CLIMATE RISK COUNTRY PROFILE

BHUTAN

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK

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ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles that are jointly developed by the World Bank Group (WBG) and the Asian Development Bank (ADB). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Veronique Morin (Senior Climate Change Specialist, WBG), Ana E. Bucher (Senior Climate Change Specialist, WBG) and Arghya Sinha Roy (Senior Climate Change Specialist, ADB).

This profile was written by Alex Chapman (Consultant, ADB), William Davies (Consultant, ADB) and Ciaran Downey (Consultant). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by MacKenzie Dove (Senior Climate Change Consultant, WBG), Yunziyi Lang (Climate Change Analyst, WBG), Jason Johnston (Operations Analyst, WBG), Adele Casorla-Castillo (Consultant, ADB), and Charles Rodgers (Consultant, ADB). This profile also benefitted from inputs of WBG and ADB regional staff and country teams.

Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

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FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group (WBG) and the Asian Development Bank (ADB) are committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

Both institutions are investing in incorporating and systematically managing climate risks in development operations through their individual corporate commitments.

For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

For the Asian Development Bank (ADB): its Strategy 2030 identified "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability" as one of its seven operational priorities. Its Climate Change Operational Framework 2017–2030 identified mainstreaming climate considerations into corporate strategies and policies, sector and thematic operational plans, country programming, and project design, implementation, monitoring, and evaluation of climate change considerations as the foremost institutional measure to deliver its commitments under Strategy 2030. ADB's climate risk management framework requires all projects to undergo climate risk screening at the concept stage and full climate risk and adaptation assessments for projects with medium to high risk.

Recognizing the value of consistent, easy-to-use technical resources for our common client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group and ADB's Sustainable Development and Climate Change Department have worked together to develop this content. Standardizing and pooling expertise facilitates each institution in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For common client countries, these profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

We hope that this combined effort from our institutions will spur deepening of long-term risk management in our client countries and support further cooperation at the operational level.

Bernice Van Bronkhorst
Global Director
Climate Change Group
The World Bank Group

Preety Bhandari
Chief of Climate Change and Disaster Risk Management Thematic Group
concurrently Director Climate Change and Disaster Risk Management Division
Sustainable Development and Climate Change Department
Asian Development Bank

KEY MESSAGES

- While data are limited, historical records indicate an increase in annual temperatures of just under 1°C over the 20th century in Bhutan, with daily minimum temperatures increasing at a greater pace than daily maximum temperatures.
- Projections of temperature rise in Bhutan are slightly greater than the global average: 3.9°C compared to 3.7°C by the 2090s under the highest emissions pathway, RCP8.5.
- Flooding is considered to be the most significant climate-related hazard faced by Bhutan, with most of the country's agricultural land and infrastructure located along drainage basins that are highly vulnerable to heavy monsoon rains and glacial-lake outbursts. The impact of flooding on human health and livelihoods is expected to grow and could be 4% of GDP by the 2030s.
- Climate models project a significant increase in the likelihood of heatwaves and droughts. These are likely to impact more severely on communities in Bhutan's lowlands.
- Higher temperatures are projected to also contribute to increased snowmelt which could change patterns of river discharge and water availability. Impacts on infrastructure could grow significantly in the second half of the 21st century.
- Agriculture is highly vulnerable to climatic conditions due to its dependence on monsoon rains and short growing periods. This is accentuated by the structure of agricultural production and concentration of agricultural activity in vulnerable areas. Around 30% of agricultural production takes place on slopes that are vulnerable to landslides and soil erosion.
- Bhutan's high reliance on hydroelectric generation represents a particular climate-vulnerability. Climate changes could have direct impacts on energy security through processes such as changing rates of sedimentation, reducing water reserves and flow regularity, and exposing infrastructure to hazards such as flooding, Glacial Lake Outburst Floods (GLOF), and landslides.
- Bhutan is vulnerable to an increase in the geographic range and incidence of vector-borne and water-borne diseases as a consequence of climate change.
- Despite Bhutan's relatively high levels of food sufficiency, food access, and nutrition continue to represent challenges. Without effective adaptation, the impact of climate change on global food security and local production is likely to increase hunger and malnourishment in Bhutan.
- Despite recent successes in poverty reduction, the likelihood that the strongest impacts of climate change will fall on the communities with the least capacity to adapt, means there is a high risk of people falling back into poverty and a widening inequality gap.

COUNTRY OVERVIEW

The Kingdom of Bhutan (Bhutan) is a landlocked country with an area of 38,394 km^2 located in South Asia and is bordered by China and India.[1] It is a mountainous country in the Eastern Himalayan ecosystem with summits ranging from 160 meter (m) to over 7,000 m above sea level,[2] abundant water resources, and a

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1 World Bank Group (2021). Data Bank. Country indicators. URL: https://data.worldbank.org/country/bhutan
2 Royal Government of Bhutan (2016). Nationally Determined Contribution of the Kingdom of Bhutan. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bhutan%20First/Bhutan-INDC-20150930.pdf

healthy primeval forest. The northern part of the country is characterized by snowcapped peaks of elevations above 7,300 m with abundant glaciers and alpine pastures. The country is bordered by mountains in the Tibet Autonomous Region, the Lesser Himalayas (Inner Himalayas), and Duars Plain along its southern border. Rivers flow southward and most join the Brahmaputra.[3] The principal rivers flowing from west to east are the Toorsa, Wang, Sankosh, and Manas. Glacier area represented approximately 1.6% of the land cover of Bhutan in 2018.[4] About 72.3% of the country is covered by forest and 13.8% of land is agricultural.[5] As the youngest and highest mountain chain on earth, the Himalaya ecosystem is ecologically fragile and considered a biodiversity hotspot.[6] Climate varies dramatically due to the country's topography and geographical location at the edge of the tropical circulation in the north and Asian monsoon circulation in the south.[7]

The country's population was 763,092 in 2019,[8] with an annual growth rate of 1.3%. Although much of the population is rural, the urban population is growing at a faster rate (**Table 1**). Bhutan has a relatively young population with about 68% between the ages of 15–64, 26% younger than 15 and 6% above the age of 65.[9] The country is considered a lower middle-income country by the World Bank. However, it is one of the fastest growing economies in the world, with hydropower making a major contribution to growth.[10] Bhutan instituted Gross National Happiness (GNH) as a development principle, with this index increasing from 0.743 in 2010 to 0.756 in 2015. In 2015, 8.4% of people were deeply happy, 35.0% extensively happy, 47.9% narrowly happy, and 8.8% unhappy.[11] The country has a GDP of $2.5 Billion (2019) with an annual growth rate of 5.5% and a GDP per capita of $3,316.20 (2019), growing at 4.3%. The economy is primarily based on industry (41%) and services (42%), with a lesser contribution from agriculture (17%). Employment in 2019 was concentrated in agriculture (55.8%) and services (34.1%), followed by industry (10.1%).[12] Bhutan is expected to graduate from its Least Developed Country (LDC) status in 2023.[13]

The Government of Bhutan has gained international attention for its policies to address climate change.[14,15] Bhutan has also been a leader in its forest management and carbon sequestration efforts from its forests have helped the country maintain its carbon negative status.[16] Identified in the country's Nationally Determined Contribution (2016),

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3 Royal Government of Bhutan (2021). Third National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20of%20Bhutan%202020.pdf
4 The status and decadal change of glaciers in Bhutan from the 1980s to 2010 based on satellite data. http://www.icimod.org/?q=13008
5 World Bank Group (2021). Data Bank. Country indicators. URL: https://data.worldbank.org/country/bhutan
6 Conservation International Critical Ecosystem Partnership Fund (2020). Himalaya Hotspot. URL: https://www.cepf.net/our-work/biodiversity-hotspots/himalaya
7 United Nations Development Program (2019). Climate Change Adaptation Bhutan Profile. URL: http://adaptation-undp.org/explore/bhutan
8 National Statistics Bureau of Bhutan (2018). 2017 Population and Housing Census of Bhutan. URL: http://www.nsb.gov.bt/publication/files/PHCB2017_national.pdf [accessed 04/08/2020]
9 World Bank Group (2021). Data Bank. Country indicators. URL: https://data.worldbank.org/country/bhutan
10 World Bank Group (2021). Bhutan Country Overview. [Accessed June 2018.] URL: http://www.worldbank.org/en/country/bhutan/overview
11 Centre for Bhutan Studies and GNH Research (2005). Bhutan's 2015 Gross National Happiness Index. URL: http://www.grossnationalhappiness.com/SurveyFindings/Summaryof2015GNHIndex.pdf
12 WBG (2021). World Development Indicators, DataBank. URL: https://databank.worldbank.org/source/world-development-indicators
13 United Nations (2021). Department of Economic and Social Affairs. Least Development Country Category: Bhutan Profile. URL: https://www.un.org/development/desa/dpad/least-developed-country-category-bhutan.html
14 Dixon, A. (2015). What can Bhutan teach the world about climate action? World Economic Forum. URL: https://www.weforum.org/agenda/2015/12/what-can-bhutan-teach-the-world-about-climate-action/ [accessed 15/08/2019]
15 Dollkr, T. (2018). Why Bhutan Needs to Adopt Enforcement Infrastructure to Meet its Greenhouse Gas Emission Goals? *Bhutan Law Network/ JSW Law Research Paper Series.* No. 18-2. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3263536
16 World Bank (2019). Bhutan Forest Note; Pathways for Sustainable Forest Management and Socio-equitable Economic Development. URL: http://documents1.worldbank.org/curated/en/118821562700584327/pdf/Bhutan-Forest-Note-Pathways-for-Sustainable-Forest-Management-and-Socio-equitable-Economic-Development.pdf

the country's vulnerability to the impacts of climate change are primarily the fragile mountainous environment and dependence on agriculture and hydropower generation for economic development. In Bhutan, hydropower is an important revenue source for the government. Given the country's limited economic diversification, hydropower disruptions from climate change events and long-term trends can lead to outsized economic impacts. Bhutan is also exposed to hazards such as flash floods, including GLOFs, forest fires, storms, and landslides.[17] Bhutan's Third National Communication to the UNFCCC (NC3) (2021) identifies the impacts of climate change on key sectors of Bhutan such as water, agriculture, energy (hydropower), human health, and glaciers. These risks and increased exposures highlight the high degree of vulnerability of the country.[18] Adaptation priorities consider the country's vulnerability to the impacts of climate change, particularly its fragile mountainous environment plus dependence on agriculture and hydropower for economic development. Bhutan is also exposed to hazards such as flash floods, including glacial lake outburst floods (GLOFs), forest fires, storms, and landslides.[19]

TABLE 1. Key indicators

Indicator	Value	Source
Population Undernourished[20]	Unknown (2017–2019)	FAO, 2020
National Poverty Rate[21]	8.2% (2017)	World Bank, 2019
Share of Wealth Held by Bottom 20%[22]	6.7% (2017)	World Bank, 2019
Net Annual Migration Rate[23]	0.04% (2015–2020)	UNDESA, 2019a
Infant Mortality Rate (Between Age 0 and 1)[22]	2.4% (2015–2020)	UNDESA, 2019a
Average Annual Change in Urban Population[24]	3.0% (2015–2020)	UNDESA, 2019b
Dependents per 100 Independent Adults[25]	45 (2020)	UNDESA, 2019
Urban Population as % of Total Population[26]	42.3% (2020)	CIA, 2020
External Debt Ratio to GNI[27]	109.2% (2018)	ADB, 2020
Government Expenditure Ratio to GDP[26]	25.0% (2019)	ADB, 2020

[17] Royal Government of Bhutan (2016). Nationally Determined Contribution of the Kingdom of Bhutan. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bhutan%20First/Bhutan-INDC-20150930.pdf
[18] Royal Government of Bhutan (2021). Third National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20of%20Bhutan%202020.pdf
[19] Royal Government of Bhutan (2016). Nationally Determined Contribution of the Kingdom of Bhutan. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bhutan%20First/Bhutan-INDC-20150930.pdf
[20] FAO, IFAD, UNICEF, WFP, WHO (2020). The state of food security and nutrition in the world. Transforming food systems for affordable healthy diets. FAO. Rome. URL: http://www.fao.org/publications/sofi/2020/en/
[21] World Bank (2019). Poverty headcount ratio at national poverty lines (% of population). URL: https://data.worldbank.org/ [accessed 17/12/20]
[22] World Bank (2019). Income share held by lowest 20%. URL: https://data.worldbank.org/ [accessed 17/12/20]
[23] UNDESA (2019a). World Population Prospects 2019. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
[24] UNDESA (2019b). World Urbanization Prospects 2018: File 6. URL: https://population.un.org/wup/Download/ [accessed 17/12/20]
[25] UNDESA (2019a). World Population Prospects 2019: POP/11-A. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
[26] CIA (2020). The World Factbook. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/
[27] ADB (2020). Key Indicators for Asia and the Pacific 2020 Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020

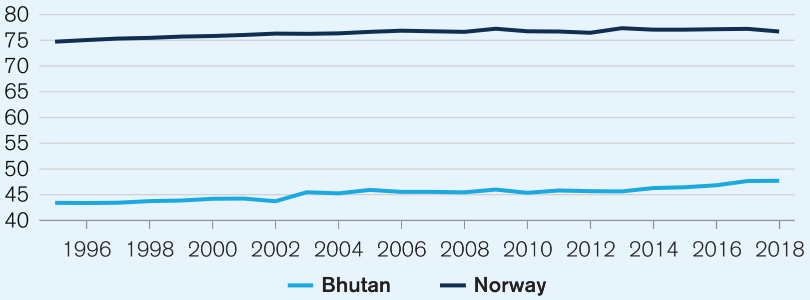
Green, Inclusive and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts globally. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies. Bhutan's responses have been guided by its Economic Contingency Plan (2020).

This document aims to succinctly summarize the climate risks faced by Bhutan. This includes rapid onset and long-term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of Bhutan, therefore potentially excluding some international influences and localized impacts. The core data presented is sourced from the database sitting behind the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG ADB staff to inform their climate actions and to direct them to many useful sources of secondary data and research.

Due to a combination of political, geographic, and social factors, Bhutan is recognized as vulnerable to climate change impacts, ranked 91 out of 181 countries in the 2020 ND-GAIN Index.[28] The ND-GAIN Index ranks 181 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is the lower their score, while the more ready a country is to improve its resilience the higher it will be. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Bhutan's progress as compared to Norway.

FIGURE 1 The ND-GAIN Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead.



[28] University of Notre Dame (2021). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

Climate Baseline

Overview

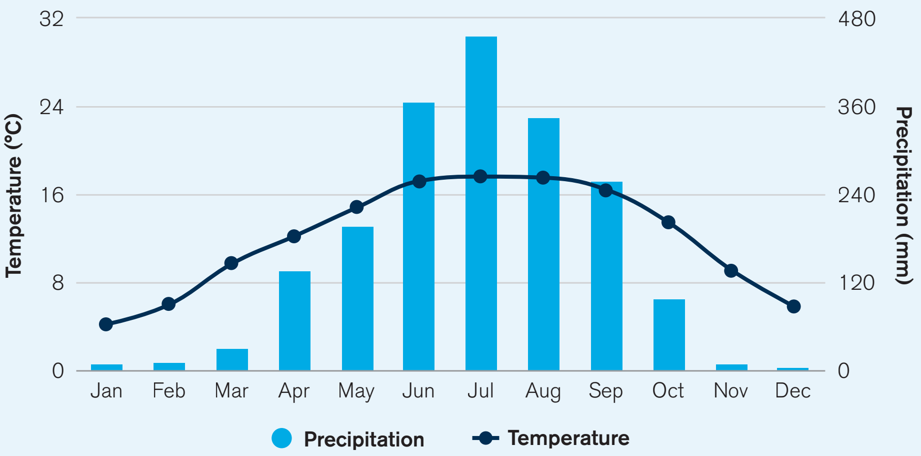
Bhutan's climate is diverse due to dramatic variations in elevation. The Duars Plain tends to be hot and humid; the Lesser Himalaya region is often cooler; while the areas in the Greater Himalayas are closest to that of alpine tundra.[29] The southern belt of the country at the foothills of the Himalayas (150–2,000 meter [m] above sea level) has a subtropical climate with high humidity, heavy rainfall, and average temperatures of approximately 15°C–30°C year-round. The central belt is characterized by river valleys (2,000–4,000 m above sea level) with cool winters, hot summers between June and September, and moderate rainfall. The Northern belt consists primarily of snowcapped peaks and alpine meadows (4,000 m above sea level) with cold winters and cool summers.[30] Precipitation ranges widely across the country and occurs primarily during the monsoon season between June and September as well as the pre-monsoon season.[29] The country is also be characterized into six agro-climatic regions: alpine, cool temperate, warm temperate, dry sub-tropical, humid sub-tropical, and wet-sub tropical.[31]

As **Figure 2** shows, there is significant seasonal range in temperatures: the summer months of June–August averaging temperatures of 24°C–29°C, compared to the winter months of December–February which are near 0°C, for the most recent climatology, 1991–2020. Average monthly rainfall follows a similar pattern, in which considerably more rainfall occurs during the summer months (approximately 240 millimeters [mm]) than during the winter months (approximately 90 mm). **Figure 3** shows the spatial variation of the observed annual precipitation and mean temperature across Bhutan.

[29] Royal Government of Bhutan (2021). Third National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20of%20Bhutan%202020.pdf
[30] Bhutan (2016). Bhutan State of the Environment Report. URL: http://www.nec.gov.bt/nec1/wp-content/uploads/2016/07/Bhutan-State-of-Environment-Report-2016.pdf
[31] Food and Agriculture Organization (2011). Irrigation in Southern and Eastern Asia in figures. AQUASTAT Survey (2011). URL: http://www.fao.org/nr/water/aquastat/countries_regions/BTN/BTN-CP_eng.pdf

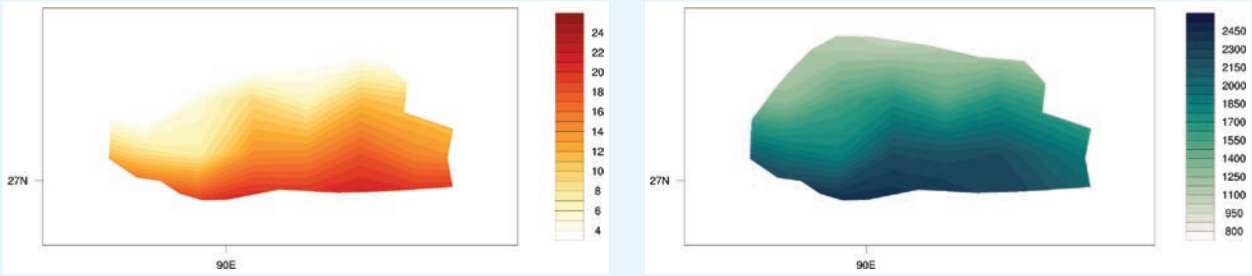
Annual Cycle

FIGURE 2. Average monthly temperature and rainfall in Bhutan, 1991–2020[32]



Spatial Variation

FIGURE 3. (Left) annual mean temperature (°C), and (right) annual mean rainfall (mm) in Bhutan over the period 1991–2020.[33] Maps represent the coordinates of Bhutan.



Key Trends

Temperature

Despite relatively little historical data, temperature increases have been experienced in the country since the 1960s. Observations show temperature increases, with minimum temperatures increasing and a faster rate than maximum temperatures. On average, temperature has been rising faster in the last half-century. There is higher variability in observed temperatures in February and March. Regions at lower elevations and in the south tend to have higher temperatures and greater precipitation, while northern regions are often cooler with less precipitation. In Bhutan, temperatures are higher during summer and decrease over winter months.[34]

[32] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical

[33] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical

[34] National Center for Hydrology and Meteorology (2019). Analysis of Historical Climate and Climate Projection for Bhutan. URL: http://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Analysis%20of%20Historical%20Climate%20and%20Climate%20Change%20Projection.pdf

Precipitation

Rainfall in Bhutan is controlled by Southwest monsoon circulation that prevails over the Indian sub-continent during summer months. This produces a seasonal cycle with rainy summer seasons over most of the country lasting from June to September. During this part of the year, most of the country has an almost sub-tropical climate, particularly the southern Dzongkhags. Therefore, these areas are prone to dry-spells and drought induced by the variability of monsoon rainfall. Recent studies point to a decline in rainfall in the country's wettest regions[35] and a weakening of the Indian Summer Monsoon over the subcontinent.[36] For Bhutan, rainfall has increased from June to September and December to February have increased aridity and is currently the country's driest season. A high degree of rainfall variability and distribution exists spatially within the country.[37] Precipitation is highest near the northern and southern borders of the country.[38]

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated.[39] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes business-as-usual scenario. For more information, please refer to the RCP Database.

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[35] Awange, J.L., Kuhn, M., Anyah, R. and Forootan, E. (2017). Changes and variability of precipitation and temperature in the Ganges–Brahmaputra–Meghna River Basin based on global high-resolution reanalyses. *International Journal of Climatology, 37*(4), pp. 2141–2159. URL: https://www.deepdyve.com/lp/wiley/changes-and-variability-of-precipitation-and-temperature-in-the-ganges-3CsLPQ2OxY

[36] Xu, C., Sano, M., Dimri, A.P., Ramesh, R., Nakatsuka, T., Shi, F. and Guo, Z. (2018). Decreasing Indian summer monsoon on the northern Indian sub-continent during the last 180 years: evidence from five tree-ring cellulose oxygen isotope chronologies. *Climate of the Past, 14*(5), pp. 653–664. URL: https://www.clim-past.net/14/653/2018/

[37] Stewart, S.B., Choden, K., Fedrigo, M., Roxburgh, S.H., Keenan, R.J. and Nitschke, C.R. (2017). The role of topography and the north Indian monsoon on mean monthly climate interpolation within the Himalayan Kingdom of Bhutan. *International Journal of Climatology, 37*, pp. 897–909. URL: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.5045

[38] National Center for Hydrology and Meteorology (2019). Analysis of Historical Climate and Climate Projection for Bhutan. URL: http://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Analysis%20of%20Historical%20Climate%20and%20Climate%20Change%20Projection.pdf

[39] Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO2 emission budgets caused by permafrost carbon release. Nature Geoscience, 11, 830-835. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_carbon-cycle

For Bhutan, these models show a trend of consistent warming that varies by emissions scenario. However, the projections in rainfall are less certain and vary by both RCP scenario as well as models. Projected precipitation trends do show a likely increase in precipitation for the country, with eastern areas experiencing higher amounts of rainfall. However, it is anticipated that Bhutan will experience an increase in intensity for extreme rainfall events. **Tables 2** and **3** below, provide information on projected temperature anomalies for the four RCPs over two distinct time horizons; presented against the reference period of 1986–2005.

TABLE 2. Projected anomaly (changes °C) for maximum, minimum, and average daily temperatures in Bhutan for 2040–2059 and 2080–2099, from the reference period of 1986–2005 for all RCPs. The table is showing the median of the CCKP model ensemble and the 10–90th percentiles in brackets.[40]

	Average Daily Maximum Temperature		Average Daily Temperature		Average Daily Minimum Temperature	
Scenario	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**
RCP2.6	1.3 (–0.6, 3.5)	1.3 (–0.6, 3.4)	1.3 (–0.1, 2.8)	1.2 (0.0, 2.9)	1.2 (–0.3, 3.2)	1.3 (–0.4, 3.2)
RCP4.5	1.7 (–0.3, 3.7)	2.5 (0.3, 4.8)	1.6 (0.2, 3.0)	2.4 (0.8, 4.0)	1.7 (0.0, 3.6)	2.3 (0.8, 4.5)
RCP6.0	1.5 (–0.6, 3.6)	2.8 (0.6, 5.2)	1.5 (0.1, 3.0)	2.8 (1.3, 4.5)	1.6 (–0.2, 3.4)	2.9 (1.2, 5.0)
RCP8.5	2.3 (0.2, 4.2)	4.7 (2.4, 7.0)	2.2 (0.8, 3.6)	4.5 (2.8, 6.5)	2.2 0.7, 4.0)	4.6 (2.8, 7.1)

TABLE 3. Projections of average temperature anomaly (°C) in Bhutan for different seasons (3-monthly time slices) over different time horizons and emissions pathways, showing the median estimates of the full CCKP model ensemble and the 10th and 90th percentiles in brackets.[39]

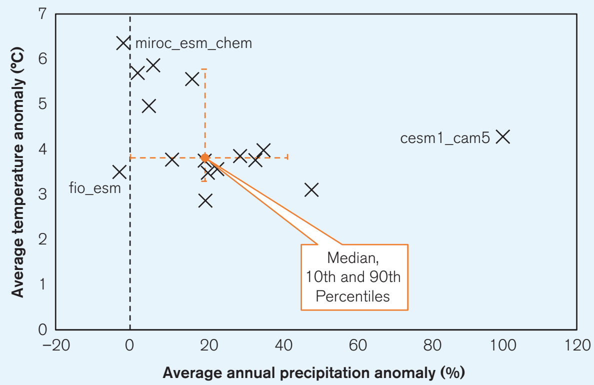
	2040–2059		2080–2099	
Scenario	**Jun–Aug**	**Dec–Feb**	**Jun–Aug**	**Dec–Feb**
RCP2.6	1.0 (–0.3, 2.6)	1.4 (0.0, 2.7)	0.9 (–0.3, 2.6)	1.5 (0.1, 2.6)
RCP4.5	1.3 (0.1, 2.6)	1.8 (0.3, 2.9)	2.0 (0.6, 3.5)	2.6 (0.9, 4.3)
RCP6.0	1.1 (0.0, 2.6)	1.7 (0.1, 3.0)	2.3 (0.9, 4.0)	3.1 (1.5, 4.6)
RCP8.5	1.8 (0.7, 3.2)	2.5 (0.9, 3.9)	3.8 (2.4, 5.6)	4.9 (3.4, 7.1)

[40] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Projections. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-projection

Model Ensemble

Climate projections presented in this document are derived from datasets available through the CCKP, unless otherwise stated. These datasets are processed outputs of simulations performed by multiple General Circulation Models (GCM) (for further information see Flato et al., 2013).[41] Collectively, these different GCM simulations are referred to as the 'model ensemble'. Due to the differences in the way GCMs represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs, this is particularly the case for rainfall related variables and at national and local scales. The range of projections from 16 GCMs for annual average temperature change and annual precipitation change in Bhutan under RCP8.5 is shown in **Figure 4**. Spatial representation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 5**.

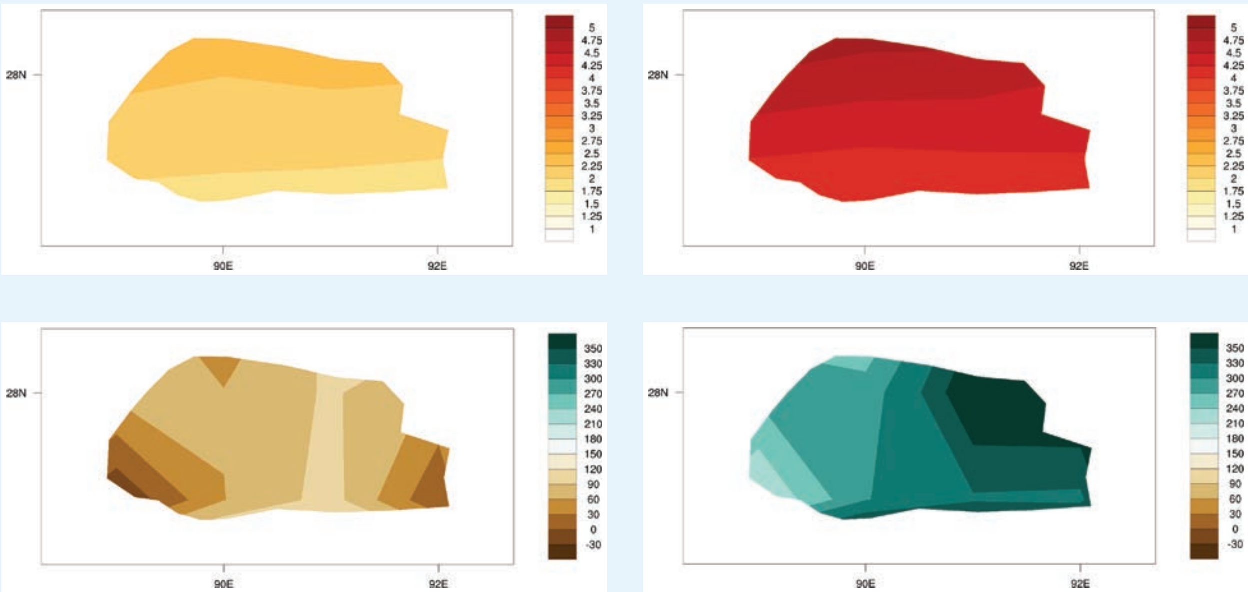
FIGURE 4. 'Projected average temperature anomaly' and 'projected annual rainfall anomaly' in Bhutan. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble that provide projections across all RCPs and therefore are most robust for comparison.



[41] Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., . . . Rummukainen, M. (2013). Evaluation of Climate Models. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 741–866. URL: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Spatial Variation

FIGURE 5. CMIP5 ensemble projected change (32 GCMs) in annual temperature (top) and precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.5.[42,43] Maps represent the coordinates of Bhutan.



Temperature

Projections of future temperature change are presented in three primary formats. Shown in **Table 2** are the changes (anomalies) in daily maximum and daily minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 6** and **7** display the monthly and annual temperature projections. While similar, these three indicators can provide slightly different information. Monthly/annual average temperatures are most commonly used for general estimation of climate change, whereas the daily maximum and minimum can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes. **Figure 7** shows, the seasonal variation exists in projected annual temperature changes. December to February is projected to experience greater change compared to the July to September: approximately 5°C under RCP8.5 emissions pathway by the 2090s.

[42] WBG Climate Change Knowledge Portal (CCKP 2021). Bhutan. Climate Data. Projections. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-projections

[43] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical

FIGURE 6. Historic and projected average annual temperature in Bhutan under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble.[44]

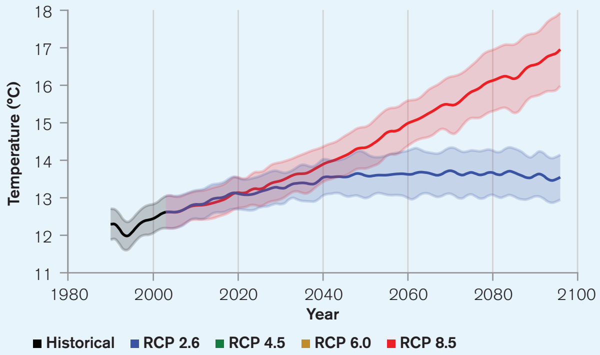
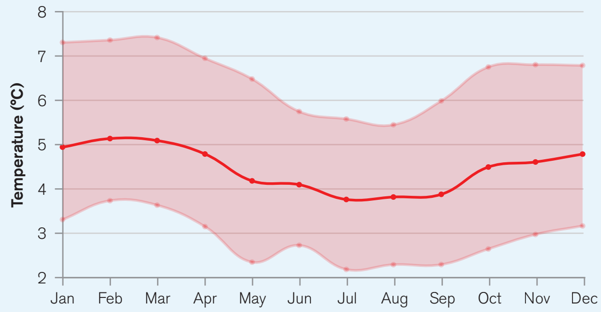


FIGURE 7. Projected change (anomaly) in monthly temperature, shown by month, for Bhutan for the period 2080–2099 under RCP8.5. The value shown represents the median of the model ensemble with the shaded areas showing the 10th–90th percentiles.[45]



Projections for annual average temperature rise for Bhutan are greater than the global average: 4.5°C, compared to 3.7°C under the RCP8.5 emissions pathway by the 2090s. Under the same pathway and time-period, annual average of monthly maximum and minimum temperatures are projected to increase greater than annual average temperatures, 4.7°C and 4.6°C, respectively.

Precipitation

Climate model projections of future rainfall are less reliable than for temperature. The CCKP model ensemble suggests increases in median annual rainfall under all emissions pathways. As the scatter plot in **Figure 4** showed, despite high uncertainty surrounding precipitation projections, 14 of the 16 models project an increase in precipitation to some degree. CCKP data shows a slight increase in precipitation levels under all emissions pathways by the 2090s. For example, median annual precipitation is projected to increase by 10% under the RCP6.0 pathway and 11% under the RCP8.5 pathway, from an historical baseline median of 1,842 mm.

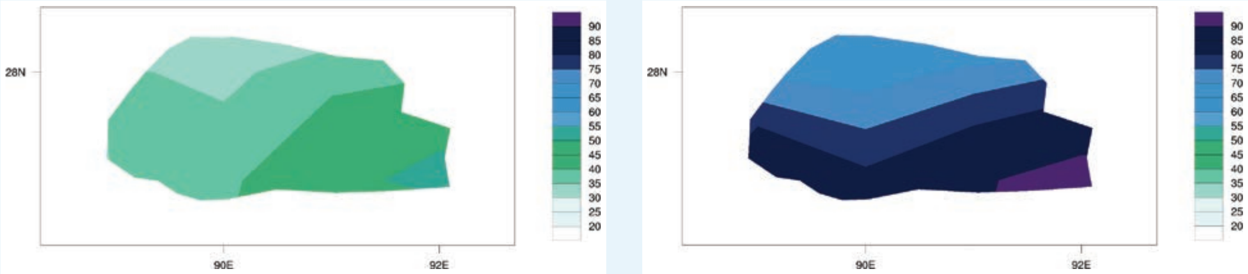
There is greater confidence around changes to the future intensity of heavy rainfall events. Under all emissions pathways, an increase in the precipitation associated with a maximum 5-day rainfall event is expected across Bhutan, with heaviest rainfall occurring in the southeastern areas of the country (**Figure 8**). The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia.[46] However, as this phenomenon is highly dependent on local geographical contexts further research is required to constrain its impact in Bhutan.

[44] WBG Climate Change Knowledge Portal (CCKP, 2021). Bhutan. Agriculture Interactive Climate Indicator Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=BTN&period=2080-2099

[45] WBG Climate Change Knowledge Portal (CCKP, 2021). Bhutan. Agriculture Interactive Climate Indicator Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=BTN&period=2080-2099

[46] Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., Roberts, N. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. URL: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2014RG000464

FIGURE 8. Projected change in the maximum 5-day rainfall (mm) over Bhutan for the period 2040–2059 (left) and for the period 2080–2099 (right) for emissions pathways RCP8.5 compared to the 1986–2005 baseline[47,48] Maps represent the coordinates of Bhutan.



CLIMATE RELATED NATURAL HAZARDS

Bhutan faces risks from natural disasters but relatively less than other countries, ranking joint 115th out of 191 countries in the INFORM 2019 Risk Index (**Table 4**).[49] The most significant natural hazard is exposure to earthquakes, due to location along the Himalayan mountain belt. Amongst the climate-related hazards covered by the index, flooding is the country's most significant, ranking 76th globally. The risks associated with other climate-related natural hazards often found in Asian countries, such as drought and tropical cyclones, are extremely low, both scoring 0 on the INFORM 2019 Index. In terms of the country's coping capacity,[50] Bhutan is ranked as having similar capacity to countries such as India and Kyrgyzstan. However, it is important to note that the INFORM Index does not include other climate-related hazards relevant to Bhutan such as landslides. The section

TABLE 4. Selected indicators from the INFORM 2019 Index for Risk Management for Bhutan. For the sub-categories of risk (e.g. "Flood") higher scores represent greater risks. Conversely the most at-risk country is ranked 1st. The average score across all countries is shown in brackets.

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
5.4 [4.5]	0.0 [1.7]	0.0 [3.2]	3.3 [3.6]	4.5 [4.5]	3.0 [3.6]	115

47 WBG Climate Change Knowledge Portal (CCKP, 2021). Bhutan. Agriculture Interactive Climate Indicator Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=BTN&period=2080-2099

48 WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical

49 European Commission (2019). INFORM Index for Risk Management. Bhutan Country Profile. URL: https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

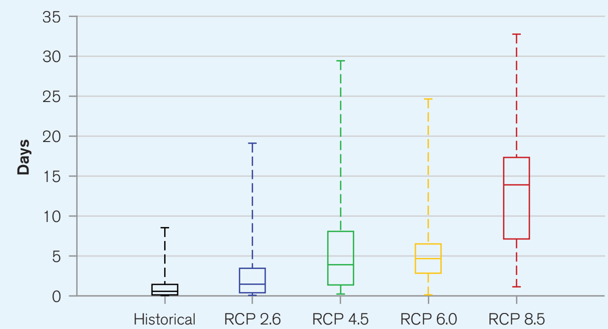
50 Coping capacity measures the ability of a country to cope with disasters in terms of formal, organized activities and the effort of the country's government as well as the existing infrastructure which contribute to the reduction of disaster risk.

that follows analyses climate change influences on the exposure component of risk in Bhutan. As seen in **Figure 1**, the ND-GAIN Index presents an overall picture of a country's vulnerability and capacity to improve its resilience. In contrast, the Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response and a country's overall risk management. In considering Bhutan's natural hazard risks, it is important to recognize the limited availability of records of disasters in Bhutan. Therefore, most of the local disasters especially floods and landslides that affect only certain locality may not be recorded in the global disaster information systems. The Department of Disaster Management (DDM) is developing a Disaster Data Management Information System (DMIS) to address this gap.

Heatwaves

The current median probability of a heat wave in Bhutan (defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 2%. By the 2090s, this is projected to increase dramatically, with the probability rising to approximately 20% under RCP4.5 and RCP6.0, and as high as 36% under RCP8.5. Another way to view extreme heat is the frequency of days above 35°C are projected to rise significantly under higher emissions pathways. As shown in **Figure 9**, the average annual frequency of dangerous days is expected to increase under all emissions pathways by the 2090s, with a particularly large potential increase under the highest emissions pathway, RCP8.5. For Bhutan, the southern regions that are tropical and at a lower altitude are at the greatest risk of prolonged exposure to extreme heat at least one in every five year, while the northern regions are at low risk.[51]

FIGURE 9. Box plots showing historical (1986–2005) and projected (2080–2099) average annual frequency of very hot days (Tmax >35°C).[43]

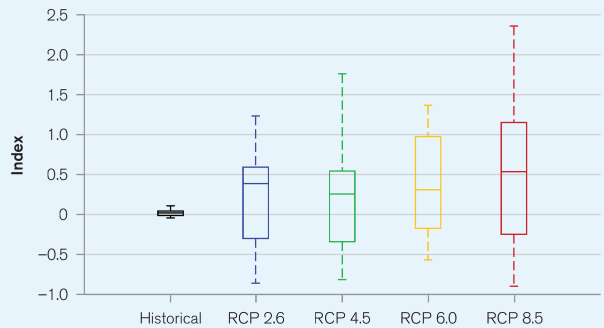


[51] World Bank (2020). Global Facility for Disaster Risk Recovery. Think Hazard Country Profile. http://thinkhazard.org/en/report/31-bhutan/EH

Drought

Two primary types of drought may affect Bhutan: meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). Agricultural drought may also occur when water availability constraints interact with crop choices and land management practices. Bhutan is projected to experience an overall increase in rainfall. As defined by the standardized precipitation evaporation index (SPEI), –2 indicates severe drought, however Bhutan shows a near 0.5 index, indicating an increase in precipitation through the end of the century. This is projected to increase to 4%–10% by the 2090s depending on RCP emissions pathway (see **Figure 10**).

FIGURE 10. Boxplots showing the annual probability of experiencing a 'severe drought' in Bhutan (–2 SPEI Index) in 2080–2099 under four emissions pathways.[52]



Flood

The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a baseline level of river flood exposure.[53] As of 2010, assuming protection for up to a 1 in 10-year event, the population annually affected by flooding in Bhutan is estimated at 7,700 people and expected annual impact on GDP is estimated at $33 million. Development and climate change are both likely to increase these figures. The climate change component can be isolated and by 2030 is expected to increase the annually affected population by 3,000 people, and GDP impact by $41 million under the RCP8.5 emissions pathway (AQUEDUCT Scenario B). This could take the annual impact of river flooding to over 4% of GDP.

The majority of the Bhutan's agricultural land and infrastructure is located along drainage basins that are highly exposed to flooding, particularly riverine flooding caused by heavy monsoon rains and glacial melt.[54] Flood risk is concentrated in the central and north western regions of the country as well as the Samtse province. Glacial retreat contributes towards the formation of supra-glacial and pro-glacial lakes, which can burst, creating a Glacial Lake Outburst Flood (GLOF) and generate flash flooding with potential for significant damage in Bhutan's river valleys,[55] where the highest concentration of the country's economic activity is based. Bhutan, alongside Nepal, has the largest socio- economic consequences of glacier flood impacts.[56] The risk of this natural hazard is pronounced in the northern expanse of the country which possess 677 glaciers, the majority of which are mountain glaciers that

[52] WBG Climate Change Knowledge Portal (CCKP 2021). Bhutan. Water Sector Interactive Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=BTN&period=2080-2099
[53] WRI (2018) AQUEDUCT Global Flood Analyzer. URL: https://floods.wri.org/# [Accessed: 22/11/2018]
[54] World Bank Group (2020). Global Facility for Disaster Risk Recovery. Bhutan. URL: https://www.gfdrr.org/bhutan
[55] United Nations Development Program (2018). Climate Change Adaptation Country Profile – Bhutan. [Accessed June 2018]. URL: http://www.adaptation-undp.org/explore/bhutan
[56] Carrivick, J.L. and Tweed, F.S., 2016. A global assessment of the societal impacts of glacier outburst floods. *Global and Planetary Change, 144*, pp. 1–16. URL: http://eprints.whiterose.ac.uk/103761/

feed into 2,674 glacial lakes. Of these glacial lakes, 25 pose a dangerous risk of bursting.[57] Within the four river basins of Bhutan, there are 567 identified glacial lakes, covering an area 55.04±0.055 km^2. Glacial lakes in Bhutan account for 19.03% of the total numbers of water bodies and 0.14% of total land area.[58]

Paltan et al. (2018) demonstrate that even under lower emissions pathways coherent with the Paris Climate Agreement, almost all Asian countries face an increase in the frequency of extreme river flows. What would historically have been a 1 in 100-year flow, could become a 1 in 50-year or 1 in 25-year event in most of South, Southeast, and East Asia.[59] Increases in the intensity of extreme precipitation events are also increasing the risk of surface (pluvial) flooding, associated impacts include infrastructural damage in urban environments, and landslide risk in rural areas. There is good agreement among models about this trend. Wilner et al. (2018) suggest this rise in flows could increase the population affected by an extreme flood by 4%–11% (**Table 5**).

TABLE 5. Estimated number of people in Bhutan affected by an extreme river flood (extreme flood is defined as being in the 90th percentile in terms of numbers of people affected) in the historic period 1971–2004 and the future period 2035–2044. Figures represent an average of all four RCPs and assume present day population distributions.[60]

Estimate	Population Exposed to Extreme Flood (1971–2004)	Population Exposed to Extreme Flood (2035–2044)	Increase in Affected Population
16.7 Percentile	11,661	12,897	1,236
Median	12,740	13,220	480
83.3 Percentile	12,804	13,253	449

CLIMATE CHANGE IMPACTS

Natural Resources

Water

Water is one of Bhutan's most abundant resources and is critical in supporting agriculture, hydroelectric energy production, and tourism. Water is also one of the country's most vulnerable sectors. Bhutan's water resources consist of glaciers, glacial and high-altitude wetlands, rivers and river basins, and ground water reservoirs.[61] The fragility of the Himalayan landscape makes GLOFs a significant threat. Groundwater and reservoirs are limited

[57] World Bank Group (2020). Global Facility for Disaster Risk Recovery. Bhutan. URL: https://www.gfdrr.org/bhutan

[58] National Center for Hydrology and Meteorology (2021). Bhutan Glacial Lake Inventory. Cryosphere Services Division. URL: https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Bhutan%20Glacial%20Lake%20Inventory%202021.pdf

[59] Paltan, H., Allen, M., Haustein, K., Fuldauer, L., & Dadson, S. (2018). Global implications of 1.5°C and 2°C warmer worlds on extreme river flows Global implications of 1.5°C and 2°C warmer worlds on extreme river flows. Environmental Research Letters, 13. URL: https://www.researchgate.net/publication/326964132_Global_implications_of_15_C_and_2_C_warmer_worlds_on_extreme_river_flows

[60] Willner, S., Levermann, A., Zhao, F., Frieler, K. (2018). Adaptation required to preserve future high-end river flood risk at present levels. Science Advances: 4:1. URL: https://advances.sciencemag.org/content/4/1/eaao1914

[61] Asian Development Bank (2016). Water: Securing Bhutan's Future. URL: https://www.adb.org/publications/water-securing-bhutans-future [accessed 10/01/2019]

to flat valleys, particularly in regions close to the Indian border. Bhutan has four major river systems which are the country's primary water resource: The Amo Chhu (Toorsa), the Wang Chhu (Raidak), the Punatsang Chhu (Sunkosh) and the Drangme Chhu (Manas) The Punatsang is one of the largest rivers in the country. All rivers depend principally on glacier melt, snow, and seasonal rainfall. While the country has an annual water availability of 94,500 m^3 per capita, most rivers are located in remote areas, limiting the main sources of irrigation and drinking water to small springs and tributaries. Water is used by households, irrigated farming, agro-processing, industry, and hydroelectric power generation.[62] It is also an important element in cultural and religious practices. Approximately 98% of the population has basic or safely managed drinking water service levels. Rapid population growth and high seasonality of precipitation continue to place increasing pressure on water resources at local and community levels.[63] The primary method of managing wastewater is through septic tanks.[64] In 2015, 63% (57% rural, 72% urban) of the population had access to safely managed sanitation while 29% (38.6% rural, 13.1% urban) had unimproved levels.[60]

Projections for future river flows due to climate change impact on glacial and river systems show mixed results, with some showing increases,[65] others, decreases.[66] Projected changes in precipitation are highly variable. However, models suggest there could be an overall increase in precipitation at the national level. Precipitation is expected to rise especially in the southern border with India during the monsoon season, when water resources are particularly abundant.[59] Projected increases in the number of days with very heavy precipitation could further increase the risk of flooding and impact runoff, erosion, and rates of river discharge. The CCKP model ensemble projects a 10%–15% increase in the volume of water falling during a 5-day extreme rainfall episode by the 2050s.[67]

The seasonal precipitation regime is also expected to change before the end of the century, with the projected number of days of consecutive dry spell set to increase by seven days in January and December.[68] Rising temperatures can also impact water resources by accelerating the rate of snowmelt. As temperatures increase, snow will likely become rain and snowmelt will likely begin earlier, thus peak river discharge may also occur earlier.[69] These conditions could increase the potential for riverine flooding and GLOFs, which can impact populations and infrastructure near rivers.

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[62] National Environment Commission (2016). National Integrated Water Resources Management Plan, Bhutan. URL: http://www.nec.gov.bt/nec1/wp-content/uploads/2016/08/IWRMP_Final.pdf

[63] WHO, UNICEF (2019). Unicef JMP Data dashboard. Bhutan. URL: https://washdata.org/data

[64] Global Analysis and Assessment of Sanitation and Drinking Water (2014). Bhutan. Sanitation, drinking-water and hygiene status overview. URL: http://www.who.int/water_sanitation_health/glaas/2014/bhutan.pdf

[65] Xu, R., Hu, H., Tian, F., Li, C. and Khan, M.Y.A. (2019). Projected climate change impacts on future streamflow of the Yarlung Tsangpo-Brahmaputra River. *Global and Planetary Change, 175*, pp. 144–159. URL: https://www.researchgate.net/publication/331200650_Projected_climate_change_impacts_on_future_streamflow_of_the_Yarlung_Tsangpo-Brahmaputra_River

[66] Li, H., Xu, C.Y., Beldring, S., Tallaksen, L.M. and Jain, S.K. (2016). Water resources under climate change in Himalayan basins. *Water Resources management, 30*(2), pp. 843–859. URL: http://folk.uio.no/chongyux/papers_SCI/WARM_14.pdf

[67] WBG Climate Change Knowledge Portal (CCKP 2021). Bhutan. Water Sector. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-sector-water

[68] Royal Government of Bhutan (2021). Third National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20of%20Bhutan%202020.pdf

[69] WBG Climate Change Knowledge Portal (CCKP 2021). Bhutan. Agriculture Sector. URL: https://climateknowledgeportal.worldbank.org/country/bhutan/climate-sector-agriculture

Forests and Biodiversity

Forests cover 72.3% of Bhutan, and the government has committed to maintaining at least 60% forest cover and supporting biodiversity alongside development. In 2016, there were ten protected areas representing 51% of the country's land surface.[70] Bhutan's forests have already experienced climate change impacts through changes in phenology, forest structure, and incidence of pests, for example in the case of bark beetle outbreaks in spruce forests.[67] Increased investment in hydropower, urbanization, industrialization, as well as pressure from tourism are expected to add pressure on land-use and protected areas. To counter this, forest policy in recent years has focused on sustainable forest management, reforestation, and the reduction of fuel wood consumption. The government has also designated small portions as community forests and non-wood forest products provide an important source of income for rural households.[71]

Changes in temperatures and precipitation patterns can impact forest composition and forest health in several ways. Rising temperatures and snowmelt can allow for northward and upslope (higher altitude) migration of forests[67] and associated species.[72] Climate projections may mean that subtropical species populate southern margins and some alpine species may decrease.[67] Increased temperature leading to an increase in invasive species can also contribute to biodiversity loss across Bhutan's forests.[73] Forest fires in Bhutan are more frequent during winters, when long, dry spells cause high day temperature and fire risks can be further exacerbated by strong winds and availability of dry brush and fuel wood. Increased drought conditions in combination to with increased lightening risks can increase risk of forest fires.[74]

Changes in precipitation patterns further stress forests, making them more vulnerable to diseases and pests. Bhutan's Ministry of Agriculture and Forests has recognized the importance of forests for soil health and erosion control and natural disaster mitigation as they prevent landslides and reduce the impact of flash floods. Changing forest structures could also impact rates of sedimentation, which could damage hydroelectric infrastructure and equipment or increase operating costs.[75]

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70 Ministry of Agriculture and Forests (2016). Bhutan's State of Parks Report. URL: http://www.moaf.gov.bt/summary-of-bhutans-state-of-parks-report-2016-2/

71 World Bank (2019). Bhutan Forest Note; Pathways for Sustainable Forest Management and Socio-equitable Economic Development. URL: http://documents1.worldbank.org/curated/en/118821562700584327/pdf/Bhutan-Forest-Note-Pathways-for-Sustainable-Forest-Management-and-Socio-equitable-Economic-Development.pdf

72 Norbu, N., Wikelski, M.C. and Wilcove, D.S. (2017). Partial altitudinal migration of the Near Threatened satyr tragopan Tragopan satyra in the Bhutan Himalayas: implications for conservation in mountainous environments. *Oryx, 51*(1), pp. 166–173. URL: https://www.cambridge.org/core/journals/oryx/article/partial-altitudinal-migration-of-the-near-threatened-satyr-tragopan-tragopan-satyra-in-the-bhutan-himalayas-implications-for-conservation-in-mountainous-environments/F5CB9EF01477F75EE58C53D7403F9109

73 Hoy, A., Katel, O., Thapa, P., Dendup, N. and Matschullat, J. (2016). Climatic changes and their impact on socio-economic sectors in the Bhutan Himalayas: An implementation strategy. *Regional environmental change, 16*(5), pp. 1401–1415. URL: https://waseda.pure.elsevier.com/en/publications/climatic-changes-and-their-impact-on-socio-economic-sectors-in-th

74 National Environment Commission (2006). Bhutan National Adaptation Programme of Action. Royal Government of Bhutan. URL: https://www.adaptation-undp.org/sites/default/files/downloads/bhutan_napa.pdf

75 Royal Government of Bhutan (2021). Third National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/TNC%20of%20Bhutan%202020.pdf

Economic Sectors

Agriculture

Agriculture is a high priority for the Government of Bhutan given its economic significance, the number of livelihoods that depend on agriculture, and the sector's vulnerability to climatic change.[76] Approximately two-thirds of the heads of poor households work in the sector.[77] Bhutan has about 5,256 km^2 of agricultural land which represent 13.8% of the total area.[78] Approximately 2.9% of the country is cultivated agricultural land, 3.2% are bare areas, 4.1% are meadows, 7.4% snow cover, 10.4% shrubs, and the rest are forests. Most agricultural land is in the provinces of Kamshing and Chhushing.[79] While rice is grown primarily in the western region, maize is grown throughout the country and is most popular in the eastern region (45% of rice production comes from six eastern regions) and represents 49% of the national food basket. Severe and very severe land degradation and low suitability currently constrain agriculture in the South-Eastern regions.[80] Land availability is also limited in mountainous terrain with steep slopes. The major crops produced are paddy, maize, buckwheat, barley, and millet, potatoes, vegetables and fruits.[81] Rice is the primary staple food except for in high elevation areas where potato is more common. Between 2010 and 2015, cereal production area decreased while yield and total production increased, alongside an increase in fertilizer use, primarily nitrogen.[82]

Climate change is also likely to influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation and temperatures. Indirect effects include through impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to aridification. On an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018) estimate 5% and 6% declines in global wheat and maize yields respectively even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[83] Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway. These changes are expected to disrupt the global food trade market with potentially negative consequences for lower income countries, such as Bhutan, which are heavily dependent on food imports.

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[76] Johnson, F.A. and Hutton, C.W. (2014). Dependence on agriculture and ecosystem services for livelihood in Northeast India and Bhutan: vulnerability to climate change in the Tropical River Basins of the Upper Brahmaputra. *Climatic change, 127*(1), pp. 107–121. URL: https://ideas.repec.org/a/spr/climat/v127y2014i1p107-121.html

[77] Parker, L. et al., (2017). Climate change impacts in Bhutan: challenges and opportunities for the agricultural sector. CCAFS Working Paper no. 191. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). URL: https://hdl.handle.net/10568/80918

[78] World Bank Group (2019). Data Bank. Country indicators. URL: https://data.worldbank.org/country/bhutan

[79] Ministry of Agriculture and Forests (2015). The Status of National Soil Resources of Bhutan, National Soil Services Centre, Department of Agriculture. Presented-13th to 15th May 2015, Bangkok, Thailand. URL: http://www.fao.org/fileadmin/user_upload/GSP/docs/asia_2015/Bhutan.pdf

[80] Food and Agriculture Organization (2019). Major Environmental Constrains Bhutan. URL: http://www.fao.org/countryprofiles/maps/map/en/?iso3=BTN&mapID=604

[81] CountrySTAT (2016). Food and Agriculture Data Network. Bhutan Country Profile. URL: http://countrystat.org/home.aspx?c=BTN

[82] FaoSTAT (2018). Bhutan Country Profile. [Accessed June 2018]. URL: http://www.fao.org/faostat/en/#country/18

[83] Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48

Agriculture in Bhutan is highly vulnerable to climate conditions due to its dependence on monsoon rains and short growing periods as well as exposure to large climatic swings found in mountainous regions.[84] The structure of agricultural production and concentration of agricultural activity in vulnerable areas makes the sector particularly susceptible to climatic changes. For example, with 31% of agriculture taking place on slopes, it is particularly vulnerable to landslides and soil erosion.[85] These may be exacerbated by the projected increases in extreme precipitation intensity.

It is also important to note that for Bhutan's subsistence farmers, agro-biodiversity is an important aspect of food security in the face of climate change.[86]

Climate projections suggest that the annual growing season length could increase by an estimated 25.9 days by the end of the century, primarily in northern regions where temperature increases are projected to be higher.[66] Climate projections also estimate that the change in daily maximum temperature could increase between 1.3°C and 3.1°C by the 2050s.[66] Increasing temperatures and an expanding number of hot days is also likely to result in adverse impacts to livestock, with high temperatures potentially impacting milk production.

In Bhutan, the number of summer days with temperatures above 25°C are expected to increase in the southern regions as are the expected days with precipitation above 20 mm; the maximum monthly rainfall with a ten-year return period is also expected to increase.[75] The majority of farmers are dependent on monsoon seasonal irrigation, therefore changes in precipitation patterns will have strong impacts on production as well as the ability for mostly rural farmers to engage in agricultural markets.[87] Limited research has addressed the net impact of these changes on production, but some studies have suggested a significantly negative outlook, even when the beneficial effects of increased CO_2 levels are considered.[88]

Over the longer-term future, sustained temperature increases, and particularly daily, monthly and annual maximum temperatures are likely to drive a northward range shift in the optimal growing ranges of current crops. Increased temperatures for some areas may result in expanded growing seasons and a net gain in agriculturally productive land. However, the increase in other stressors may offset these gains. Specifically, the risk that an increase in the frequency of very hot days (>35°C) (**Figure 11**) and potential water resource limitations may damage yields, as has been suggested at the global level.[89] There is however, significant differences between emissions pathways, with higher emissions scenarios resulting in notably larger increases in daily maximum temperatures (**Figure 12**).

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[84] Chhogyel, Ngawang & Kumar, Lalit. (2018). Climate change and potential impacts on agriculture in Bhutan: A discussion of pertinent issues. Agriculture & Food Security. 7.DOI: 10.1186/s40066-018-0229-6. URL: https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-018-0229-6

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[88] Mendelsohn, R. (2014). The Impact of Climate Change on Agriculture in Asia. Journal of Integrative Agriculture, 13(4), 660–665. URL: https://www.sciencedirect.com/science/article/pii/S2095311913607017

[89] Elliott, J., Deryng, D., Müller, C., Frieler, K., Konzmann, M., Gerten, D., [. . .] Wisser, D. (2014). Constraints and potentials of future irrigation water availability on agricultural production under climate change. Proceedings of the National Academy of Sciences: 111: 3239–3244. URL: https://www.pnas.org/content/111/9/3239

FIGURE 11. Increase in the annual average number of hot days (>35°C) in Bhutan under two emissions pathways. RCP2.6 (blue) and RCP8.5 (red)[43]

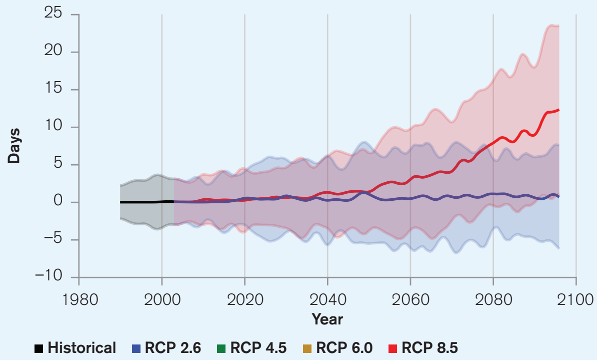
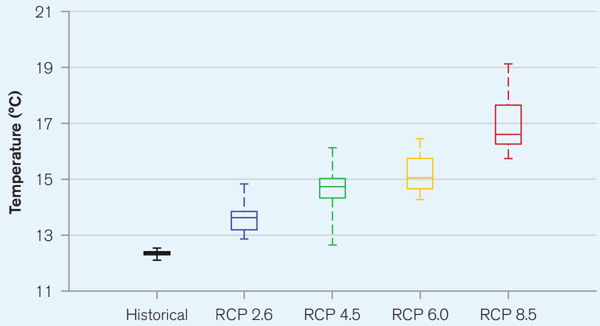


FIGURE 12. Average daily maximum temperature in Bhutan under four emissions pathways over the period 2080–2099[43]



Energy

Bhutan has 1.3 million tons of coal reserves in the south-west, with extraction utilized solely for domestic consumption.[90] Bhutan possesses a vast hydropower potential of 30 GW, of which 23.76 GW is technically and economically feasible.[91] In 2016, Bhutan had an installed capacity of 1.6 GW installed capacity from hydropower, providing 99.5% of electricity generated.[92] Domestic production exceeds the 300 MWh of domestic peak demand; hence, most electricity is exported, with approximately 80% of energy generated exported to India. Despite abundant electricity production, fuelwood remains the primary energy source at the residential level (56.8%) followed by electricity (15.7%), petroleum (19%), and coal (8%). The country uses imported fuels for transportation and thermal fuel for heating and mechanical production. Approximately 100% of urban and 98% of rural households had access to electricity in Bhutan in 2017.[93]

The abundance of hydroelectric power generation has not only been an asset to the country's development but also a pathway for its low-carbon growth. Bhutan is currently exploring potential for developing new export markets for hydroelectricity as a means to further diversify its economy. However, Bhutan's reliance on hydropower for development and growth makes the country highly vulnerable to climate change impacts that can disrupt power generation and existing assets. Changes in river flow would have direct impacts on energy security given changing rates of sedimentation, changing precipitation patterns, reducing water reserves in the form of snow and glaciers, and

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90 Alam, Firoz, et al. (2017). Sourcing green power in Bhutan: A review. *Energy Procedia* 110 (2017): 586–591. URL: https://ac.els-cdn.com/S1876610217302199/1-s2.0-S1876610217302199-main.pdf?_tid=777170d4-0f4c-402f-b82e-079869837fb1&acdnat=1528979077_f9fb4aea1a7832923e6386a935a78ed4

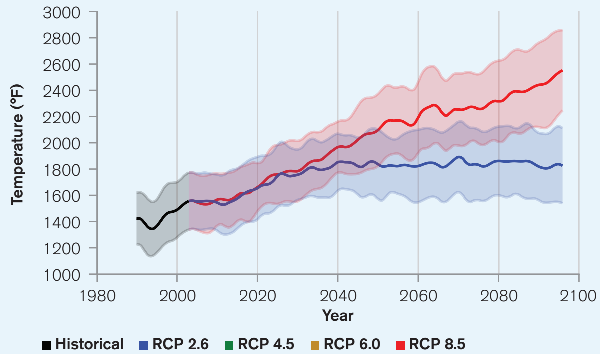
91 Bhutan (2016). Economic Development Policy. URL: http://www.moea.gov.bt/wp-content/uploads/2017/07/Economic-Development-Policy-2016.pdf

92 Alam, Firoz, et al. (2017). Sourcing green power in Bhutan: A review. *Energy Procedia* 110 (2017): 586–591. URL: https://ac.els-cdn.com/S1876610217302199/1-s2.0-S1876610217302199-main.pdf?_tid=777170d4-0f4c-402f-b82e-079869837fb1&acdnat=1528979077_f9fb4aea1a7832923e6386a935a78ed4

93 World Bank Group (2017). Bhutan's Living Standard Survey Report. URL: http://www.nsb.gov.bt/publication/files/pub2yo10667rb.pdf

exposing infrastructure to hazards such as flooding, GLOFs, and impacts of erratic rainfall patterns. More research is required to better understand the implications of these changes in combination with local development, but early evidence suggests potential declines in hydropower potential in the second half of the 21st century[94] (although some studies do point to an increase in hydropower potential).[95]

FIGURE 13. Historic and projected annual cooling degree days in Bhutan (cumulative degrees above 65°F) under RCP2.6 (blue) and RCP8.5 (red). The values shown represent the median of 32 GCM model ensemble with the shaded areas showing the 10–90th percentiles.[43]



Changes in temperature are expected to translate into an increase in cooling demands from the population. These rising temperatures are projected to increase cooling degree days by 400°C in the 2050s and 1,000°C by the 2090s, primarily in the summer months.[96] This increase in demand places strain on energy generation systems which is compounded by the heat stress on the energy generation system itself, commonly due to its own cooling requirements, which can reduce its efficiency.[97] Increased temperatures are also likely to reduce need for heating in winter months,[98] specifically, a reduction in energy needs is expected for northern regions that currently experience colder climates while increases in energy needs for cooling are concentrated in southern regions that currently experience tropical weather.[66] **Figure 13** shows the cooling degree days for Bhutan through the end of the century.

Communities

Poverty and Inequality

Bhutan's rural areas are most at risk to altered seasonal patterns and climate change. The prevalence of poverty in these areas, coupled with their reliance on agriculture strongly tied to monsoonal systems, means they are least equipped to mitigate and adapt to the consequences of climate change.[53] For example, a study in the Punakha District found 91% of the households surveyed were affected by monsoon pattern changes, impacting water availability for

[94] Beldring, S., & VoksØ, A. (2012). Climate Change Impact on Flow Regimes of Rivers in Bhutan and Possible Consequences for Hydropower Development. Hydro Nepal: Journal of Water, Energy and Environment, 11, 67–68. URL: https://www.nepjol.info/index.php/HN/article/view/7167

[95] Turner, S.W., Hejazi, M., Kim, S.H., Clarke, L. and Edmonds, J., 2017. Climate impacts on hydropower and consequences for global electricity supply investment needs. *Energy, 141*, pp. 2081–2090. URL: https://www.pnnl.gov/sites/default/files/media/file/Climate%20impacts%20on%20hydropower%20and%20consequences%20for%20global%20electricity%20supply%20investment%20needs.pdf

[96] A degree day is the difference between the daily mean temperature and 65°F. If the daily mean temperature is above 65°F, the result is called a cooling degree day.

[97] ADB (2017). Climate Change Profile of Pakistan. URL: https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf

[98] Santamouris, M., Cartalis, C., Synnefa, A., & Kolokotsa, D. (2015). On the impact of urban heat island and global warming on the power demand and electricity consumption of buildings—A review. Energy and Buildings, 98, 119–124. URL: https://pdfs.semanticscholar.org/17f8/6e9c161542a7a5acd0ad500f5da9f45a2871.pdf

irrigated rice farming.[99] Despite recent successes in poverty reduction, agriculture's vulnerability to shocks, often climate-related, ensure there is a high risk of people falling back into poverty.[100] Bhutan's government have sought to address the links between climate change and poverty by strengthening capacity for training in the subject of Environment Climate and Poverty mainstreaming.

Many of the climate changes projected for Bhutan are likely to disproportionately affect the poorest groups in society. For instance, heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[101] Poorer businesses in Bhutan's lowland areas will be least able to afford air conditioning, an increasing need given the projected increase in cooling degree days (**Figure 13**). Poorer farmers and communities are also least able to afford local water storage, irrigation infrastructure, and technologies for adaptation.

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.[102] In Bhutan, the nexus of gender and climate and disaster risks has not been analyzed to-date.

Human Health

Nutrition

Despite the country's relatively high levels of food sufficiency, food access and nutrition continue to represent challenges in Bhutan. In 2015, 21.2% of children between 0 to 59 months old were stunted (twice as many in rural compared to urban areas), and wasting rates of 4.3% for children under 5, as well as having a high prevalence of anemia.[103] The impact of climate change on global food security is projected to impact the number of people in Bhutan at risk of hunger.[104]

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[99] Warner, K. and Van der Geest, K., 2013. Loss and damage from climate change: local-level evidence from nine vulnerable countries. *International Journal of Global Warming, 5*(4), pp. 367–386. URL: https://www.researchgate.net/publication/258120139_Loss_and_damage_from_climate_change_Local-level_evidence_from_nine_vulnerable_countries

[100] Bhutan (2014). Bhutan - Poverty Assessment (English). National Statistics Bureau. URL: http://documents.worldbank.org/curated/en/914381468013483608/Bhutan-Poverty-assessment-2014

[101] Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., Hyatt, O. (2016) Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. Annual Review of Public Health: 37: 97–112. URL: https://www.ncbi.nlm.nih.gov/pubmed/26989826

[102] World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf

[103] World Food Programme (2017). Bhutan Transitional Interim Country Strategic Plan Year 2018. URL:http://www1.wfp.org/operations/bt01-bhutan-transitional-icsp-january-december-2018

[104] Gbegbelegbe, Sika & Chung, Uran & Shiferaw, Bekele & Msangi, Siwa & Tesfaye, Kindie. (2014). Quantifying the impact of weather extremes on global food security: A spatial bio-economic approach. Weather and Climate Extremes. 4. 10.1016/j.wace.2014.05.005. URL: https://www.sciencedirect.com/science/article/pii/S2212094714000474

The World Food Programme estimates that without adaptation the risk of hunger and child malnutrition on a global scale could increase by 20% by 2050.[105] Springmann et al. (2016) assessed the potential for excess, climate-related deaths associated with malnutrition.[106] Two key risk factors are expected to be the primary drivers: a lack of fruit and vegetables in diets, and health complications caused by increasing prevalence of people underweight. The authors' projections suggest there could be approximately 46 climate-related deaths per million population linked to lack of food availability in Bhutan by the year 2050 under RCP8.5.

Heat-Related Mortality

Research has established a threshold of 35°C (wet bulb ambient air temperature) for the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[107] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. Climate change could push global temperatures closer to this temperature 'danger zone' both through slow-onset warming and intensified heat waves.

Honda et al. (2014)[108] used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0) to estimate that without adaptation, annual heat-related deaths in the South Asian region, could increase by 149% by 2030 and 276% by 2050. The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[109] The World Health Organization describe that under a high emissions pathway, heat-related deaths in people of 65+ years could increase to 49 deaths in every 100,000 by the 2080s, from a model baseline of 0 deaths between 1961 and 1990.[110] Increase temperatures can also exacerbate poor air quality and could lead to chronic diseases and hospitalizations and premature mortality. Major cities in Bhutan, such as Thimphu and Paro are experiencing increasing urbanization and deterioration in air quality, which are likely to present additional health challenges for urban communities.[111]

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[105] WFP (2015). Two minutes on climate change and hunger: A zero hunger world needs climate resilience. URL: https://docs.wfp.org/api/documents/WFP-0000009143/download/

[106] Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., . . . Scarborough, P. (2016). Global and regional health effects of future food production under climate change: a modelling study. The Lancet: 387: 1937–1946. URL: https://www.ncbi.nlm.nih.gov/pubmed/26947322

[107] Im, E. S., Pal, J. S., & Eltahir, E. A. B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances, 3(8), 1–8. URL: https://advances.sciencemag.org/content/3/8/e1603322.full

[108] Honda, Y., Kondo, M., McGregor, G., Kim, H., Guo, Y-L, Hijioka, Y., Yoshikawa, M., Oka, K., Takano, S., Hales, S., Sari Kovats, R. (2014). Heat-related mortality risk model for climate change impact projection. Environmental Health and Preventive Medicine 19: 56–63. URL: https://www.ncbi.nlm.nih.gov/pubmed/23928946

[109] Mitchell, D., Heaviside, C., Schaller, N., Allen, M., Ebi, K. L., Fischer, E. M., . . . Vardoulakis, S. (2018). Extreme heat-related mortality avoided under Paris Agreement goals. Nature Climate Change, 8(7), 551–553. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6181199/

[110] World Health Organisation (2015) Climate and Health Country Profile – 2015, Bhutan. URL: https://apps.who.int/iris/bitstream/handle/10665/246124/WHO-FWC-PHE-EPE-15.17-eng.pdf?sequence=1&isAllowed=y [accessed 22/08/2019)

[111] Dolkar, S. T. (2018). Air pollution becoming a serious concern in Bhutan. BBS. January 22, 2018. URL: http://www.bbs.bt/news/?p=88662

Disease

The World Health Organization describes Bhutan's vulnerability to an increase in the geographic range and incidence of vector-borne and water-borne diseases as a consequence of climate change.[105] The threat from the Zika virus is rising in Bhutan, with climate change cited as a contributing factor.[112] Tshering and Sithey (2008) suggest a relationship between increased incidences of malaria and increased temperature, however noting caution should be exercised given non-climatic variables not accounted for can also contribute to an increase.[113] In global research, relationships have been identified between diarrheal disease and both drought and flooding. In Bhutan, there is a strong association between diarrhea and seasonal temperature and precipitation.[114] These highlight the need for further research into Bhutan in order to constrain the potential for increased disease incidence as a result of climate change-enhanced natural hazards.[115]

POLICIES AND PROGRAMS

National Adaptation Policies and Strategies

TABLE 6. Key national adaptation policies, plans and agreements

Policy/Strategy/Plan	Status	Document Access
Nationally Determined Contribution (NDC) to Paris Climate Agreement	Submitted	September, 2017
Technology Needs Assessment (TNA) and Technology Action Plans (TAP) for Climate Change Adaptation	Completed	March, 2013
Disaster Management Act of Bhutan, 2013	Enacted	2013 (Dzongkha)
National Communications to the UNFCCC	Three submitted	Latest: February, 2021
Bhutan National Adaptation Program of Action (NAPA)	Enacted	May, 2006
Climate Change Policy, 2020	Submitted	January, 2020
Bhutan 2020	Submitted	2020
12th 5-Year Plan	Submitted	2018
Modernizing Weather, Water, and Climate Services: A roadmap for Bhutan	Published	2015
Bhutan State of the Climate 2020	Submitted	2020
Records Of Extreme Weather Events in Bhutan	Submitted	2020

[112] Dhimal, M., Dahal, S., Dhimal, M.L., Mishra, S.R., Karki, K.B., Aryal, K.K., Haque, U., Kabir, M.I., Guin, P., Butt, A.M. and Harapan, H. (2018). Threats of Zika virus transmission for Asia and its Hindu-Kush Himalayan region. *Infectious diseases of poverty*, *7*(1), p.40. URL: https://www.ncbi.nlm.nih.gov/pubmed/29759076

[113] Tshering D, Sithey G. (2008). Climate change and health in Bhutan. Thimpu: Royal Society for Protection of Nature. URL: http://pubs.iied.org/G03037/?a=D+Tshering [accessed 11/01/2019]

[114] Wangdi, K. and Clements, A.C., 2017. Spatial and temporal patterns of diarrhea in Bhutan 2003–2013. *BMC infectious diseases*, *17*(1), p.507. URL: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-017-2611-6

[115] Wu, X., Lu, Y., Zhou, S., Chen, L., & Xu, B. (2016). Impact of climate change on human infectious diseases: Empirical evidence and human adaptation. Environment International, 86, 14–23. URL: https://www.ncbi.nlm.nih.gov/pubmed/26479830

Climate Change Priorities of ADB and the WBG

ADB Country Partnership Strategy

ADB agreed a Country Partnership Strategy (CPS) with Bhutan covering the period 2019–2023. Climate change issues were addressed across all three pillars of the CPS.

Under Pillar 1: Dynamic Economic Reforms for a Resilient and Diversified Economy, ADB support the government to reform policies to promote efficient use of energy and invest more in alternative renewable energy sources, including solar power, biogas, and wind power. ADB will also help the hydropower industry increase its fiscal resources by making use of the carbon market.

Under Pillar 2: Improved Connectivity for Better Access to Information and Markets, ADB will support Bhutan in investing sustainably in climate resilient land and air transport networks to enable people and goods to travel reliably and efficiently. ADB will also help improve regional cooperation and integration by supporting the development of hydropower generation capacity to increase cross-border trade.

Under Pillar 3: Greater Inclusiveness Through More Equitable Socioeconomic Development, ADB will help Bhutan build smart, green, and livable cities. ADB will help municipalities to enhance the livability, safety, and sustainability of main urban areas. ADB will also support the implementation of green and efficient public transportation.

WBG Country Partnership Framework

The World Bank agreed a Country Partnership Framework (CPF) with Bhutan covering the period FY2021–FY2024. The CPF aims to reduce the country's vulnerability to climate change and natural disasters and create new economic opportunities. A shift from conservation and subsistence use to conservation and sustainable management of natural resources will create needed jobs and livelihoods, while maintaining Bhutan's commitment to environmental conservation. Bhutan's natural wealth is also a key contributor to tourism; another important area of job creation, and the private sector can play a role in supporting high-value, low-impact eco-tourism development. The CPF is aligned with the country's development vision articulated in the Constitution, Bhutan Vision 2020, and the 12th 5-year plan. It was also informed by the Bank Group's Systematic Country Diagnostic (SCD) for Bhutan, which is a comprehensive analysis of the country's development challenges.

CLIMATE RISK COUNTRY PROFILE

BHUTAN

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK