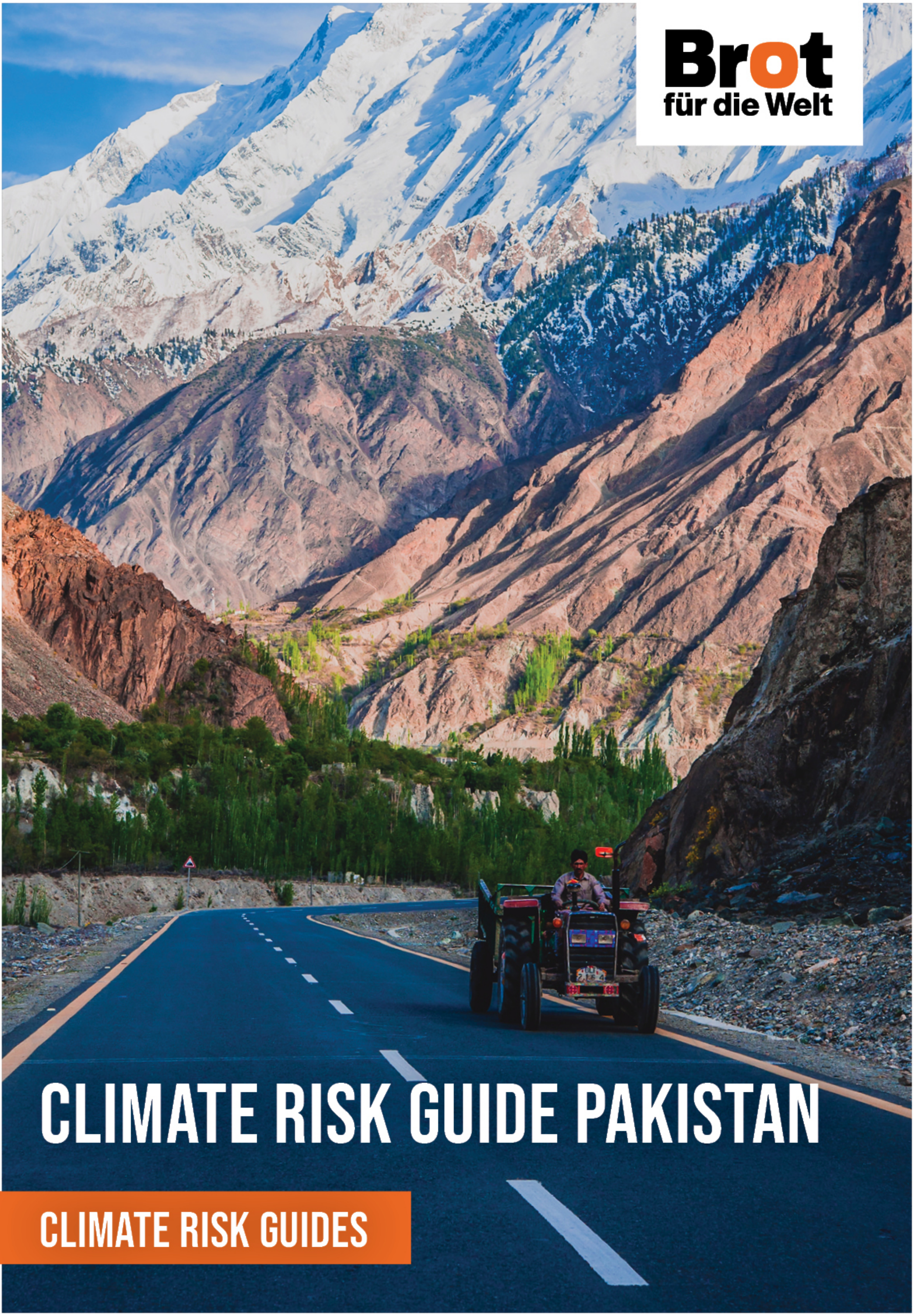

Brot für die Welt

CLIMATE RISK GUIDE PAKISTAN

CLIMATE RISK GUIDES

IMPRINT

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Abbreviations

CO2	Carbon dioxide
CO2eq	CO2-equivalent emissions, usually measured in metric tonnes (tCO2eqq)
GHG	Greenhouse gas/es
IPCC	Intergovernmental Panel on Climate Change
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution (the climate pledge of states)
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

The climate is no longer a relatively stable system. It is changing more and more rapidly due to rising emissions of greenhouse gases caused by us humans. Yet many of these changes are dynamic. This means that climate observations from the past only help us to a limited extent to predict the effects of climate change in the future. This means that traditional coping capacities are increasingly reaching their limits. In addition, some of the potential damages caused by climate change are so severe, or are about to become so severe, that they exceed the limits of adaptive capacity and therefore need to be covered separately, for example through climate risk insurance.

For these reasons, climate change cannot be ignored when planning projects and programmes. Understanding the climatic conditions in a project region and developing an idea of

- how they might change in the near future,
- what the potential hazards are,
- how vulnerable the project is to them
- and what the resulting risks are for the achievement of the project objectives, but also for the target groups and the region as a whole

are indispensable foundations of good project and programme planning.

Climate proofing of projects in the concept note development phase is an important part of the application process. If it transpires that projects are particularly climate-sensitive, further steps such as conducting a climate risk analysis will be required.

This publication is intended to help with these steps. It is aimed primarily at the staff of Bread for the World and our partner organisations, but also at other interested parties.

In this publication we present the key characteristics of the three main climatic zones of Pakistan. We briefly show the trends for the most important climatic parameters for the coming decades for these zones, taking into account different scenarios in combating climate change. Based on this, we develop a climate risk profile for each zone with hazard potentials, vulnerabilities and resulting specific risks. This is supplemented by a brief introduction to the most important climatological terms and the elementary principles of climate change, as well as a concluding brief overview of the basics of climate adaptation and a further reading list.

This is supplemented by a brief introduction to the most important climatological terms and the elementary principles of climate change, as well as a concluding brief overview of the basics of climate adaptation and a further reading list.

The study of this publication is not a substitute for a deeper examination of the specific climate-related issues in the course of project planning, but it can provide an introduction or a general overview of the challenges of climate change for the different provinces of Pakistan.

We hope you enjoy reading.

A short guide to climate and climate change

Climate

The **climate** is a long-term pattern of average weather (at least 30 years) in a particular area. Therefore, the climate does not describe the current weather but an average calculation. The climate consists of several variables, such as temperature, precipitation and wind.[1]

The **mean temperature** is defined as the average of minimum and maximum temperatures in the course of a year.

Precipitation is expressed in millimetres. One millimetre of precipitation means 1 litre of precipitation on one square metre.

Both precipitation and temperature are shown in a **climate diagram**. The months from January to December are shown on the horizontal axis. The respective temperature at a specific time of the year can be read on the left vertical axis. The red graph shows the maximum temperature, i.e. the maximum temperature in April was 32.36°C. The orange graph shows the average temperature. The minimum temperature is shown in yellow. On the right horizontal axis the precipitation can be read. Precipitation is shown in the diagram as a light blue bar.

[1] Intergovernmental Panel on Climate Change. https://www.ipcc.ch/sr15/chapter/glossary/

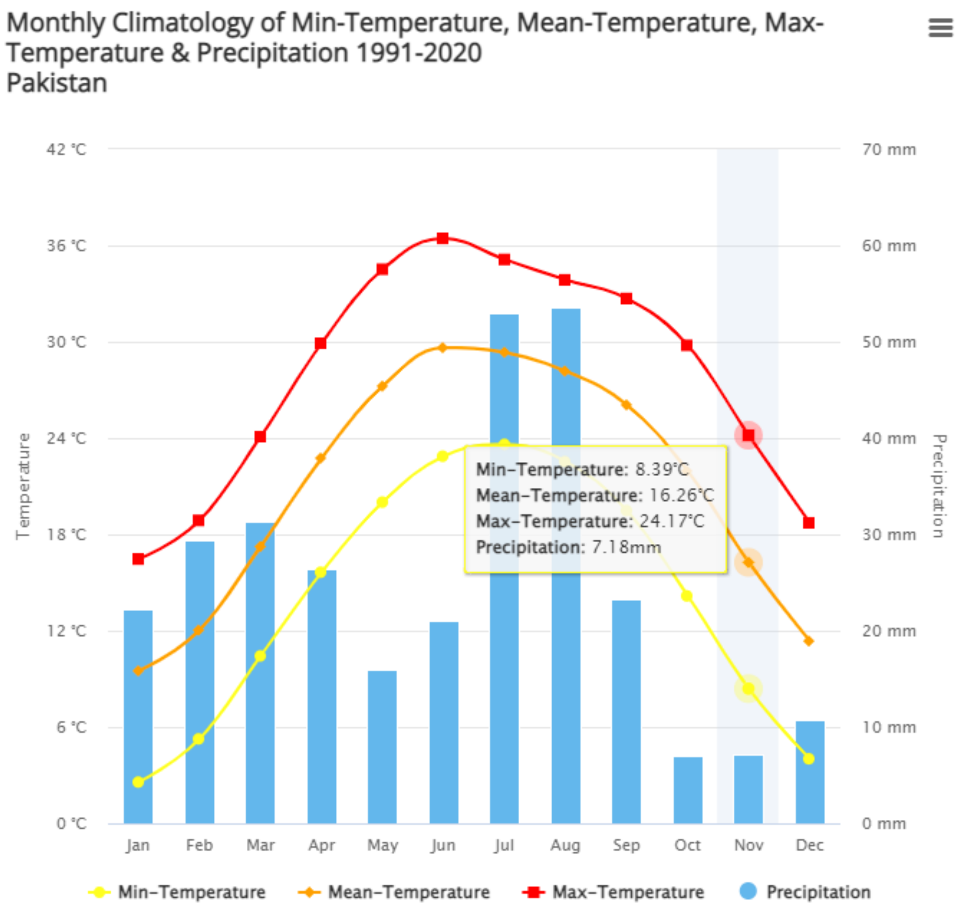

Figure 1: Climate diagram from Pakistan. Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

The **global climate system** is an interactive complex system consisting of five main components: the atmosphere, the oceans, the cryosphere, the land surface and the biosphere. The primary energy source for the climate system is the sun. The way in which these components interact at a specific location determines its climate. This is why climate varies from region to region. The world can be divided in different **climate zones**.

The climate zoning of the world according to the **Koeppen-Geiger climate classification** is based on temperature and precipitation, and divides climates into five main climate groups: A tropical; B dry; C temperate; D continental; and E polar. To further differentiate the five main climates, there are further classification options, which describe for example whether the region is a rainforest or a tundra. Lastly, there is the possibility to further differentiate according to the temperatures in winter and summer. In total, there are 31 possibilities for the assignment of a climate zone for a region.

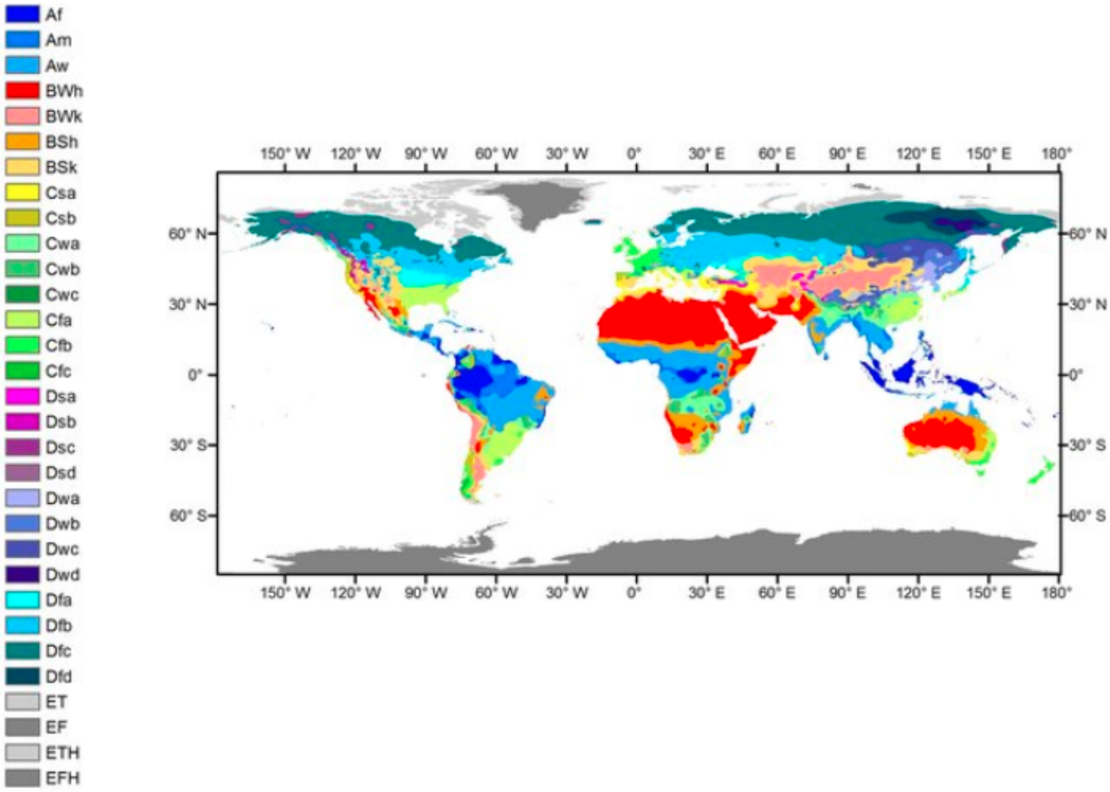

Figure 2: The Koeppen-Geiger climate classification global map
Source: https://doi.org/10.5194/hess-11-1633-2007

The **atmosphere** is the most important component of the climate system. Figure 3 shows the **earth's energy budget** and the influence of the atmosphere on radiation, serving as a filter, or protection shield. Incoming solar radiation is partly reflected by the atmosphere, partly absorbed by it, partly absorbed by the earth surface, and partly reflected by earth. Carbon dioxide and other greenhouse gases, which are part of the atmosphere, play a crucial role in the energy budget. Their increase due to human-made emissions in terms of atmospheric concentration causes global warming.

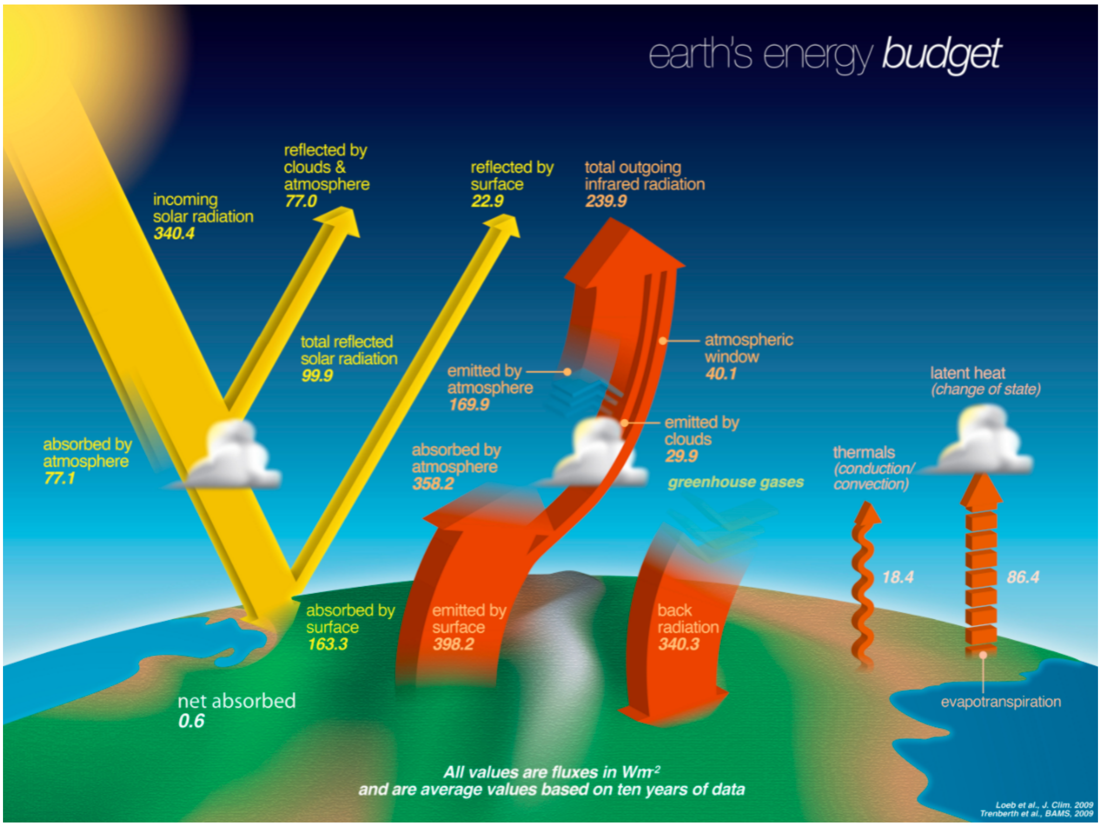

Figure 3: The energy budget of the earth. Source: NASA: https://www.nasa.gov/sites/default/files/thumbnails/image/ceres-poster-011-v2.jpg

The **hydrosphere** includes all liquid surfaces, i.e. fresh water, such as in rivers or lakes, and salt water as in seas. Energy, or heat, is moved not only in the atmosphere from places with an energy surplus to places with an energy deficit, but also in oceans, in the form of currents. These balancing movements follow the first law of thermodynamics. Furthermore, oceans are important carbon sinks, i.e. they store large amounts of carbon dioxide, and thus help to mitigate climate change.

The **cryosphere** contains water in solid form, including ice sheets in Greenland and Antarctica, glaciers, permafrost (permanently frozen soils) and snow-covered areas. Important for the climate is the high reflective capacity (albedo) of snow- and ice-covered surfaces. With less ice coverage, global warming would accelerate significantly.

The **land surface**, especially soils and vegetation, plays an important role in evaporation. In areas such as the tropics, evaporation plays a major role due to high temperatures and the availability of water. Thus, tropical landscapes, especially forests, can produce their own rainfall. The topography, especially the relief, is an important shaping of the climate, too. Mountains can serve as effective barriers between different climate zones. Topography is also important for wind systems. The more fissured the surface of the earth, the more the climate differs, even on a small scale.

The **biosphere**, both terrestrial and marine, has a significant impact on the greenhouse effect. Marine and terrestrial plants, especially forests, can store a large amount of carbon dioxide.

Climate change

The **United Nations Framework Convention on Climate Change (UNFCCC)**, in its Article 1, defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (Intergovernmental Panel on Climate Change – IPCC).[2]

CO2 released from burning fossil fuels to generate electricity, heat and air conditioning is the main source of **GHG (greenhouse gas) emissions**, followed by CO2, nitrous oxide and methane emissions originating from agriculture, deforestation and other land-use changes. Industries, transportation, construction and the waste sector are the other economic sectors that cause global warming. The sectors that cause the most emissions vary from country to country. In developing countries, agriculture and land-use changes tend to cause most emissions, while the energy sector tends to be the most emission-intense in emerging economies and developed nations. The common goal for all is to achieve GHG neutrality by 2050 – or even 5-10 years earlier in rich nations. Decarbonisation pathways will be as different as current emission profiles. Achieving carbon neutrality requires huge investments, a system change to a circular economy, and international collaboration.

2 https://www.ipcc.ch/sr15/chapter/glossary/

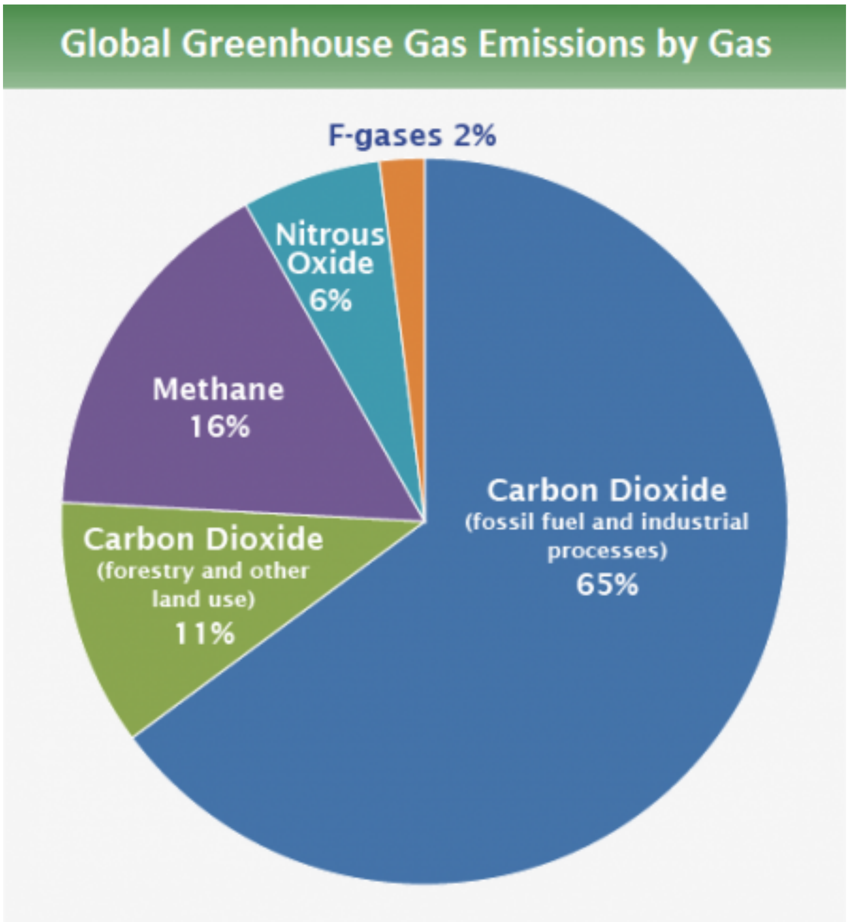

Figure 4: Global greenhouse gas emissions by gas

Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

Greenhouse gas effect: Greenhouse gases effectively trap the sun's warmth in the lower atmosphere, where they allow shortwave solar radiation to enter the atmosphere but block the long-wave radiation reflected from earth. Since the beginning of the industrial revolution, the concentration of carbon dioxide in the atmosphere has risen by almost 50%, first slowly and then increasingly faster since the 1990s, from 280 parts per million (ppm) in 1880 to 418 ppm in May 2021. In 2019, annual human-made GHG emissions totalled 43 billion tons.

Climate change impacts: Rising temperatures melt the ice, including glaciers, Arctic Sea ice and ice sheets in Greenland and Antarctica. The melting of this ice causes the sea level to rise. Coastlines can therefore change as a result of **sea level rise**. Due to climate change, **extreme weather events** are intensified by the consequences of climate change, for instance: more frequent and more extreme storms; mid-latitude and tropical extreme rainfalls and flooding, particularly in Asia; and severe drought and crop failure. These impacts have a huge potential to undo development successes.

Since 1980, losses caused by climate extremes have quadrupled. Most at risk are vulnerable, predominantly rural, populations whose livelihoods depend on intact ecosystems, as in agriculture, forestry and fisheries sectors. How threatening the risk is can be seen in the warning of the insurer Swiss Re Group that 50% of global GDP is in peril, as climate change puts 20% of the world's countries at risk of ecosystem collapse.

A better world is still possible, if strong and effective climate action is taken now. The IPCC Special Report on Global Warming of 1.5°C (2018)[3] analysed the change needed to avoid a climate catastrophe: halve global carbon dioxide (CO_2) emissions by 2030; immediately switch investments from fossil to renewable energies, achieving 100% renewable energy supply within 15-20 years; turn soils, agrarian land and forests from greenhouse gas emission sources to sinks; and, finally, achieve carbon neutrality, i.e. global net zero emissions, by 2050.

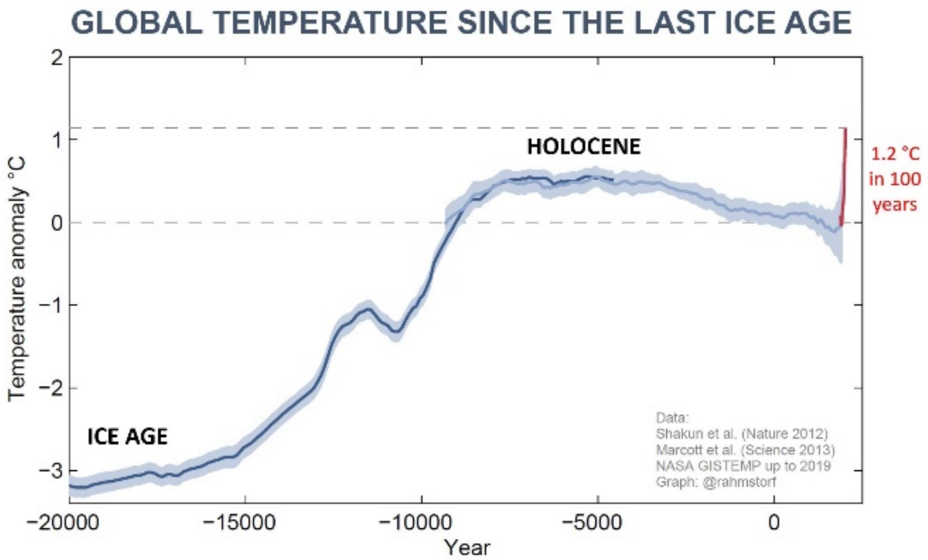

Figure 5: Global temperature rise

The future we get will be defined by **climate action** in the 2020s. Only through limiting global warming to 1.5°C global temperature rise can we prevent massive burdens falling on current and future generations. It is incumbent on us to take ambitious and structured climate actions in all aspects of work. As a first step, a programme could calculate its current GHG emissions. A carbon footprint calculator can be found at: https://www.carbonfootprint.com/calculator.aspx

[3] https://www.ipcc.ch/sr15/

The climate of Pakistan

In this publication, we present the key characteristics of the five main climatic zones of Pakistan.

Climatic zones	Provinces
Zone A	northern North-West Frontier; northern areas
Zone B	southern North-West Frontier; northern Punjab; northern Federally Administered Tribal Areas
Zone C	southern Federally Administered Tribal Areas; north-western Balochistan
Zone D	southern Punjab; north-eastern Balochistan
Zone E	southern Balochistan; Sindh

Table 1: Pakistan's climatic zones and the corresponding provinces
Source: Word Bank/Qasim 2014

The climate in Pakistan varies depending on the region. It is warm and dry on the coast and along the lowland plains of the Indus River. It is cold in the northern uplands and in the Himalayas. Rainfall is very low on average throughout the country, except at monsoon times in the north, where there can be up to 200mm of rain per month. The monsoon season is usually from July to September.

There are four seasons in Pakistan: a cold dry winter from December to February; a hot and dry spring from March to May; the rainy season (especially in the north) in summer from June to September; and the retreating monsoons from October to November.[4]

Our climate projections show the climate anomalies as compared to the reference period 1995–2014. The climate projections are based on climate model data from the Coupled Model Inter-comparison Project 6 (CMIP6), overseen by the World Climate Research Programme and building the data foundation of the IPCC 6th Assessment Report (IPCC 2021). This set of climate model data is used to project the future climate in different scenarios of future emission development, as a combined result of different mitigation efforts and

[4] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

pathways of socio-economic development. These scenarios are called Shared Socioeconomic Pathways (SSPs). So far, five have been developed:[5]

- SSP1, the sustainability pathway, allowing for a limit to global warming well below 1.5°C; two sub-scenarios
- SSP2, a middle-of-the-road scenario of decisive but delayed climate action, leading to around 2.5°C temperature rise
- SSP3, a scenario of delayed action, characterised by regional rivalry, leading to around 3.5°C temperature rise
- SSP4, another scenario of delayed climate action, characterised by growing inequality, leading to around 3°C temperature rise
- SSP5, the worst-case scenario of far-delayed phase-out of fossil fuels, leading to 4.5°C temperature rise.

How scenarios 1, 2 and 3 translate into different climate futures in Pakistan's climatic zones is shown in the following chapters.

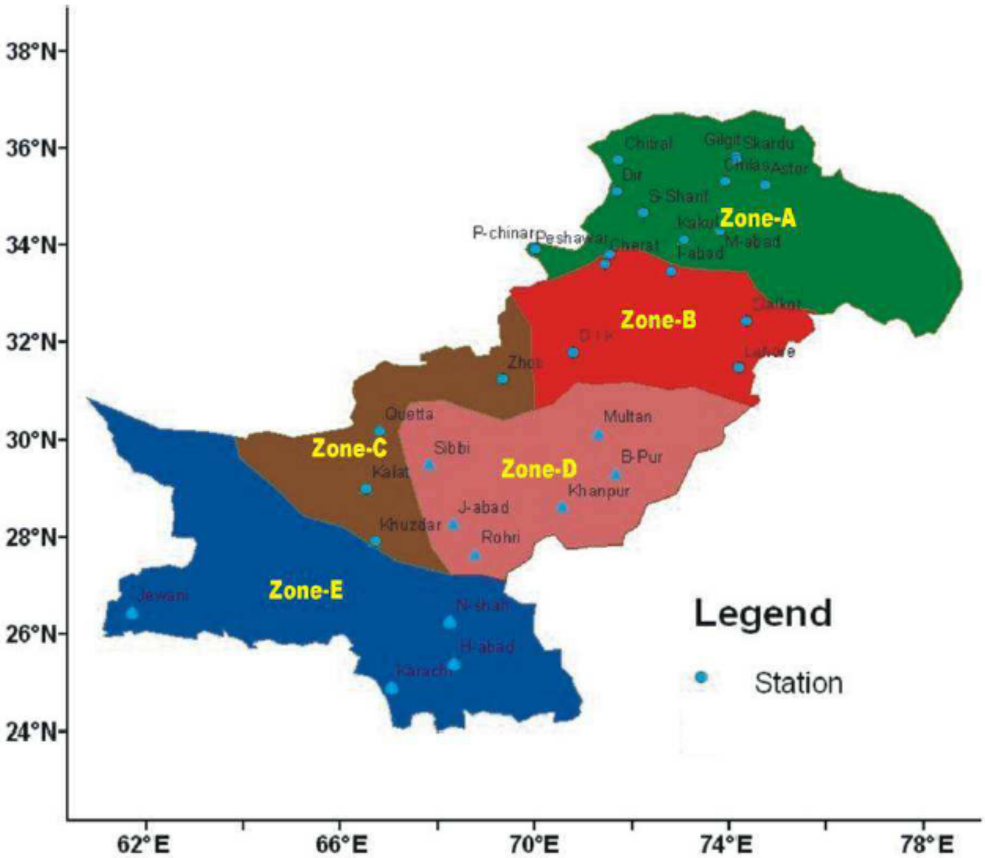

Figure 6: Climatic zones of Pakistan
Source: Qasim 2014

[5] https://doi.org/10.5194/gmd-13-3571-2020

The climate of Zone A

Zone A comprises the northern North-West Frontier and the northern areas alongside the Himalayas (which the World Bank Knowledge Hub noted as ‘Administrative unit not available’). The climate in Zone A is dependent on location – predominantly either extremely cold sub-Arctic climate in the high mountains (Dfd) or hot summer humid continental climate in the lower regions (Dfa), according to the Koeppen-Geiger Climate Classification.[6] Annual average rainfall here is 352 millimetres (mm).

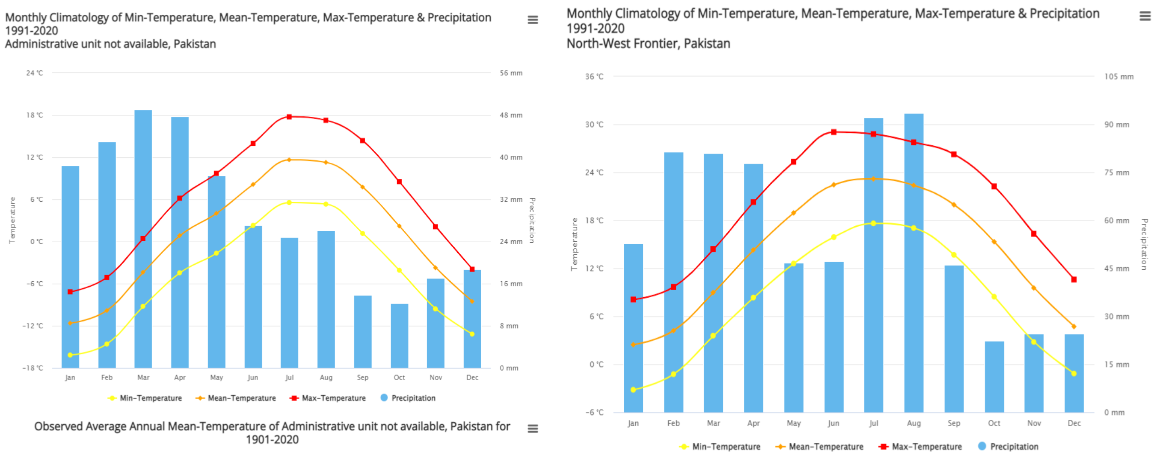

Figure 7: Climate diagrams of the northern area and North-West Frontier in Pakistan
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

Key trends of observed climate change in Zone A

Temperatures in Zone A have risen over the past 30 years: Since the 1970s, the mean annual temperature has risen by 0.7°C in the northern area and 0.55°C in North-West Frontier. Between 1971 and 2020, the average temperature rose at a rate of 0.2 per decade, with a steepening rise in the late 1990s. Extreme events have increased in both magnitude and frequency. Since 1995, in the northern areas, which are largely located in the Himalaya region, there has been a significant rise in minimum temperature of 0.85°C. There are no significant changes in precipitation so far.

[6] https://climateknowledgeportal.worldbank.org/country/pakistan

Climate projections for Zone A

In the northern areas and the North-West Frontier mean temperatures are projected to rise by 0.7°C by 2030 and in a range from 0.96°C to 1.22°C by 2040 (best- and worst-case scenarios). By 2060, further temperature rises would be quite limited in the best-case scenario. By 2100, mean temperatures in the northern areas in this scenario would be only 0.4°C higher than in 2013. In the SSP2-4.5 scenario – or 'middle-of-the-road' scenario – mean temperature would rise by 2.7°C in the northern areas. In the worst-case scenario, temperatures would rise by as much as 6.24°C. Annual mean minimum and maximum temperatures are also projected to rise. The highest temperature levels would be reached in June.

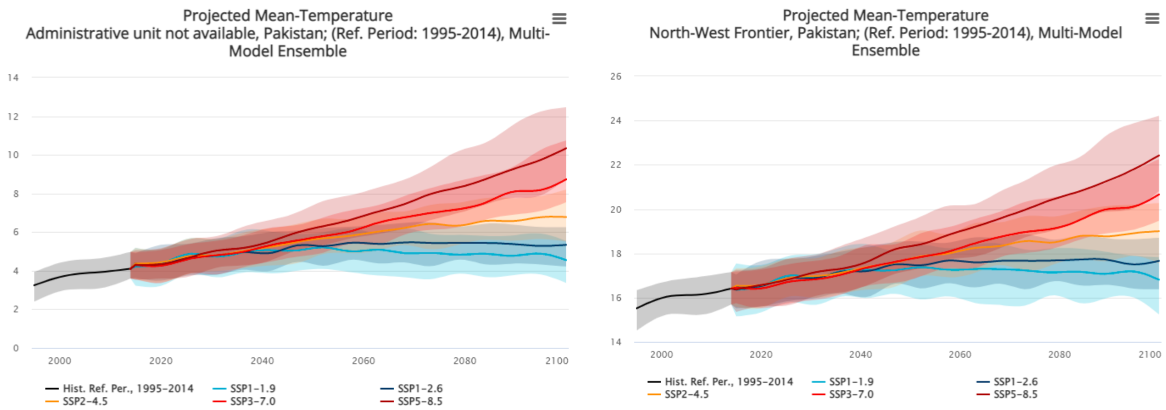

Figure 8: Projected mean temperatures in the northern areas and the North-West Frontier in 2020–2100 in different emission pathway scenarios

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

The number of projected hot days with maximum temperatures above 35°C is zero in the northern areas due to their location in the mountains. However, it is striking that the number is expected to increase to five by 2100 in the worst-case scenario. In North-West Frontier the number of hot days is expected to vary in the three provinces between 82 and 89 days annually by 2050 and between 82 and 127 days annually by 2100 – according to the most optimistic and the most pessimistic scenarios, respectively. In the middle-of-the-road scenario, there will be an average of 95 annual hot days by 2100. Increasing heat will have a severe impact on health and livelihoods in the future. The number of frost days (temperatures below 0°C) decreases significantly. In the northern areas the number of frost days is expected to vary between 171 and

158 days annually by 2050 and between 180 and 113 days annually by 2100 (best- and worst-case scenario).

Climate hazards, vulnerabilities and risks in Zone A

Zone A, with its extremely cold sub-Arctic climate in the high mountains and hot summers with humid continental climate in the lower regions, is susceptible to the climate hazards of precipitation-triggered landslides[7] caused by rapid snow and ice melt.

Figure 9: Precipitation-triggered landslides in Pakistan

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/vulnerability

Heat waves are likely to increase in terms of both magnitude and frequency. Due to the rising temperatures and increasing number of hot days, **forest fires** and droughts are expected to increase.

[7] https://thinkhazard.org/en/report/40409-pakistan-administrative-unit-not-available

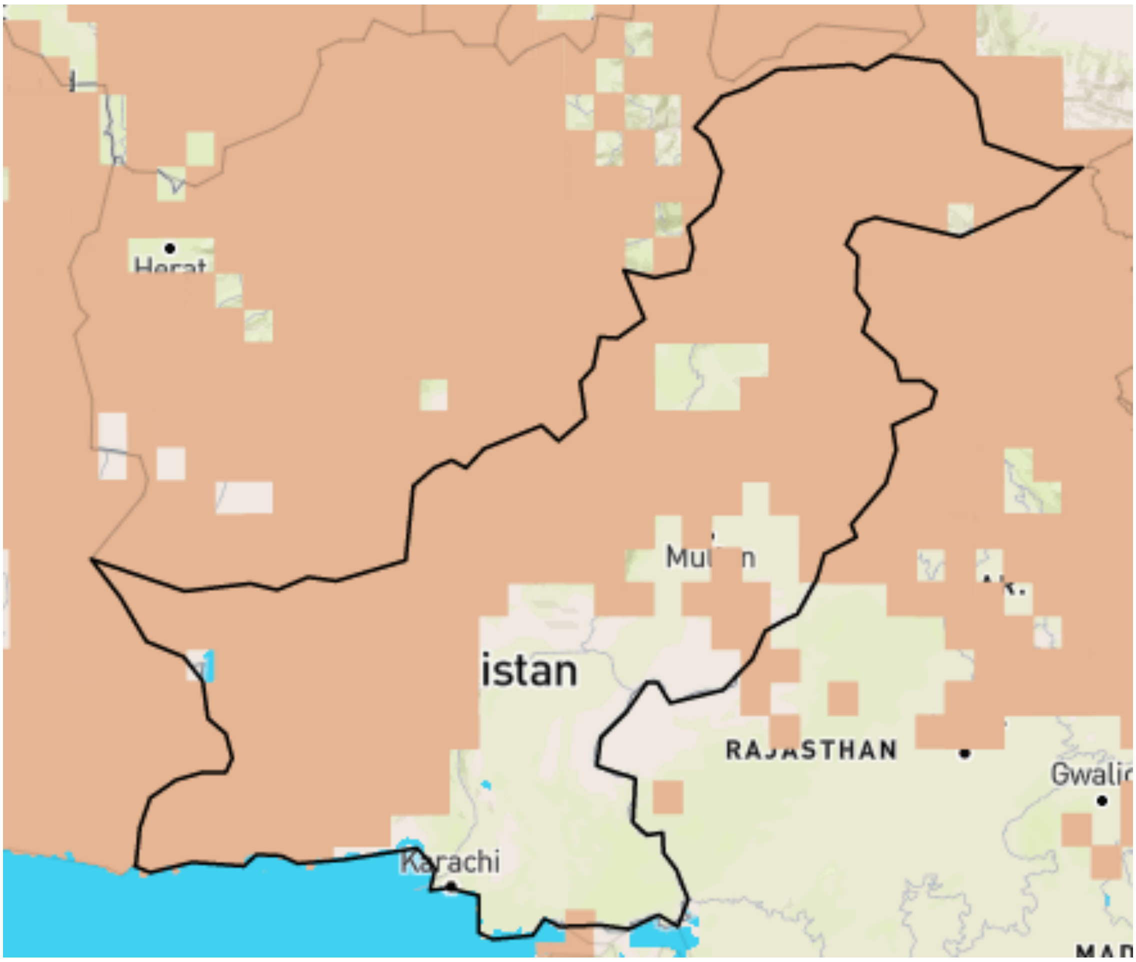

Figure 10: Drought risk map Pakistan

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/vulnerability

Resulting climate risks: The combination of hazards makes settlements and infrastructures along flood-prone rivers particularly vulnerable. The economic sectors most at risk are agriculture and fisheries.

In terms of **vulnerabilities**, higher temperatures in combination with greater evaporation and potentially scarcer water sources in the dry season will negatively affect agriculture, which needs to adapt to these changing conditions in terms of crop varieties and planting seasons. Costs of production are likely to increase because of the need for more frequent and more efficient irrigation. Higher temperatures, less available water, and more heatwaves will heighten life stresses, lead to more vector-borne diseases and pests, and put elderly people and those with pre-existing vulnerabilities at risk, leading to more cardiovascular or respiratory diseases, lower work productivity (especially for outdoor activities) and more diarrhoeal diseases, among other things.

The climate of Zone B

Zone B includes the southern North-West Frontier, northern Punjab and the northern Federally Administered Tribal Areas. The climate is predominantly either sub-polar oceanic climate in the west (Cfc) or humid sub-tropical climate in the eastern regions (Cfa), according to the Koeppen-Geiger Climate Classification.[8] Annual average rainfall in Zone B is 725 millimetres (mm).

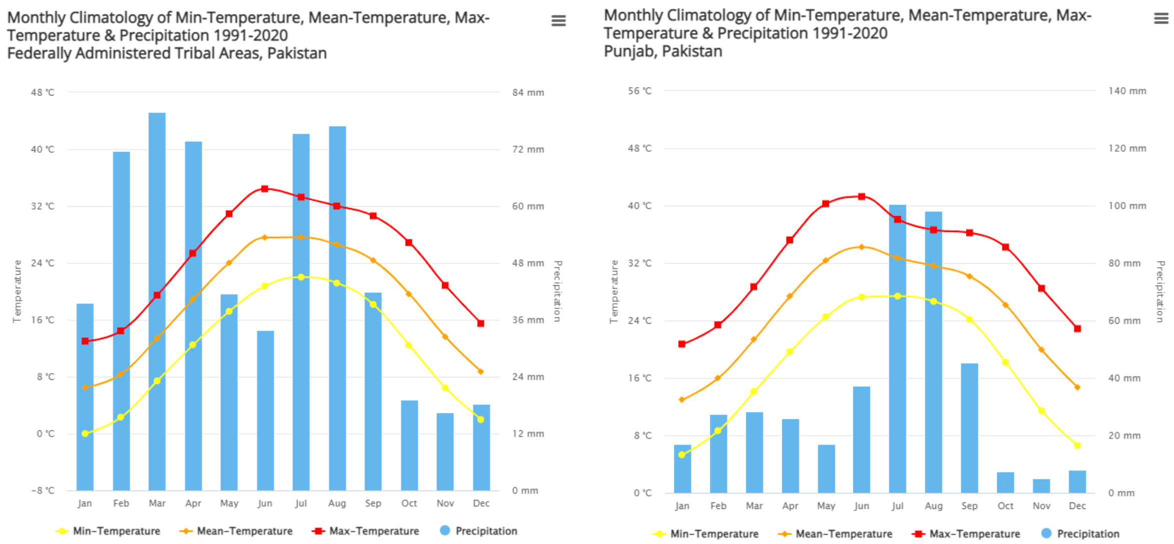

Figure 11: Climate diagrams of Federally Administered Tribal Areas and Punjab, Pakistan
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical.

Key trends of observed climate change

Temperatures in Zone B have risen over the past 30 years. Since the 1970s, the mean annual temperature has risen by 0.54°C in the Federally Administered Tribal Areas, 0.55°C in North-West Frontier and 0.62°C in Punjab. A particularly strong rise in temperatures has been recorded between 1995 and 2000. Extreme events have increased in both magnitude and frequency. In all the areas in Zone B, the minimum temperature rises faster than the average temperature. In Punjab, the rise in minimum temperature from the 1970s to the present is 0.75°C.[9] In Punjab, since the early 2000s, there has been an increase in the amount of annual rainfall from 322mm to 519 mm.

[8] https://climateknowledgeportal.worldbank.org/country/pakistan

[9] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

Climate projections for Zone B

Mean temperatures in Zone B are projected to rise by 0.5°C by 2030 and in a range from 0.8°C to 1.06°C by 2040 (best- and worst-case scenarios). By 2060, further temperature rises would be quite limited in the best-case scenario. By 2100, mean temperatures in the Federally Administered Tribal Areas in this scenario would be only 0.46°C higher than in 2013. In the SSP2-4.5 scenario – or 'middle-of-the-road' scenario – mean temperatures would rise by 2.51°C in the Federally Administered Tribal Areas. In the worst-case scenario, temperatures would rise by as much as 5.96°C.[10] Annual mean minimum and maximum temperatures are also projected to rise. Highest temperature levels would be reached in June.

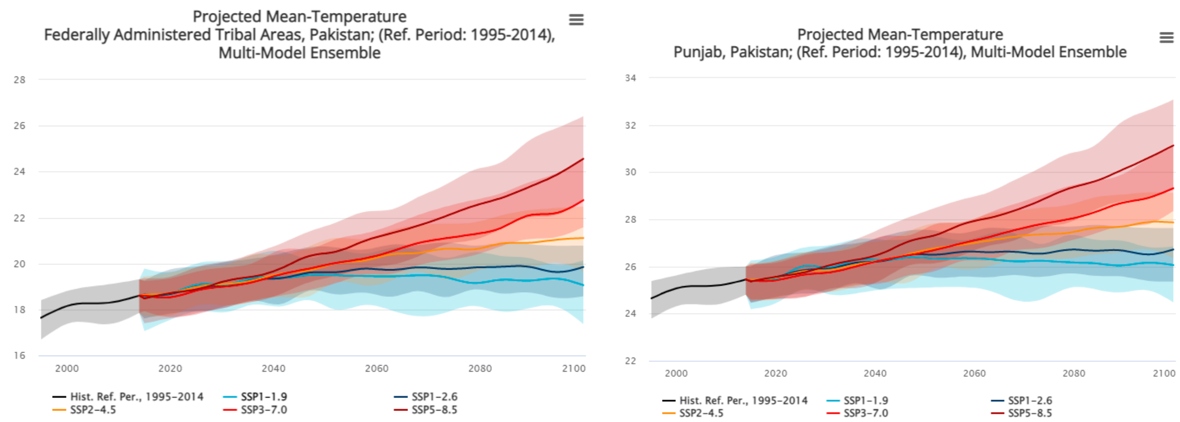

Figure 12: Projected mean temperatures in Federally Administered Tribal Areas and Punjab, Pakistan, Zone B in 2020–2100 in different emission pathway scenarios

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

Particularly notable is the projected increase in Punjab in the number of very hot days, i.e. maximum temperatures above 35°C, from 175.4 days in 2013 to 183.7 days in 2040 and 226.4 days in 2100 in the worst-case scenario. This increase could be reduced to 196 days in a middle-of-the-road scenario and even limited to 180 days in a scenario with immediate and massive emission reduction.[11]

[10] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

[11] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

Climate hazards, vulnerabilities and risks in Zone B

The main climate hazards in the intermediate climate areas of Zone B – that is, the coastal provinces North Central, Northern, eastern and southern part of North Western – are floods, heat waves and precipitation-triggered landslides. Apart from these sudden-onset extreme events, sea level rise and salinity intrusion are the most significant slow-onset climate hazards in coastal areas.

Precipitation-triggered landslides are caused by rapid snow and ice melt.

Due to the increase in the number of very hot days and consistently dry days, there is a higher probability that **heat waves** will occur more often and with higher temperatures, especially in the dry season (March to June).[12] This will result in water scarcity and more wildfires.

Resulting climate risks: The combination of hazards makes settlements and infrastructures in coastal areas along flood-prone rivers particularly vulnerable. The economic sectors most at risk are agriculture and fisheries. Risks to human health will also significantly increase.

In terms of **vulnerabilities**, higher temperatures in combination with increased evaporation and potentially scarcer water sources in the dry season will negatively affect agriculture, which needs to adapt to these changing conditions in terms of crop varieties and planting seasons. Costs of production are likely to increase, because of the need for more frequent and more efficient irrigation.

Higher temperatures, less available water and more heatwaves will aggravate life stresses, lead to more vector-borne diseases and pests, and put elderly people and those with pre-existing vulnerabilities at risk, leading to more cardiovascular or respiratory diseases, lower work productivity (especially for outdoor activities), and more diarrhoeal diseases, among other things.[13]

[12] https://climateknowledgeportal.worldbank.org/country/sri-lanka/climate-data-projections

[13] https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15507-WB_Sri%20Lanka%20Country%20Profile-WEB.pdf

The climate of Zone C

Zone C includes the southern Federally Administered Tribal Areas and north-western Balochistan and the climate is cold in winter and hot in summer.[14] The climate is predominantly either cold semi-arid climate in the west (BSk) or hot semi-arid climate in the eastern regions (BSh), according to the Koeppen-Geiger Climate Classification.[15] Annual average rainfall is 251 millimetres (mm).

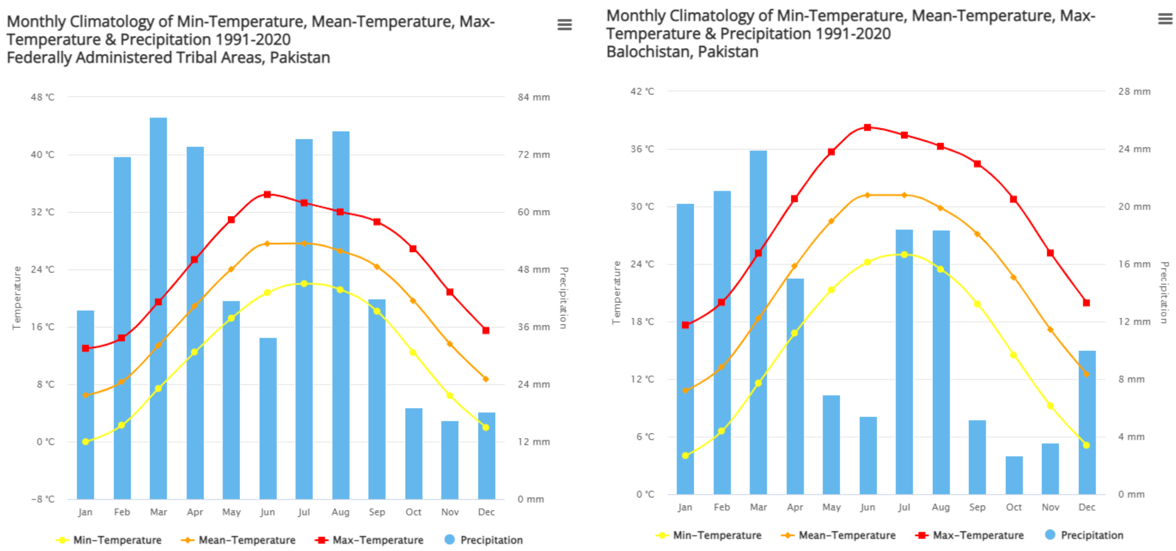

Figure 13: Climate diagrams of Federally Administered Tribal Areas and Balochistan, Pakistan

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical.

Key trends of observed climate change

Temperatures in Zone C have risen over the past 30 years. Since the 1970s, the mean annual temperature has risen by 0.54°C in the Federally Administered Tribal Areas and 1.08°C in Balochistan. A particularly strong rise in temperature was seen from the 1990s to the early 2000s. Extreme events have increased in both magnitude and frequency. In combination with the strongly rising temperatures in Balochistan, precipitation has decreased from 207mm

[14] Qasim 2014

[15] https://climateknowledgeportal.worldbank.org/country/pakistan

in the 1970s to 57mm in 2018, although since 2018 the amount of precipitation has increased again.

Climate projections for Zone C

In the southern Federally Administered Tribal Areas and north-western Balochistan, mean temperatures are projected to rise by 0.5°C by 2030 and in a range from 0.8°C to 1.06°C by 2040 (best- and worst-case scenarios). By 2060, further temperature rises would be quite limited in the best-case scenario. By 2100, mean temperatures in the Federally Administered Tribal Areas in this scenario would be only 0.46°C higher than in 2013. In the SSP2-4.5 scenario – or 'middle-of-the-road' scenario – mean temperatures would rise by 2.51°C in the Federally Administered Tribal Areas. In the worst-case scenario, temperatures would rise by as much as 5.96°C.[16] Annual mean minimum and maximum temperatures are also projected to rise. The highest temperature levels would be reached in June.

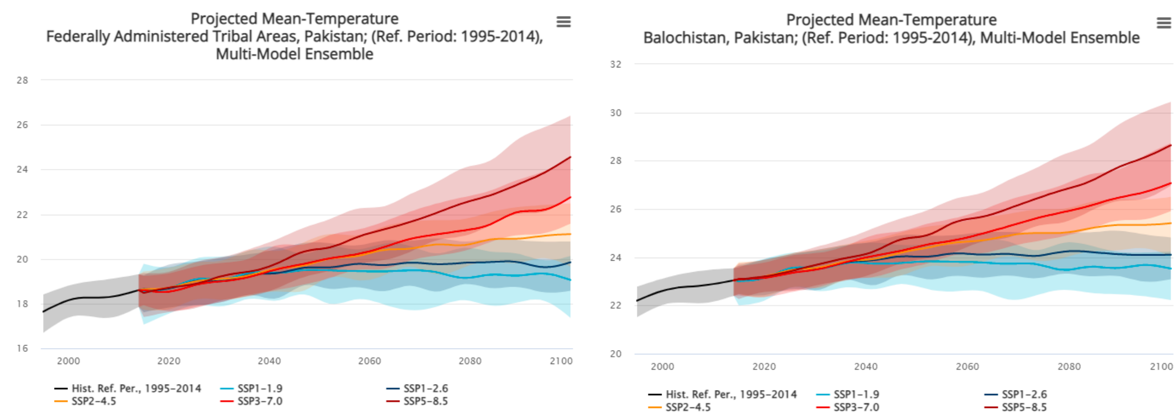

Figure 14: Projected mean temperature in Federally Administered Tribal Areas and Balochistan, Pakistan, in 2020–2100 in different emission pathway scenariosSource: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections.

Annual mean minimum and maximum temperatures are projected to rise in a quite similar order as the average temperatures. Of concern is the projected steep increase of the number of very hot days in Balochistan, i.e. maximum temperatures above 35°C, from 121.5 days in 2013 to 135 days in 2040 and 196.8 days in 2100 in the worst-case scenario. This increase could be limited to 128 days in a scenario with immediate and massive emission reduction and reduced to 153.4 days in a middle-of-the-road scenario.[17]

[16] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections
[17] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

Climate hazards, vulnerabilities and risks in Zone C

The main climate hazards in Zone C are floods, landslides and heat waves. Apart from these sudden-onset extreme events, drought is one of the most significant slow-onset climate hazards.

Precipitation-triggered landslides are caused by rapid snow and ice melt in the northern areas, in addition to heavy rainfall.

The high risk of **riverine flooding** along the main rivers and their tributaries is another severe hazard, and is projected to increase with rising temperatures.[18]

Heat waves are likely to increase in terms of both magnitude and frequency. Due to the rising temperatures and the increasing number of hot days, **forest fires** and drought are expected to occur more often.

Resulting climate risks: The combination of hazards makes settlements and infrastructures along flood-prone rivers particularly vulnerable. The economic sectors most at risk are agriculture and fisheries.

In terms of **vulnerabilities**, higher temperatures in combination with increased evaporation and potentially scarcer water sources in the dry season will negatively affect agriculture and fisheries, which need to adapt to these changing conditions in terms of crop varieties, planting seasons, and water management. Costs of production are likely to increase because of the need for more frequent and more efficient irrigation. Higher temperatures, less available water and more heat waves aggravate stresses to life, lead to more vector-borne diseases and pests, and put elderly people and those with pre-existing vulnerabilities at risk, leading to more cardiovascular or respiratory diseases, lower work productivity (especially for outdoor activities), and more diarrhoeal diseases, among other things.

[18] https://thinkhazard.org/en/report/2740-sri-lanka-northern/FL

The climate of Zone D

Zone D includes southern Punjab and north-eastern Balochistan. This is the hottest and driest zone of Pakistan.[19] The climate is predominantly either hot desert in the east (BWh) or hot semi-arid in the western regions (BSh), according to the Koeppen-Geiger Climate Classification.[20] Average annual rainfall here is 520 millimetres (mm).

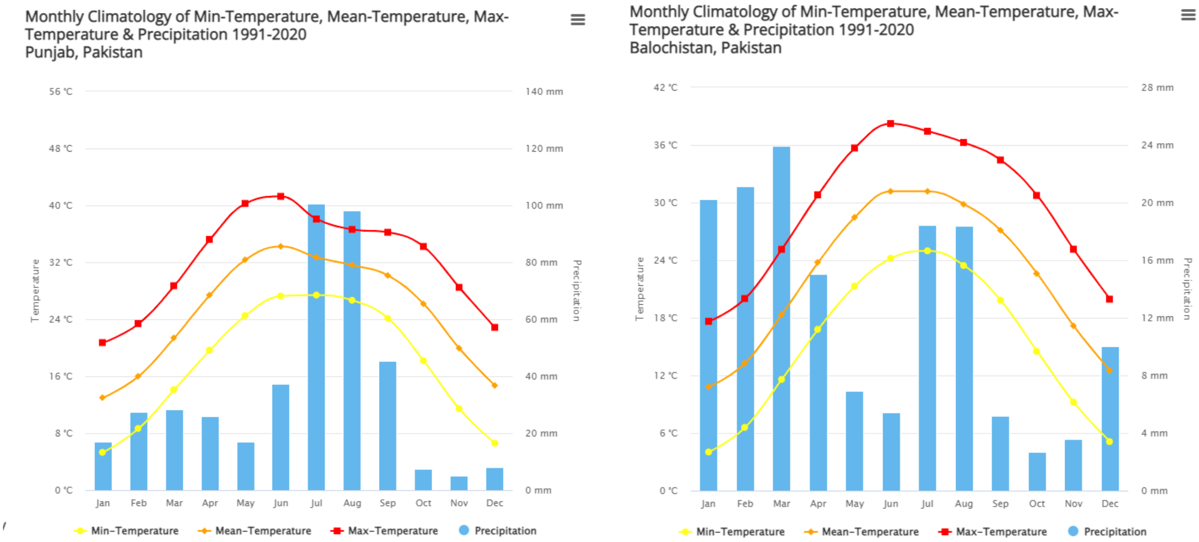

Figure 15: Climate diagrams of Punjab and Balochistan, Pakistan

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical.

Key trends of observed climate change

Temperatures in Zone D have risen over the past 30 years. Since the 1970s, the mean annual temperature has risen by 0.62°C in Punjab and 1.08°C in Balochistan. A particularly strong rise in temperature was seen from the 1990s to the early 2000s. Extreme events have increased in both magnitude and frequency. In combination with the strongly rising temperature in Balochistan, precipitation has dramatically decreased from 207mm in the 1970s to 57mm in 2018, although since 2018 the amount of precipitation has increased again. In the Punjab region there has been no significant change in the amount of precipitation.[21]

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[19] Qasim, 2014

[20] https://climateknowledgeportal.worldbank.org/country/pakistan

[21] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

Climate projections for Zone D

In southern Punjab and north-eastern Balochistan, mean temperatures are projected to rise by 0.55°C by 2030 and in a range from 0.83°C to 1.01°C by 2040 (best- and worst-case scenarios). By 2060, further temperature rises would be quite limited in the best-case scenario. By 2100, the mean temperatures in Punjab in this scenario would be only 0.61°C higher than in 2013. In the SSP2-4.5 scenario – or 'middle-of-the-road' scenario – mean temperature would rise by 2.42°C in Punjab. In the worst-case scenario, temperatures would rise by as much as 5.68°C.[22] Annual mean minimum and maximum temperatures are also projected to rise. The highest temperature levels would be reached in June.

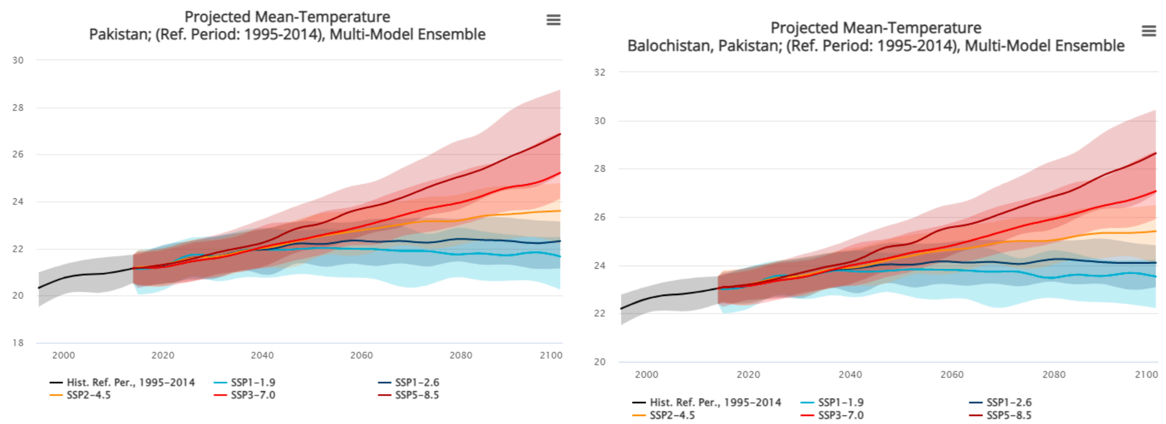

Figure 16: Projected mean temperature in Punjab and Balochistan, Pakistan, in 2020–2100 in different emission pathway scenarios
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections.

Annual mean minimum and maximum temperatures are projected to rise in a quite similar order as the average temperature. Particularly notable is the projected increase in the number of very hot days in Balochistan and Punjab, i.e. maximum temperatures above 35°C, from 121.5 days in 2013 to 135 days in 2040 and 196.8 days in 2100 in the worst-case scenario. This increase could be limited to 128 days in a scenario with immediate and massive emission reduction and reduced to 153.4 days in a middle-of-the-road scenario.[23]

[22] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections
[23] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

Climate hazards, vulnerabilities and risks in Zone D

The main climate hazards in Zone D are floods, extreme heat and wildfires. Apart from these sudden-onset extreme events, drought is one of the most significant slow-onset climate hazards.

The high risk of **riverine flooding** along the main rivers and their tributaries is another severe hazard and is projected to increase with rising temperatures.[24]

Heat waves are likely to increase in terms of both magnitude and frequency. Due to the rising temperatures and the increasing number of hot days, **forest fires** and drought are expected to increase.

Figure 17: Map showing wildfires
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/vulnerability

[24] https://thinkhazard.org/en/report/2740-sri-lanka-northern/FL

Precipitation-triggered landslides are caused by rapid snow and ice melt, as well as by heavy rainfall.

Resulting climate risks: The combination of hazards makes settlements and infrastructures along flood-prone rivers particularly vulnerable in coastal areas. The economic sector most at risk is agriculture.

In terms of **vulnerabilities**, higher temperatures in combination with greater evaporation and potentially scarcer water sources in the dry season will negatively affect agriculture, which needs to adapt to these changing conditions in terms of crop varieties and planting seasons. Costs of production are likely to increase because of the need of more frequent and more efficient irrigation. Higher temperatures, less available water and more heatwaves will heighten life stresses, lead to more vector-borne diseases and pests, and put elderly people and those with pre-existing vulnerabilities at risk, leading to more cardiovascular or respiratory diseases, lower work productivity (especially for outdoor activities), and more diarrhoeal diseases, among other things.

The climate of Zone E

Zone E includes southern Balochistan and Sindh. The climate is warm dry sub-tropical.[25] Average annual rainfall is 261 millimetres (mm).

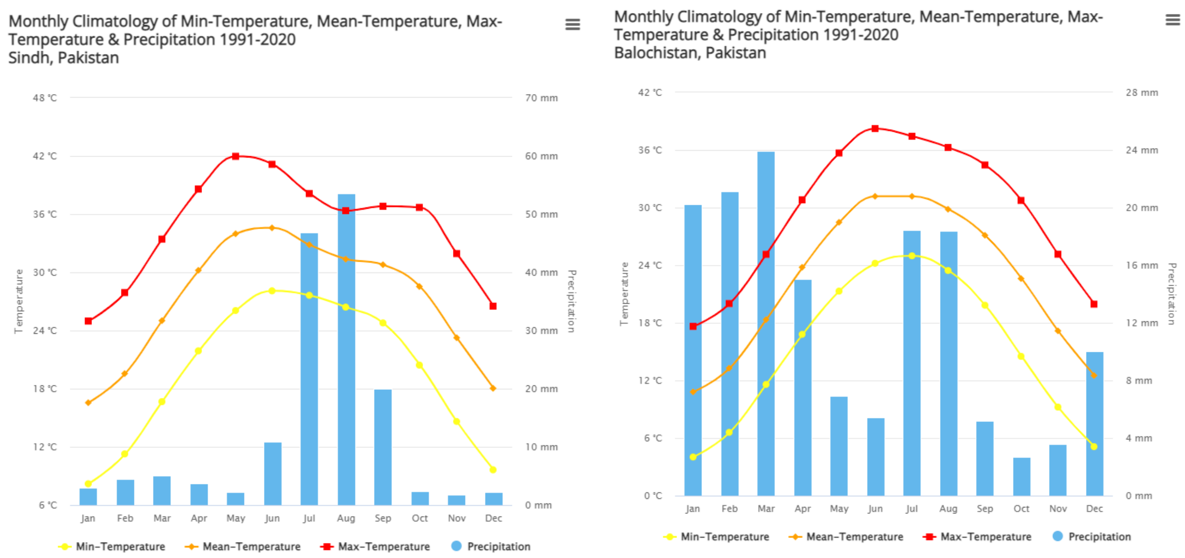

Figure 18: Climate diagrams of Sindh and Balochistan, Pakistan

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical.

Key trends of observed climate change

Temperatures in Zone E have risen over the past 30 years. Since the 1970s, the mean annual temperature has risen by 0.68°C in Sindh and 1.08°C in Balochistan. A particularly strong rise in temperatures was seen from the 1990s to the early 2000s. Extreme events have increased in both magnitude and frequency. In combination with the strongly rising temperatures in Balochistan, precipitation has decreased from 207mm in the 1970s to 57mm in 2018, although since 2018 the amount of precipitation has increased. In the Sindh region there has been no significant change in the amount of precipitation.[26]

[25] Qasim 2014

[26] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-historical

Climate projections for Zone E

In the Sindh and Balochistan, mean temperatures are projected to rise by 0.48°C by 2030 and in a range from 0.78°C to 1.01°C by 2040 (best- and worst-case scenarios). By 2060, further temperature rises would be quite limited in the best-case scenario. By 2100, mean temperatures in Sindh in this scenario would be only 0.46°C higher than in 2013. In the SSP2-4.5 scenario – or 'middle-of-the-road' scenario – mean temperature would rise by 2.28°C in Sindh. In the worst-case scenario, temperatures would rise by as much as 5.°C.[27] Annual mean minimum and maximum temperatures are also projected to rise. The highest temperature levels would be reached in June.

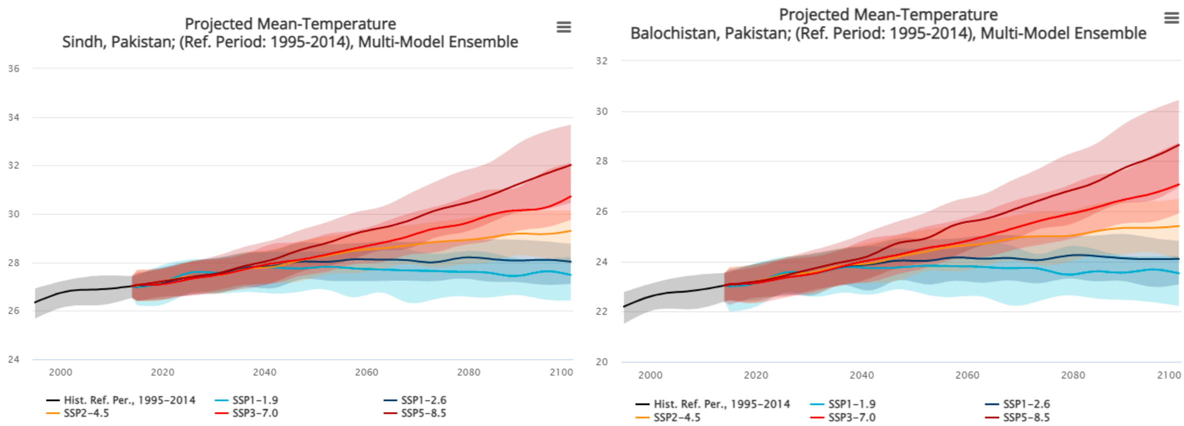

Figure 19: Projected mean temperature in Sindh and Balochistan, Pakistan, in 2020–2100 in different emission pathway scenarios

Source: https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections.

Notable is the projected increase in the number of very hot days in Balochistan, i.e. maximum temperatures above 35°C, from 121.5 days in 2013 to 135 days in 2040 and 196.8 days in 2100 in the worst-case scenario. This increase could be limited to 128 days in a scenario with immediate and massive emission reduction and reduced to 153.4 days in a middle-of-the-road scenario.[28] In Sindh, the number of hot days is increasing significantly, from 177.6 days in 2013 to 194 days in 2040 and 252.7 days in 2100 in the worst-case scenario. This increase could be limited to 187 days in a scenario with

[27] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

[28] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections

immediate and massive emission reduction and reduced to 214 days in a middle-of-the-road scenario.[29]

Climate hazards, vulnerabilities and risks in Zone E

The main climate hazards in the dry climate of Zone E are cyclones, floods, tsunamis and storm surges. Apart from these sudden-onset extreme events, sea level rise is one of the most significant slow-onset climate hazards.

The high risk of **riverine flooding** and high risk of coastal flooding along the main rivers and their tributaries is another severe hazard and is projected to increase with rising temperatures.[30]

Figure 20: Flood risk map, Pakistan
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/vulnerability

[29] https://climateknowledgeportal.worldbank.org/country/pakistan/climate-data-projections
[30] https://thinkhazard.org/en/report/2740-sri-lanka-northern/FL

The south-eastern part of Zone E is particularly susceptible to cyclones.[31] **Cyclones and tsunamis** often affect the southern coast of the country, especially in the months from May to November. According to climate projections, it is likely that future cyclones will be more severe in this region, and their frequency might increase.[32] Damages can occur not only due to wind but also to cyclone-induced heavy rainfall and subsequent flooding.

Figure 21: Maps showing cyclones and tsunamis in Pakistan
Source: https://climateknowledgeportal.worldbank.org/country/pakistan/vulnerability

Heat waves are likely to increase in terms of both magnitude and frequency. Due to the rising temperatures and increasing number of hot days, **forest fires** and drought are expected to increase.

Resulting climate risks: The combination of hazards makes settlements and infrastructures along flood-prone rivers particularly vulnerable in coastal areas. The economic sectors most at risk are agriculture and fisheries.
In terms of **vulnerabilities**, higher temperatures in combination with greater evaporation and potentially scarcer water sources in the dry season will negatively affect agriculture, which needs to adapt to these changing conditions in terms of crop varieties and planting seasons. Costs of production are likely to increase because of the need for more frequent and more efficient irrigation. Mangrove forests will come under pressure with rising sea levels, leading to higher coastal erosion and increased pressure on sea life. Therefore, adaptation measures will need to be undertaken to protect coastal fisherfolk and other people who depend on mangrove forests. Rising sea levels also shrink the availability of land, put coastal infrastructure and settlements at

[31] https://climateknowledgeportal.worldbank.org/country/sri-lanka/vulnerability
[32] https://climateknowledgeportal.worldbank.org/country/sri-lanka/vulnerability

risk, and lead to the need for investments in coastal protection and defence. Stronger cyclones increase the vulnerability of coastal population settlements, infrastructure and livelihoods. Higher temperatures, less available water and more heat waves will heighten life stresses, lead to more vector-borne diseases and pests, and put elderly people and those with pre-existing vulnerabilities at risk, leading to more cardiovascular or respiratory diseases, lower work productivity (especially for outdoor activities), and more diarrhoeal diseases, among other things.

Building climate resilience: basic terms and adaptation options for Pakistan

Climate change adaptation is an adjustment in natural or human systems in response to current or expected climate stimuli or their effects.

Climate disaster risk management is a systematic process of implementing policies, strategies and measures to reduce the impacts of natural hazards and related environmental and technological disasters. This includes, among other things, disaster risk reduction, preparedness, response, recovery and rehabilitation.

Climate proofing is an approach to identify, address and minimise project-related climate risks.

Climate resilience is defined as the capacity of a socio-ecological system to (1) absorb stresses and maintain functions in the face of external stresses caused by climate change, and (2) adapt, re-organise and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

Climate risk assessment is a methodology to determine the nature and extent of risk by both analysing hazards and their potential likelihood and intensity and also estimating impacts through the evaluation of conditions of vulnerability and the identification of exposed people, property, infrastructure, services, livelihoods and their environment.

Disaster risk refers to the potential disaster losses of sudden or slow-onset events in lives, health, livelihoods, assets and services which could be incurred by a particular community or a society over some specified future time period. Disaster risk is a function of hazard, exposure, vulnerability and capacity.

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Gender sensitivity and gender responsiveness: A gender-sensitive programme considers gendered norms, roles and inequalities and reflects an awareness of these issues. A gender-responsive programme goes one step further and looks for solutions that pro- actively work to address and reduce gender inequalities.

Hazard: A hazard is a dangerous phenomenon, substance, human activity or condition that might cause loss of life or injury or lead to other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

The National Adaptation Plan (NAP) process was established under the UNFCCC to help countries conduct medium- and long-term climate adaptation planning. It is a flexible programme that builds on each country's existing adaptation programmes and actions, and helps to align adaptation with other national policies.

Nationally Determined Contributions (NDCs) are the pledges of climate action (adaptation and mitigation) of State Parties to the UNFCCC under the Paris Agreement.

Vulnerability comprises the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard and, hence, disaster. There are many aspects of vulnerability arising from physical, social, economic or environmental factors.

If a project or programme is categorised in the climate-proofing process as being exposed to climate risks, a climate risk assessment should be carried out in order to fully understand the risks. Based on the results of this assessment, a risk reduction and adaptation plan should be developed to avert or minimise the risk. Adaptation plans typically show how the climate impact chain leading to negative impacts on the project can be modified by taking adaptation measures that will minimise risks.

The following table shows a sample of possible adaptation options for sectors that are at risk.

Sector	Adaptation options	Sources of practical information
Agriculture	Drought-/heat tolerant varieties (Drip water) irrigation (Drought) Vertical gardening (salinity) Floating gardens (flood) Erosion control (landslides) Changing cropping patterns Agroecological pest control	https://climateportal.ccdbbd.org/solution-navigator/ https://www.adaptationcommunity.net/agroecology/
Forestry	Afforestation/reforestation Resilient plant & tree species Sustainable forest management /Agroforestry	https://worldagroforestry.org
Coastal zones	Build typhoon shelters Mangrove reforestation Resilient aquaculture Early warning systems	https://www.adaptation-undp.org/undp-helps-vietnam’s-coastal-communities-adapt-climate-change https://www.giz.de/en/worldwide/18661.html
Settlements	Flood-/storm-proof houses Stormwater management Natural shade & ventilation	https://www.unep.org/news-and-stories/story/5-ways-make-buildings-climate-change-resilient http://bengaluru.urbanwaters.in/about-the-million-wells-campaign/
Energy	Climate resilient infrastructure	https://climateportal.ccdbbd.org/solution-navigator/

	Decentralised energy systems	

Pakistan's key adaptation policies and reports can be found at: https://climateknowledgeportal.worldbank.org/country/pakistan/adaptation.

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PSMSL – Permanent Service for Mean Sea Level: Access to global sea level monitoring stations. Free and accessible data from 1960 until 2015.

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