverage is currently less than 50 percent of its target population; moreover, the areas that are relatively remote and disadvantaged are seeing the lowest coverage. Furthermore, climate change-specific guidance and tools have not so far been developed or integrated into the program.

The absence of a systematic approach for capacity development on climate-related health risks and emergency preparedness and response is a key performance challenge for Pakistan's health workforce. Both professional training (for example, medical and nursing schools) and continued professional development (for example, on-the-job and in-service training) mechanisms

lack comprehensive information on understanding and reducing the health risks of climate change. Climate change has so far not been prioritized in human resource planning mechanisms, including the National Human Resources for Health Vision.

Although some training materials have been developed for certain climate-related health risks, they are far from being universal. Knowledge on the health impacts of extreme heat is a good example of where materials have been developed. Many healthcare professionals are cognizant of heat-health risks due to the Heat Emergency Awareness and Treatment (HEAT) manual and the accompanying treatment algorithm created to train them in the delivery of care during heat wave events. However, evidence points to the need for additional training and awareness raising to further expand knowledge of the signs and symptoms of heat illnesses, as well as treatment procedures [74]. Beyond extreme heat, more gaps on other topics exist, with some having relatively simple solutions. For example, community health workers previously trained to deliver psychosocial interventions have not yet been trained to meet post-flood mental health needs [75].

4.4 HEALTH INFORMATION AND DISEASE SURVEILLANCE SYSTEMS

Health information systems are currently fragmented, and vertical coverage is insufficient. This coverage gap has been acknowledged in the Pakistan National Health Vision (2016–2025). Routine health information in Pakistan is captured through a number of manual and electronic health and management information systems (MIS). Health facilities — at the primary and secondary level — relay information through the District Health Information System (DHIS). The DHIS has good coverage: established across almost 90 percent of districts in the country, it has overall high reporting rates, with information

collated on a monthly basis at the facility level. However, there are also simultaneous vertical programs and functions of health services delivering information through their respective MIS, thus resulting in duplicative efforts.

Climate and weather information is not sufficiently integrated into the DHIS and early warning systems (EWS) to inform the prevention and management of climate-sensitive health risks, as well as the early response to them.

Although EWS exist for some climate change-related disasters, integration with the health sector is limited. This being said, the National Contingency Plan for Monsoons (2020) does, in fact, highlight the need for an active-disease EWS in provincial health departments, when preparing for disease outbreaks ahead of the monsoon season. Pakistan is also included in the Famine Early Warning System (FEWS) that provides an early warning of acute increases in malnutrition. Although hospitals currently do not collect data to track heat-related morbidity or mortality levels through admissions and emergency case records, there have, however, been efforts in Pakistan to map out urban heat islands in cities to help locate hotspots and guide the establishment of first-response centers. Nonetheless, additional work is needed to expand these efforts.

4.5 ESSENTIAL MEDICAL PRODUCTS AND TECHNOLOGIES

Pakistan has a National Essential Medicines List with policy measures and operative guidelines for regulating essential medicines and laboratories; however, gaps exist between policy and practice. Issues include frequent shortages and the lack of drug inspectors, thus restricting the health system's capacity to operationalize health technologies and the delivery of medicines, including for climate-sensitive diseases [76]. Stockpiles of essential medical supplies are also needed in

vulnerable areas to support a disaster response and recovery.

There has been no assessment of technologies to ensure that health equipment is resilient to climate change. The incorporation of new technologies to build resilience in the health sector to climate change needs further exploration, such as building designs that enhance cooling (that is, increasing urban green spaces or painting roofs white) and the effective utilization of renewable and sustainable energy sources within the health sector. Even the application of innovative technologies employed outside the health sector could be relevant, as they may have impacts on human health, such as climate-smart food systems and agriculture.

4.6 SERVICE DELIVERY

The devolution of federal responsibilities for health and population welfare to the provincial level has led to challenges in health service delivery. These include increased fragmentation, reduced national institutional capacities and technical expertise, as well as the development of parallel vertical programs at the federal and provincial levels. This is a likely reason for existing inefficiencies and compromised service quality. Moreover, the coordination of service delivery across a range of health care and public health programs, including those that are important to reduce risks related to climate change, is lacking in Pakistan.

There have been no comprehensive reviews of the current health care infrastructure in Pakistan to identify climate change-related vulnerabilities. It is unclear to what extent infrastructure assessments of the health sector have been conducted, building designs have incorporated projected climate change impacts, and retrofitting measures have been carried out. This being

said, a comprehensive approach for some climate change-related health risks to reduce the overall burden of disease have been identified. The Karachi Heatwave Management Plan, for example, highlights efforts to reform existing buildings and land use regulations in the city. However, the implementation of these actions has been slow and national standards for sustainable cooling do not exist as yet. The National Disaster Reduction Policy (2013) offers advice to provincial-level disaster planning commissions in collaborating on infrastructure design to understand and reduce the disaster risks.

Baseline information is lacking on key environmental determinants of health, including WASH coverage in healthcare facilities. Climate change impact studies on water quality and quantity are also important information gaps in Pakistan. Projected increases in intense rainfall, coupled with encroachments in sewerage channels, may also lead to urban flooding in major cities, especially Karachi, Lahore, Rawalpindi, Quetta, and Hyderabad. There is a need to build climate-resilient water and sanitation systems and infrastructure in both rural and urban areas. This includes efforts to promote education and social awareness in confronting and controlling water pollution, as well as waterborne and water-related diseases, particularly at the subnational levels, by creating and supporting water regulatory authorities.

Minimum standards for climate-sensitive healthcare infrastructure have not been developed, thereby increasing the vulnerability of existing facilities. The 2010 flood damaged over 500 healthcare facilities [77]. To illustrate their vulnerability to flood events, hospital facilities were overlaid with 100-year flood extent data to identify facilities located in flood-prone areas. Results show that 13 percent (535 of 4,046 hospitals) are vulnerable, especially facilities in provinces

such as Sindh, where hospitals are sited within the 100-year flood extent.¹¹

4.7 FINANCING

Public financing for health in Pakistan is low and insufficient to meet public health needs.

Pakistan experienced a nominal fivefold increase in government spending on health in FY2017/2018 compared to FY2005/2006 [78]. However, health public expenditure has not kept abreast with growing population and inflation. The level of spending for health has averaged around 3 percent of GDP for the last 15 years, compared to 9.8 percent globally. The current allocation of the healthcare budget, at the federal and provincial levels, for services and human resource development is not sufficient to meet the strategic goals of the Pakistan National Health Vision (2016–2025). Approximately 4 percent of the total expenditure was allocated to health [78] — below the recommended 15 percent of the total budget required to strengthen health systems according to the Abuja declaration. Although the current health expenditure per capita has increased from 15.58 percent in 2000 to 39.5 percent in 2019 [79], the health sector in the country remains under-resourced to meet the needs of the people. Accordingly, a nominal 10 percent increase per annum in public health expenditure is required to meet population health demands [78].

Pakistan’s historically low public financing on health has led to significant out-of-pocket (OOP) payments, therefore increasing poverty, especially in light of ongoing climate-related risks. Financing for health comprises OOP expenditures, taxes, and employee contributions, as well as community and private insurance [80]. OOP payments are the largest source of health

¹¹ Analysis of hospitals within the 100-year flood extent uses an outdated administrative boundaries map.

financing in Pakistan [81]. In 2018, total health expenditures from public sources constituted 40.9 percent, while private expenditures were 58.5 percent, of which 88 percent fell under the OOP expenditure category. The OOP expenditure level is higher than the recommended WHO threshold of 20 percent, significantly increasing the risks of impoverishment and vulnerability for poor households. Although public hospitals provide free access to services, the facilities are under-resourced in the face of high demand [81]. In fact, in 2015, it was estimated that close to 5 percent of households spent more than 10 percent of their incomes on health — the largest share of which was spent on medicines (67 percent). Medicines, for instance, are purchased privately, accounting for 50 percent of the OOP expenditure [81]. This is of particular concern in the case of large-scale disasters such as those related to climate change.

Health financing sources include general taxes and mandatory health insurance, but resources are not earmarked exclusively for health. General government taxation is the second-largest source of health finance in Pakistan [81]. It comprises primarily indirect taxes, as there are no earmarked taxes for the health sector. General taxation is channeled in annual development plans and includes external sources of funds from donors [80]. Unlike most developing countries, the health sector in Pakistan is not heavily reliant on donor financing [80]. In 2012, for instance, external resources for health, as a share of total health expenditure, represented 4.7 percent [81]. Additionally, the revenue collection for health includes mandatory and voluntary health insurance, constituting approximately 7 percent of health financing. Although not earmarked only for health, mandatory financing includes social security contributions through employers and the private sector, as well as deductions from private savings (known as *Zakat*) [81]. Approximately 1 percent of total private expenditure is voluntary

health insurance, funded through contributions to private schemes [81].

Pakistan has health insurance programs, but risk pooling does not seem to account for climate and health-related risks. In general terms, illnesses and health care costs are not evenly distributed, with some population groups facing higher health risks, which may be exacerbated by climate change. Climate change can augment underlying health burdens, while increasing the potential and size of certain catastrophic financial health risks, especially among the most vulnerable. Although Pakistan has health insurance schemes, they only account for 5 percent of the population [80], and potentially exclude the poor and climate-vulnerable populations. Risk pooling can address this challenge. However, risk pooling through health insurance in Pakistan is poor, due to the fragmented insurance system and the lack of a coordinated system to allocate resources across public facilities [81].

Strategies to mobilize health funds will, to a large extent, determine the mechanisms and ability to pool resources to address such risks. General revenues are most suited for pooling risks, if health services are accessible to the entire population, or for subsidizing the premiums of high-risk groups. As the country has low public health expenditure and relies heavily on the private sector for the delivery of health services, the limited risk pooling in public health financing has resulted in OOP expenditures being high [78]. Non-government pools of funding for health include private health insurance and social security funds. Further, as previously noted, OOP expenditure, which constitutes the largest share of total health expenditures, is not pooled at any level. Finally, these arrangements do not take into account any considerations for pooling funds for climate-related risks, thereby falling

short of providing any form of financial protection for the poor and vulnerable populations affected by climate and health-related risks.

Pakistan is resource-constrained, with a limited fiscal space for financing climate-resilient activities to promote health. Pakistan was ranked seventh on the list of the most vulnerable countries, in terms of climate finance resources to manage the outcomes of climate change [82]. Due to its limited climate financing capacity, the country primarily relies on donors to cover the gap. To enhance climate adaptation, Pakistan requires USD7–14 billion a year; however, the total grants received by the country has not reached that level [82]. Consequently, climate-related health issues receive limited finance.

Limited experience with strategic purchasing in the Pakistan health sector precludes climate and health results from being appropriately achieved. Prioritizing basic health services and preventive programs is the most effective approach that governments can adopt to strategically purchase health services. The shift from passive budgeting to strategic purchasing can ensure improvements in health outcomes while strengthening governance and accountability mechanisms. Further, it is incumbent upon governments to embrace an equity lens to assure pro-poor healthcare service delivery. The selection of providers, using public funds, should take into consideration capacity, quality, and price. To this end, considerations for different provider payment mechanisms need to be given due attention to incentivize provider behaviors that are geared toward achieving strategic objectives. Finally, dimensions related to regulation, provider autonomy, and competition are fundamental for successful strategic purchasing arrangements.

In Pakistan, there is limited experience with strategic purchasing, along with the insufficient coordination of benefits and the adaptation of programs to cover the vulnerable. This being said, one example where new strategic purchasing interventions were proposed is within the *Sindh Health Strategy* [83]. This Strategy articulated two result areas that are aimed at improving strategic purchasing for priority services as well as enhancing strategic planning, budgeting, and financial management. In this respect, it outlined steps toward strengthening contract management capacity, introducing results-based financing mechanisms, and supporting innovative methods to finance human resources. In addition, it stipulated strategic steps to prioritize and rationalize health financing while improving public budgeting and overall public financial management. While there are no current considerations for climate in the thinking on strategic purchasing in Pakistan, this should be prioritized moving forward to ensure that climate and health results are appropriately addressed.

TABLE 8.

Summary of the adaptive capacity gaps of the health system for Pakistan as they relate to climate change

HEALTH SYSTEM BUILDING BLOCK	SUMMARY OF GAPS IN ADAPTIVE CAPACITY
Leadership and Governance	<ul style="list-style-type: none"> • Pakistan is committed to meeting the climate challenge through both adaptation and mitigation measures; however, the coordination mechanism to facilitate cross-sector action on climate change and health is limited.
Health Workforce	<ul style="list-style-type: none"> • The number of skilled health professionals is well below the WHO minimum threshold for achieving UHC, and with notable urban-rural discrepancies. • There are existing HRH capacity issues, pertaining to the lack of a proper skill mix, low quality of education, the lack of standards and accreditation, poor absorption capacity, immigration — both internal and external, and career structure challenges. • There is no systematic approach for capacity development on climate-related health risks, and emergency preparedness and responses constitute a key challenge for Pakistan’s health workforce.
Health Information and Disease Surveillance Systems	<ul style="list-style-type: none"> • Health information and surveillance systems are currently not integrated; moreover, they do not include climate / weather data or information on other environmental factors. • There is no comprehensive climate-informed health EWS.
Essential Medical Products and Technologies	<ul style="list-style-type: none"> • There are important gaps between policy and practice for essential medical products and technologies, including frequent shortages and the lack of drug inspectors. • There has been no assessment of technologies to ensure that the health equipment is resilient to climate change.
Health Service Delivery	<ul style="list-style-type: none"> • Health service delivery is challenging in Pakistan, stemming from fragmentation, reduced national institutional capacities and technical expertise, along with the development of parallel vertical programs at the federal and provincial levels. • There has been no comprehensive review of the health care infrastructure in Pakistan to identify climate change-related vulnerabilities. • Minimum standards for climate-sensitive healthcare infrastructure have not been developed, thereby increasing the vulnerability of existing facilities.
Financing	<ul style="list-style-type: none"> • Pakistan’s historically low public financing on health has led to significant OOP payments, thereby increasing poverty, especially in light of ongoing climate-related risks. • Risk pooling in Pakistan does not account for climate and health-related risks. • Limited experience with strategic purchasing in Pakistan precludes climate and health results from being appropriately achieved.

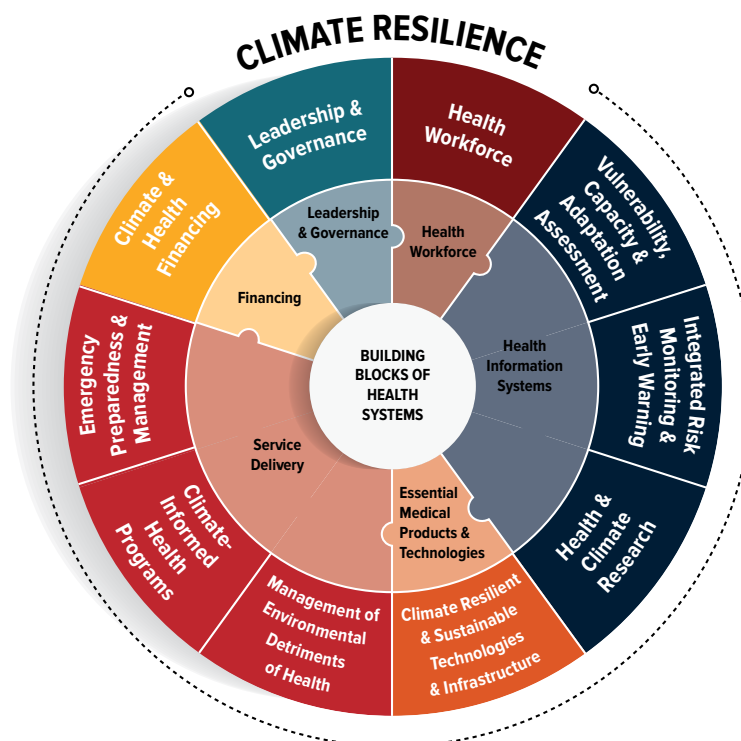


RECOMMENDATIONS TO ENHANCE HEALTH SYSTEM RESILIENCE TO CLIMATE CHANGE

This section describes recommendations to enhance health system resilience to climate change, including health interventions and strategies for adaptation. The recommendations, produced by the reflection on the findings of this assessment, are guided by the 10 components of WHO’s operational framework for building climate-resilient health systems (Figure 6). It also draws on consultations with key stakeholders in Pakistan and the draft Pakistan Climate and Health Policy / Action Plan. See also Annex VI for relevant line ministries for each of the described key recommendations, Annex VII for examples of “No-Regrets” recommendations for climate change and health in Pakistan, and Annex VIII for the menu of health adaptation options organized by climate-related health risk.

FIGURE 6.

WHO’s operational framework for building climate-resilient health systems



Source: World Health Organization, 2015, Operational Framework for Building Climate Resilient Health Systems.

Strengthen a climate-health policy environment at the national and subnational levels.

While Pakistan has ratified a number of international agreements and developed national policies and strategies related to climate change, the majority of them do not include a specific health focus. As such, GoP would be well-advised to ensure that health is featured prominently in its national adaptation plans and strategies. To this end, the integration of climate-related health risks into the next iteration of the Pakistan National Health Vision would be a critical step. Subnational plans for certain climate risks exist, but they are far from comprehensive. In light of this, it is recommended that subnational adaptation plans that are further developed are modified to provide specific climate-related health actions. A good example is the Karachi Heat Health Action Plan, which could be rolled out for all major population centers, with prioritization for cities in vulnerable areas such as Lahore and Islamabad.

Enhance coordination mechanisms for climate and health action.

In the first instance, this would involve the designation of a national climate and health focal point to liaise with stakeholders at different levels. Establishing coordination mechanisms with key actors both inside and outside the health sector, including with line ministries of climate change, agriculture, planning and development, and transportation, among others, would be beneficial.

Develop health workforce capacity to manage climate and health risks.

Climate information presented in this assessment could be used to train policy makers and planners in the health sector to inform the design of health sector programs and enhance day-to-day service delivery, as well as during and after extreme weather events (for example, heatwaves and floods). Beyond capacity development efforts at the policy level, a more intensive training for service providers

and community health workers is fundamental to operationalizing key interventions at the programmatic level. As a first priority, the focus on the management of extreme heat exposure risk is essential. This is especially significant in regions such as Sindh, Punjab, and Balochistan, where the most substantial increases in heat exposure are projected and capacity may be limited for addressing related health risks.

Furthermore, building the capacity of lady health workers (LHWs) would be ideal to enable this important and efficient cohort to manage climate and health risks at the community level, thus focusing on preventive and promotive health services.

Realizing the intended objectives of the proposed capacity development actions requires two cardinal steps: (a) introduce formal pedagogical training on climate change and health, as part of medical, paramedical, and nursing curricula, at higher-education and vocational institutions; and (b) develop training and awareness raising materials tailored for health providers and community health workers on climate change, health risks, and adaptation responses.

Develop an intersectoral platform to monitor climate-related health risks and support the establishment of a climate-informed disease early warning and response system.

Under the patronage of the Ministry of Climate Change and Environmental Coordination, it is recommended that the surveillance of key climate risks, as they relate to health, be conducted to inform the operationalization of the Ministry of National Health Services and Regulations and Coordination programs (MoNHSRC). This is important for the broader understanding of health risks that is informed by real-time climate information.

Further, expanding health surveillance to capture spatiotemporal patterns of climate-sensitive diseases and determine population health risk is

imperative. Building on prior efforts to strengthen the disease early warning system (DEWS), it is recommended for the scope of such a system to be further expanded in order to incorporate climate-sensitive diseases. This would require intersectoral collaboration with existing DRM efforts related to respective EWS around disasters (that is, for floods and heatwaves) to enable the real-time analysis of subsequent health impacts to inform a timely health response.

Climate-proof health infrastructure and technologies. Here, the vulnerability of health facilities is analyzed in relation to potential structural damage from climate-related hazards (that is, flooding). However, the assessment of the existing infrastructural characteristics — encompassing building design and construction (including retrofitting) — is beyond the scope of this assessment, and therefore, warrants a further in-depth analysis. The same can be said of the contribution of healthcare facilities to increasing urban temperatures (that is, the urban heat island effect), which needs to be further studied. In light of findings stemming from these proposed assessments, the government may wish to revisit building codes to ensure that they are climate-smart and that appropriate consideration is given to the likely impacts of climate-related hazards. In addition, energy efficiency should be considered as part of these building codes, including sustainable cooling options for health facilities and medical warehouses for vaccines and drugs.

Establish a national risk register for climate-health risks in Pakistan, with seasonal climate outlooks to inform health-sector programming. The aim of this register would be to ensure that GoP is prepared to manage health emergencies from climate-related hazards. The register would cover the likelihood, scale, and extent of such emergencies affecting the population to help inform the government's emergency response. In

tandem and feeding into the proposed national risk register, the government would be well-advised to develop seasonal climate outlooks. They would serve to inform disease control and / or prevention programs as well as facilitate a multi-sectoral response to climate-related health risks (involving first-responders, disaster management authorities, rural support agencies, and LHWs).

Pool health funds to cover climate-related health risks and include climate risk considerations in strategic purchasing. With the exception of OOP payments, all revenues for health are pooled through public and private health insurance and in central and provincial government budgets, and then transferred to providers. It is important for the health system to provide financial protection for the vulnerable to maintain access to health services for climate-related health needs, while also preventing financial hardship. This could include the consideration of a pre-payment mechanism that provides such financial protection for climate-related health impacts through the pooling of resources. Moreover, this could involve a bold move toward a provider payment mechanism that incentivizes healthcare providers to focus on climate-related health outcomes. In this respect, a strategic purchasing mechanism that pays for climate results would need to be designed and implemented across the provinces of Pakistan, particularly those most vulnerable to climate-related health risks.

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ANNEX I. ASSUMPTIONS ON THE COURSE OF FUTURE GLOBAL CLIMATE CHANGE

Predicting the future climate of any country requires several assumptions to be made about the direction of the future global climate. World Bank’s Climate and Health Vulnerability Assessments (CHVAs) uses climate information from the World Bank Group’s Climate Change Knowledge Portal (CCKP). Observed changes in mean annual, mean maximum, and mean minimum temperatures and precipitation are presented on CCKP for the period 1901–2021. Climate data in the World Bank Group’s CCKP is derived from the Coupled Model Intercomparison Project, Phase 6 (CMIP6), the foundational data used to present global climate change projections in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). CMIP6 relies on the Shared Socioeconomic Pathways (SSPs), which represent possible societal development and policy scenarios, which are used to represent the climate response to different plausible future societal development storylines and associated contrasting emission pathways to outline how future emissions and land use changes translate into responses in the climate system. For the purposes of the World Bank’s vulnerability assessments, this assessment uses the SSP3-7.0 scenario, being business-as-usual.

In addition to selecting the most likely scenario of future global climate, it is also useful to define a baseline period to represent the current climate within which observed health impacts have occurred. It is also useful to define future time periods that can be used as a comparison against this baseline, and for which assumptions or models can be used to predict changes in future climate-related disease burdens. The World Bank’s CHVAs use two 20-year time periods that together cover the next four decades to show imminent and medium-term climatic changes in a given country.

The baseline period covers 30 years, since this has conventionally been the length of time over which climatic conditions are measured to reduce noise from annual or other cyclical variations.

Looking to the future, 20-year time periods are used because of the accelerating pace of change of global climate; moreover, doing so enables climate-related threats to be analyzed over a sufficiently proximate timescale.

- **2030s:** This 20-year period extends from 2020 to 2039, with 2030 as the chronological mid-point. The 2030s can be seen to represent the immediate upcoming years to which countries and their governments need to respond with the utmost urgency.
- **2050s:** This 20-year period extends from 2040 to 2059, with 2050 as the chronological mid-point. The 2050s can be seen to represent a medium-term period — still well within the lifetime of current populations for which countries and governments have sufficient time to make profound changes in preparation for expected threats.

ANNEX II. NET CHANGE IN FUTURE MONTHLY PRECIPITATION ACROSS PAKISTAN

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC
Balochistan												
2030s	1.92	-1.98	1.32	0.13	0.3	1.34	5.37	5.34	1.6	0.0	-0.09	0.94
2050s	0.12	-3.16	-0.4	0.42	0.31	1.81	5.93	5.57	1.92	0.03	-0.11	-0.45
Federal Capital Territory												
2030s	5.46	-8.18	1.88	-7.01	5.75	12.46	17.51	12.38	8.38	1.35	-2.32	8.24
2050s	-0.61	-0.43	-3.81	2.18	6.29	8.5	26.77	28.45	13.72	1.96	-1.58	3.47
Khyber Pakhtunkhwa												
2030s	3.47	-2.39	7.17	-4.49	5.27	8.17	3.92	4.15	4.13	-1.49	-2.45	4.61
2050s	1.14	1.29	0.47	3.19	5.23	5.41	10.44	15.17	3.68	1.09	2.2	2.55
Punjab												
2030s	0.76	-2.33	0.69	-1.15	2.15	6.81	6.73	8.47	7.89	0.43	-0.48	1.35
2050s	-0.35	-2.12	-1.01	1.54	2.54	9.43	14.49	14.44	12.22	1.32	-0.54	0.1
Sindh												
2030s	0.0	-0.02	0.0	0.0	0.0	2.59	10.19	17.01	7.27	0.04	0.0	0.0
2050s	0.0	-0.03	-0.02	0.01	0.0	3.34	15.62	21.84	10.65	0.44	0.0	-0.01

Source: Climate Change Knowledge Portal

Note: Figures above are in millimeters (mm)

ANNEX III. METHODS FOR THE ESTIMATION OF MOSQUITO SUITABILITY, UNDER RCP 8.5, IN PAKISTAN

Predicted spatiotemporal distributions of *Anopheles (An.) stephensi*, *An. culicifacies*, *Aedes (Ae.) aegypti*, and *Ae. albopictus* were determined, using a raster-based suitability model that is constructed with Google Earth Engine through the adaptation of methodology presented by Frake et al. (2020) [84]. This methodology uses abiotic variables specific to the thermal tolerances of vector species and biotic variables that consider the species' habitat preferences. Suitable areas are defined as those geographic areas that would support vector survival.

At the outset, four models were constructed to define suitability for each mosquito species. For each model, parameter thresholds for all input variables were selected, based on a literature review of the species' thermal tolerance and habitat characteristics (see Table 1). Thresholds were then used to create binary maps for each predictor (that is, suitable [1] or unsuitable [0]) that were combined, using Boolean logic, to produce suitability for each target species. To demonstrate malaria and dengue vulnerability as a function of vector suitability, Boolean logic was again used to combine suitability maps for *An. stephensi* and *An. culicifacies* for malaria vulnerability, and *Ae. aegypti* and *Ae. albopictus* for dengue vulnerability.

Population vulnerability was demonstrated by spatially overlaying vulnerability maps for malaria and dengue, with population data from the Global Human Settlement Layers (2015) used to calculate the number of people residing in suitable areas, by region. Population data were held constant in all models, in the absence of spatial population projection information. The output spatial resolution of products was set at 1000 m.

TABLE A1.

Data sources and thresholds for vector species' thermal tolerance and habitat characteristics

CHARACTERISTIC	DATA SOURCE	PRODUCT	SPATIAL RESOLUTION	THRESHOLD
Temperature	NASA	NEX-GDDP	0.25 degrees	<i>An. stephensi</i> Min: 15°C Max: 36°C <i>An. culicifacies</i> Min: 12°C Max: 41°C <i>Ae. aegypti</i> Min: 15°C Max: 35°C <i>Ae. albopictus</i> Min: 20°C Max: 30°C
Land Cover	Copernicus Global Land Service	Proba-V-C3	100 m	See Table 2*
Water Resources	JRC	GSW1_0	30 m	> 0% water occurrence
Flow Accumulation	WWF	HydroSHEDS	500 m	> Q2**
Population	JRC	GHSL/P2016/POP_GPW_GLOBE_V1		

* The table providing information for each species, by land cover type, is forthcoming.

** Quartiles 1–4 of the precipitation range are presented to identify areas of varying water inundation potential.

ANNEX IV. KEY CLIMATE CHANGE AND HEALTH-RELATED POLICIES IN PAKISTAN

POLICY OR PLAN	RELEVANCE FOR CLIMATE CHANGE AND HEALTH	CLIMATE CHANGE AND HEALTH RISKS
National (climate change and health)		
Health and Climate Action Plan (under draft)	It will be the first national action plan specific to climate change and health.	Vector-borne diseases (VBDs) (dengue and malaria); waterborne, airborne and foodborne diseases (including pollen allergies); health effects of extreme heat; nutrition-related diseases; injuries; and mental illnesses will be discussed.
National (Climate Change)		
Nationally Determined Contributions (NDC) (2021)	The updated NDCs (2021) include health as a key priority for climate change action.	Priority risks may VBDs, waterborne diseases (WBDs), nutrition-related diseases, air pollution / air quality, and extreme weather events such as heatwaves, floods, and droughts.
2nd National Communication to the UNFCCC (2018)	This document includes a section on health vulnerabilities and adaptation needs in relation to climate change.	VBDs (dengue and malaria); waterborne, airborne, and foodborne diseases (including pollen allergies); health effects of extreme heat; nutrition-related diseases; injuries; and mental illnesses are discussed.
National Climate Change Policy (NCCP) Framework for Implementation (2013)	This policy includes a description of health adaptation actions across five strategies.	VBDs (dengue and malaria); heat-related mortality; injuries and deaths related to extreme weather events; diarrheal diseases; and mental health are discussed.
NCCP (2021)	Health is included as a priority sector and policy measures of interest - including assessment of health vulnerabilities, integration of climate-related measures in health national plans, capacity building of health personnel, preparedness measures for ensuring essential medical products, surveillance and information systems, among others.	Injuries related to extreme weather event such as flooding; WBDs related to changing rainfall patterns; VBDs (dengue and malaria); and mental health are discussed.
National (Health)		
Pakistan National Health Vision (2016–2025)	This plan mentions building health system resilience to disasters (including climate change) as a strategic priority.	There is no discussion of specific climate-related health risks.
Provincial		
Provincial Disaster Management Plans	Provinces and districts have contingency and disaster risk management (DRM) plans, with a specific focus on monsoons and flooding events.	Health is mentioned to varying degrees, including disease early warning systems (DEWS), the protection of healthcare facilities, and enhanced health service delivery.
Municipality level		
Karachi Heat Action Plan (2018)	This plan focuses on the prevention of health risks related to heat.	Extreme heat-related health risks and adaptation options are discussed.

ANNEX V. ADAPTIVE CAPACITY AND CLIMATE CHANGE-RELATED HEALTH RISKS GAP ANALYSIS

HEALTH SYSTEM BUILDING BLOCKS	SELECTED CLIMATE CHANGE-RELATED HEALTH RISKS			
	HEAT-RELATED RISKS	VECTOR-BORNE DISEASES (VBDS)	WATERBORNE AND WATER-RELATED DISEASES	FOOD SECURITY AND NUTRITION
Leadership and governance	A Heat-Health Action Plan or Strategy was developed in Karachi. The health impacts of extreme heat are not mentioned in climate change, or health sector policies or planning.	Climate change is not considered in strategic planning for VBDS (for example, the National Malaria Strategic Plan). Dengue and chikungunya are not highlighted as emerging climate-sensitive VBDS.	The link with the MoNHSRC needs to be strengthened across sectors to improve the climate resilience of the water sanitation and hygiene (WASH) infrastructure. Sub-national interventions are lacking. The advocacy role needs strengthening to integrate climate change-related risks.	Climate change integration into strategic planning, and interventions for food security and nutrition are lacking.
Health workforce	Some training materials exist, but the MoNHSRC staff have not completed training on the identification of extreme heat and clinical responses for the condition.	Training — linking climate / weather variables to VBDS, particularly epidemiology and the use of climate / weather data at sub-national levels — should be provided.	A baseline understanding of WASH, as well as the climate relationship and interventions is needed.	Climate change is not incorporated into training models across programs.
Health information and disease surveillance system	MoNHSRC does not record heat-attributable mortality. Some mapping of urban hot spots to identify at-risk populations have been done (that is, Karachi). An evaluation of the Heat-Health Warning System in Karachi is needed.	Basic surveillance of VBDS needs to be improved. There is no integration of climate / meteorological data.	Climate data is not integrated into health information systems (HIS). No risk assessments of WBDs and climate change have been done. No early warning systems (EWS) for climate-sensitive diseases exist.	Further assessment is needed to understand the relationships between climatic factors and nutrition / food insecurity.
Essential medical products, technologies, and infrastructure	Healthcare facilities have not been assessed to determine potential risks related to extreme heat, and cooling measures have not been implemented.	Laboratory, testing, and control capabilities need to continue to be strengthened for effective malaria and dengue response and elimination.	The distribution of essential medications (for example, vaccines) is lacking in rural / remote areas.	No baseline information on equipment / medication related to undernutrition, including new technologies related to sustainable agriculture, is available.

HEALTH SYSTEM BUILDING BLOCKS	SELECTED CLIMATE CHANGE-RELATED HEALTH RISKS			
	HEAT-RELATED RISKS	VECTOR-BORNE DISEASES (VBDS)	WATERBORNE AND WATER-RELATED DISEASES	FOOD SECURITY AND NUTRITION
Health service delivery	There are no extreme heat programs in MoNHSRC: extreme heat is not included in DRM plans / operations.	Climate change is not incorporated into standard operating procedures (SOPs) for VBDS. Community-based interventions / awareness building can include the link between VBDS and climate change.	Baseline information on safe WASH in healthcare facilities and interventions needed to improve resilience to climate change is lacking.	Nutrition programs in remote, rural areas are needed, particularly before, during, and after drought and flooding events.
Financing	Though extreme heat is prioritized in some city-level budgets, it is not highlighted in heat-health projects.	Surveillance of malaria and dengue, as well as the additional analysis of the VBD risk associated with climate change, needs investment.	The distribution of funds to improve WASH, especially in rural areas, is needed.	Climate-smart agriculture systems, including water harvesting and irrigation to manage rainfall variability, are needed.

ANNEX VI. KEY RECOMMENDATIONS AND RELEVANT LINE MINISTRIES IN PAKISTAN

HIGH-LEVEL RECOMMENDATIONS	RELEVANT LINE MINISTRIES	WHO'S CLIMATE AND HEALTH OPERATIONAL COMPONENT
Strengthen a climate-health policy environment at national and subnational levels.	Ministry of National Health Services and Regulations and Coordination (MoNHSRC); Ministry of Climate Change and Environmental Coordination; Provincial Health Authorities; Municipality Health Authorities	Leadership and governance
Enhance coordination mechanisms for climate and health action.	MoNHSRC; MoCC (Climate Change Council and Climate Change Authority)	
Develop health workforce capacity to manage climate and health risks.	MoNHSRC; Ministry of Federal Education and Professional Training; Pakistan Medical Association; Pakistan Nursing Council	Health workforce
Develop an intersectoral platform to monitor climate-related health risks and support the establishment of a climate-informed disease early warning and response system.	MoNHSRC; MoCC; Pakistan Meteorological Department; Directorate of Malaria, Dengue, and other Vector Borne Disease Control; Ministry of National Food Security & Research; National Disaster Management Authority	Integrated risk monitoring and early warning
Climate-proof health infrastructure and technologies.	MoNHSRC; Ministry of Water Resources; Ministry of National Food Security & Research; Ministry of Energy; Public Private Partnership Authority (PPPA); Ministry of National Food Security & Research; Ministry of Planning Development and Special Initiatives	Climate-resilient and sustainable technologies
Establish a national risk register for climate-health risks in Pakistan with seasonal climate outlooks to inform health sector programming.	MoNHSRC; National Disaster Management Authority; Provincial Disaster Management Authority; National Commission on the Status of Women	Emergency preparedness and management
Pool health funds to cover climate-related health risks and include climate risk considerations into strategic purchasing.	MoNHSRC; Ministry of Finance; Water and Power Development Authority	Climate and health financing

ANNEX VII. EXAMPLES OF “NO REGRETS¹²” RECOMMENDATIONS FOR CLIMATE CHANGE AND HEALTH IN PAKISTAN

COMPONENT 1: LEADERSHIP AND GOVERNANCE

Options to strengthen leadership and governance include the following:

National (Health)

- The finalization of the Health and Climate National Action Plan should incorporate all available evidence and senior endorsements to facilitate implementation.
- Integrate climate-related health risks into the Pakistan National Health Vision (2016–2025).
- Develop and deliver climate and health-related workshops and national policy briefs aimed at senior health sector policymakers, as well as other key sectors, to advocate for and develop climate and health policies and plans at the national level.
- Establish legal and coordination mechanisms within the MoNHSRC specific to climate change, including the designation of a national climate and health focal point.
- Facilitate a memorandum of understanding between MoNHSRC and other key stakeholders at the national level, including other sectors such as agriculture, planning and development, and transportation. This could potentially include the establishment of a cross-governmental climate change and health working group.

Subnational

- Develop subnational adaptation plans for climate and health to enable the prioritization of adaptation needs and ensure the allocation of sufficient financial resources for implementation at provincial levels.
- Develop city-level policies and plans for climate-related health risks. As a first step, the heat health action plan developed for Karachi could be rolled out for all major population centers, with prioritization for particular cities in vulnerable areas such as Lahore and Islamabad.

COMPONENT 2: HEALTH WORKFORCE

Options to strengthen the health workforce include the following:

- Conduct climate-health analytics to inform health workforce planning. Evidence to inform policy making is critical for developing a strategic health workforce plan that is aligned with Pakistan’s current and projected climate-related health risks. To this end, while this assessment has reviewed the Human Resources for Health (HRH) dimensions related to climate change, a more in-depth analysis is necessary to elicit the health workforce needs and knowledge that are tailored to the Pakistan context. This would include considerations of the size of the health workforce, the skill mix, and the geographical distributions of personnel necessary to meet expected health needs, including addressing urban-rural disparities.

¹² “No-Regrets” Approach: “No-regrets” actions are actions by households, communities, and local / national / international institutions that can be justified from economic, social, and environmental perspectives, whether natural hazard events or climate change (or other hazards) take place or not. “No-regrets” actions increase “resilience,” defined as the ability of a “system” to deal with different types of hazards in a timely, efficient, and equitable manner. Increasing resilience is the basis for sustainable growth in a world of multiple hazards [86], [87], [88].

- Make use of climate information to train the health sector's policy makers and planners to enable them to inform the design of health sector programs and enhance day-to-day service delivery, as well as during and after extreme weather events.
- Develop training and awareness raising materials tailored for health providers and community health workers on climate and health in Pakistan. In addition to the conventional areas of climate and health focus (for example, malaria and dengue), an emphasis on emerging diseases (for example, Japanese encephalitis [JE], yellow fever, and Zika) is also equally important, particularly for areas along the intended China Pakistan Economic Corridor (CPEC). A full range of climate and health risks, such as extreme heat and nutrition, would need to be incorporated. It is recommended that the delivery of such training occur at both the national and subnational levels, utilizing a training-of-trainers (ToT) approach.

COMPONENT 3: VULNERABILITY, CAPACITY, AND ADAPTATION ASSESSMENT

Options to strengthen vulnerability, capacity, and adaptation assessments include the following:

- Establish mechanisms for the routine update of climate and health vulnerability assessments (CHVAs) to inform policy and programming. Building on this assessment, periodic updates of climate and health vulnerability as well as adaptive capacity assessments are necessary. Given the pace at which climate risks are developing and the associated disease burden, it is recommended that CHVAs for Pakistan are conducted every five years to capture new information and update the stakeholders on climate-related health risks. In addition, expanding the scope of the CHVA to include an in-depth, finer-scale quantitative analysis of climate-related health risks is essential for informing policy. For example, examining the causal pathways and impacts of climate change on water quality and waterborne diseases (WBDs) would be a valued addition to the provision of precise estimates of the projected WBD risk. Further, future CHVAs could potentially also incorporate economic modeling, capturing the costs of inaction and determining the cost-benefit of cost-effective adaptive measures.
- Utilize modeling techniques, including climate, disease, and economic scenarios, to guide future vulnerability adaptation assessments. This could integrate outputs from tools currently under development by the World Bank, including the Climate and Health Economic Valuation Tool (CHEVT), as well as others. These tools could make use of the information collected in this CHVA and other CHVAs.

COMPONENT 4: INTEGRATED RISK MONITORING AND EARLY WARNING

Options to integrated risk monitoring and early warning systems include the following:

- Support the expanded and enhanced coverage of health surveillance for climate-sensitive diseases, for example, in terms of geographic, population, and seasonal aspects. This would include linking with environmental / meteorological monitoring structures to develop climate-informed early warning systems (EWS) and response mechanisms. For example, air quality monitoring systems that are linked effectively to public health communication channels to disseminate education risk messaging can inform the public and reduce the adverse health outcomes related to air pollution. Additionally, hospitals should update their admissions and emergency case records to track heat-related morbidity and mortality levels.

- Introduce a systematic approach to the monitoring of climate and health vulnerabilities. It is imperative that climate and health-specific indicators are identified to enable the monitoring of climate-sensitive diseases while simultaneously assessing the impacts of intervention measures, especially for climate-vulnerable populations. For example, reestablishing diarrheal disease monitoring at district levels across Pakistan would be important to elucidate the impact of climate events on diarrheal disease.
- Review the extent to which human, animal, and plant disease surveillance systems are integrated and incorporate climate factors to ensure that the One Health approach is utilized and strengthened.
- Collect information to establish agreed-upon baselines for monitoring vulnerable populations / regions, and existing or new health-related human resource, technical, and health services delivery capacity.
- Support the identification and / or development of indicators to measure climate change and health impact and integrate the response capacity into national and provincial monitoring systems. This would also support future vulnerability and adaptation assessments.

COMPONENT 5: HEALTH AND CLIMATE RESEARCH

Options to strengthen climate and health research include the following:

- Develop research partnerships to conduct studies and projects on key climate change and health topics, such as modeling studies to quantify the current and projected burden of climate-sensitive diseases; economic analyses to better understand the healthcare costs related to climate change; the quantification of the health co-benefits of climate change mitigation actions; operational research to test and evaluate the implementation of evidence-based interventions, such as targeted resource deployment for extreme weather events; as well as the development and testing of contextualized climate change and health risk communication materials and dissemination approaches.
- Additionally, research priorities have been identified for specific climate-related health risks, such as studies on climate-resilient crops and the analysis of water demands under different climate scenarios.

COMPONENT 6: CLIMATE-RESILIENT AND SUSTAINABLE TECHNOLOGIES AND INFRASTRUCTURE

Options to strengthen the climate resilience of health technologies and infrastructure include the following:

- Conduct health technology assessments (HTAs) targeted at understanding the value and benefits of adaptation measures in the health sector in Pakistan. HTAs ensure a systematic evaluation of health technologies, with the aim of informing the policy on cost-effective options that can be adopted. To this end, GoP would be well-advised to conduct HTAs that consider climate adaptation in their design to identify value-for-money and to inform implementation.
- Assess current laboratory capacities to diagnose current and future climate-related disease, particularly emerging and reemerging communicable disease (CD), as well as noncommunicable disease (NCD) burdens.
- Establish and support the implementation of the use of national building codes that should also be extended to healthcare facilities. Importantly, this should include the incorporation of climate

risk projections into these codes, for example, to include siting and construction, functioning and operation, energy and water supplies, as well as the sanitation services of healthcare facilities.

- Establish procedures to implement the above building codes to also retrofit, refurbish, and maintain the existing health infrastructure.
- Support the integration of new and innovative technologies for monitoring environmental change (for example, satellite imagery) to inform measures that will improve the performance of the health system, for example, to direct the support of local health capacity planning to respond to anticipated increases in NCD burdens due to heat impacts. Other examples would relate to droughts and nutrition, precipitation, heat, and humidity and VBDs, as well as the mapping of the air quality impact on health outcomes. Mental health services should also be considered.
- Introduce sustainable cooling measures for healthcare facilities and laboratories, which would enhance energy efficiency, space cooling, and medical cold chains, and ensure sustainable refrigerant technologies. These measures should follow a hierarchy of interventions, starting from passive measures, such as building design and vegetative shading, to more active technologies, such as powered air conditioning as a secondary option.
- Develop structures to integrate health and climate considerations into the urban design to reduce the threat of urban heat islands. This could involve strengthening health impact assessments through to specific initiatives, such as supporting urban tree planting, in large cities.

Actions have also been identified that will contribute to enhanced sustainability and reduced GHGs in the health sector, such as the following:

- Assess the carbon footprint of Pakistan's health sector.
- Health facilities could implement transportation planning to minimize air pollution and associated GHGs.
- Prioritize sustainability in the selection of health system procurement strategies, procedures, and products. This would include the focus on the incorporation of low-carbon, energy-efficient technologies, such as photovoltaic cells, solar-powered machinery, vaccine chains, and water pumps.
- Promote modern energy cooking solutions (MECS), such as low emissions cookstoves, to reduce solid fuel use and household air pollution.
- Promote and, where necessary, further develop regulations that support sustainable healthcare waste management.

COMPONENT 7: MANAGEMENT OF ENVIRONMENTAL DETERMINANTS OF HEALTH

Options to strengthen the management of environmental determinants of health include the following:

- Develop improved national regulations and policies on key environmental health services and determinants (for example, drinking water, air quality, food system, housing, transport, energy, and waste management).
- Increase research on climate and environmental determinants of health in Pakistan. Data linking climate to environmental determinants of health (for example, air pollution, as well as water quality and quantity) in Pakistan was not available at the time of conducting this CHVA. Therefore, it is recommended that further research be conducted to explore the linkages between climate and environmental determinants in Pakistan on population health outcomes. It may include under-

standing the climate impacts on WASH infrastructure and WBDs, climate-driven water availability on nutrition outcomes via a reduction in agricultural productivity, and the effects of climate change on air pollution and its subsequent impacts on health.

- Map out areas using unsafe drinking waters and unimproved sanitation facilities, assess service delivery gaps, and invest in improved drinking water, sanitation, and the sewage infrastructure to improve water quality and reduce climate-driven exposures.
- Support community-led efforts to improve sanitation practices and controls to prevent foodborne diseases.
- Establish a climate and environmental health database to support the development of national regulations on the management of environmental health services (for example, water supply, sanitation, and food safety).
- Integrate environmental health policies and services into national public health promotion and protection programs.
- Increase support for focused interventions and integrate them with the non-health sector. Interventions could include, for example, promoting sustainable irrigation practices by smallholder farmers, establishing a central repository of water data / analysis to be integrated with health information, and / or adopting innovative technologies to improve wastewater treatment and water efficiency through water reuse strategies.

COMPONENT 8: CLIMATE-INFORMED HEALTH PROGRAMS

Options to strengthen climate-informed health programs include the following:

- Engage communities and strengthen primary health care (PHC) to create a climate-informed health system. Many of the recommendations proposed thus far feed into climate-informed health programming. As previously mentioned, moving toward a climate-informed health system requires cross-sectoral collaboration, given the multifaceted nature of climate-health risks. Further recommendations in this area include engaging community groups and leaders to support dialogues and the development of prospective climate and health programs and policy options, as well as to strengthen PHC in managing current and future climate-related risks.
- Use mainstream and social media to spread awareness and issue warnings related to preventive measures in order to improve population health literacy related to climate-sensitive health risks.
- Engage district-level community groups and leadership structures to support dialogues and the development of prospective climate and health programs and policy options, as well as their integration into the planning and support of health promotion programs directed toward climate-related health threats.

COMPONENT 9: EMERGENCY PREPAREDNESS AND MANAGEMENT

Options to strengthen emergency preparedness and management for climate change-related disasters include the following:

- Enhance contingency planning for deployment and response in relation to acute climate shocks at all administrative levels. These should include integrating health considerations for climate-related hazards, such as floods, droughts, heat waves, and consequent disease outbreaks, as well as longer-term climate stressors and sea-level rises (SLRs). This should include integrating climate-re-

lated health considerations into provincial-level monsoon contingencies to support stakeholders in organizing activities related to the preparedness of emergency responses. Further, contingency planning should consider stockpiling and distribution plans to support the disaster response. To this end, scenario-based simulation exercises will be important for testing, identifying bottlenecks in implementation, and further refining future contingency planning.

- Establish seasonal climate outlooks to inform a disease control / prevention program ahead of potential extreme weather events, and facilitate multisectoral engagement with first responders, disaster management authorities, rural support agencies, and lady health workers (LHWs) to conduct community outreach and awareness regarding climate-sensitive diseases.
- Ensure climate-related health risks are integrated into stockpiling and distribution plans to support disaster response supplies (for example, water purifiers).

COMPONENT 10: CLIMATE AND HEALTH FINANCING

Options to strengthen climate and health financing include the following:

- Support revenue collection for climate-related health risks. At the national level, it would be useful to allocate (that is, earmark) a proportion of the national health funding for adaptation and mitigation policies. This funding would need to be reflected in national health strategies and budget formulations and could come either from central treasury or other funds, including external sources. If a country is weak in raising revenue, it will tend to rely more on user fees for its revenue.
- Explore and promote the financial benefits of the health co-benefits of climate action. There are economic benefits underlying the mobilization of financial resources in Pakistan to support the health sector in assessing the co-benefits of climate action in other health-determining sectors and in identifying climate actions that bring the greatest benefits to health.
- Facilitate access to international and external donor funding opportunities and mechanisms. They should include the Green Climate Fund, the Global Environment Facility, and the Adaptation Fund for the allocation of funds toward health-based adaptation measures, the control of climate-sensitive diseases, research projects, and mitigation projects, including NDCs.

ANNEX VIII. MENU OF HEALTH ADAPTATION OPTIONS BY CLIMATE-RELATED HEALTH RISK

COMPONENT	HEAT-RELATED RISK	VECTOR-BORNE DISEASES (VBDS)	WATER-RELATED DISEASES	NUTRITION, FOOD SECURITY, AND FOOD SAFETY
Component 1: Leadership and Governance	Develop and implement national heat health policy and subnational plans.	Implement a National Action Plan on VBDS.	Promote the creation of subnational-level water regulatory authorities and engage with communities on policy options.	Incorporate climate change risks into food safety standards.
Component 2: Health workforce	Conduct heat-health training for health workers. Ensure occupational heat exposures are managed.	Provide subnational-level training to enhance the capacity of dengue prevention and control, as well as the knowledge of climate change-related factors.	Raise the awareness of health workers on the climate change impact on water sanitation and hygiene (WASH) and waterborne diseases (WBDs).	Incorporate educational materials on climate change impacts on food security and nutrition into health worker training.
Component 3: Vulnerability, capacity, and adaptation assessment	Conduct assessments on high-risk groups at subnational levels and incorporate economic analyses.	Conduct district- and community-level assessments to better understand local risks related to VBDS and the capacity for managing outbreaks.	Conduct vulnerability assessments of water shortages, rainfall extremes, unpredictable river flows, and baseline WASH coverage in healthcare facilities.	Conduct vulnerability assessment of nutrition to climate change. Assess the nutrition benefits of climate-smart agricultural interventions.
Component 4: Integrated risk monitoring and early warning	Set up heatwave alert systems for urban and rural populations.	Building from health information system, establish virus and vector surveillance, as well as incorporate climate-informed seasonal outlooks.	Integrate climate / weather information with WBD surveillance systems to forecast outbreaks.	Develop and include long-term strategies for nutrition interventions into the FEWS (famine early warning system).
Component 5: Health and climate research	Conduct studies to further explore the impacts of extreme heat on health systems, including urban heat island mapping.	Conduct climate change modeling studies to estimate dengue risk projections and inform adaptation decisions.	Model water security / demand projections under different climate scenarios and impacts on WBDs.	Analyze the long-term effects of food insecurity on health and economy.

COMPONENT	HEAT-RELATED RISK	VECTOR-BORNE DISEASES (VBDS)	WATER-RELATED DISEASES	NUTRITION, FOOD SECURITY, AND FOOD SAFETY
Component 6: Climate-resilient and sustainable technologies and infrastructure	<p>Cool down spaces in healthcare facilities to prevent overheating and protect IT and equipment.</p> <p>Energy-efficient or passive measures of cooling to reduce energy costs should be implemented.</p>	<p>Improve laboratory capabilities for the testing and diagnosis of endemic as well as novel and re-emerging diseases. Develop a list of essential medicines needs for VBD outbreaks.</p>	<p>Improve WASH systems in health-care facilities to withstand extreme weather events (for example, drainage systems and health-care waste management).</p>	<p>Improve drainage systems in crop fields at risk of floods. Explore smart agriculture and crop diversification practices.</p>
Component 7: Management of environmental determinants of health	<p>Institute housing standards and urban planning (built environment) to reduce heat risks. Ensure household water security. Set up occupational health management.</p>	<p>Conduct community awareness campaigns to increase the awareness of the climate sensitivity of VBDS and engage vulnerable groups in outbreak prevention.</p>	<p>Improve household water security. Community-led total sanitation should be promoted to achieve the “Open Defecation-Free” status.</p>	<p>Promote community-led efforts to map out food insecurity and inform interventions to improve the food system in a changing climate.</p>
Component 8: Climate-informed health programs	<p>Ensure that heat risks are incorporated into maternal health guidance, guidance for diabetes management, etc.</p>	<p>Incorporate climate change information into VBD prevention and outbreak response standard operating procedures (SOPs).</p>	<p>Standard Operating Procedures (SOPs) for drinking water and sanitation provision. Public awareness-raising campaigns should be conducted on hygiene, particularly handwashing.</p>	<p>Implement interventions involving the establishment of gardens or food-growing opportunities. Community-mediated delivery of nutrition services, including screening, should be conducted.</p>
Component 9: Emergency preparedness and management	<p>Include heat into disaster risk management (DRM) operations.</p>	<p>Include VBD outbreaks into DRM plans at the national, provincial, district, and community levels.</p>	<p>Develop WASH-focused emergency preparedness and response plans, including a stockpiling and distribution plan for supplies (for example, purifiers).</p>	<p>Reinforce the food production and distribution chain to withstand impacts from extreme weather events.</p>
Component 10: Climate and health financing	<p>Finance sustainable cities / cool cities that address heat risks.</p> <p>Other interventions related to heat-health responses (for example, cool roofs) should be implemented.</p>	<p>Formulate proposals for external donors to support the control of VBDS.</p>	<p>Allocate resources to build climate-resilient WASH in provincial health investment plans.</p>	<p>Invest in the dissemination of crop varieties and breeds adapted to changing climatic conditions.</p>



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