



Climate Factsheet

Bhutan (BTN)

Geography and People

- » The Himalayan Kingdom of Bhutan is situated in the eastern Himalayas between latitudes 27° 28' 0" N and longitudes 89° 38' 30" E.¹
- » The total land area of Bhutan is 38,394 Km².⁸
- » Bhutan is entirely landlocked and is bordered by China to the north and India to its south, east, and west.¹

Topographically, the features most dominant in Bhutan are²⁰

The snowcapped peaks

Alpine pastures in the North

Deep valleys formed by fast-flowing rivers

Southern Bhutan is dominated by rugged foothills and alluvial plains with broad river valleys

- » The lowest point is 98 meters above sea level (masl), in southern Bhutan's Drangme Chu/Manas river basin.¹
- » The highest point is 7570 masl – tall Gangkhar Puensum, which has the distinction of being the highest unclimbed mountain in the world.¹
- » Most of the major rivers in Bhutan originate from glaciers and are fed by watersheds. Rivers in Bhutan flow mainly from north to south, with tributaries flowing in an east-west direction.¹

- » The main rivers in Bhutan are the Amochhu, Wangchhu, Punatsangchhu, and the Manas river. The Mangdechhu and Drangmechhu converge to form the Manas river, before it crosses the southern border, flowing into India.¹
- » Glaciers in Bhutan occur from an elevation of 4075 meters.²⁰
- » According to the Bhutan Glacier Inventory in 2018, Bhutan has 700 glaciers, that cover 629.55 km².¹³
- » The Punatsang Chhu basin has the highest number of glaciers at 341, making up 48.71% of Bhutan's total glaciers.¹³
- » The Tarina Glacier has retreated around 0.7 km from 1967 to 1998, while the Raphstrang Glacier retreated around 0.5 km between 1988 to 1993.¹⁸

According to the latest land cover assessment carried out in 2016, 70.77% of the total area is comprised of forests. Broad-leaved forests constitute 65% of the total forest area and Conifer forests make up 35% of the total forest area.

In 2016, forest area has increased marginally⁴

70.46% → 70.77%



- » Shrubs are the next largest category of land cover, taking up 3.39% of the country's total forest area.⁴
- » Built-up and non-built-up areas combine to take up 0.21% of the total area. The cultivated agricultural area takes up 2.76% of Bhutan's total land area.⁴

» Over 51.44% of the country's total land area is protected through a network of five National Parks, four Wildlife Sanctuaries, one Strict Nature Reserve, eight Biological Corridors, and a Royal Botanical Park.⁴

According to 2017 biodiversity statistics ¹	
11,248	Total species are found in Bhutan
5,369	Species Under the Plantae Kingdom
5,114	Species under the Animalia Kingdom
690	Species of Fungus
55	Species under the Chromista Kingdom
18	Species of Eubacteria
2	Species of Protozoa under the Protista Kingdom

» The country is home to some of the rarest populations of flora and fauna on the planet and is a hotspot for biodiversity. This is attributed to the country's high forest cover, pristine environment, relatively low human interference with nature, strong conservation efforts, and a good network of protected areas.¹

» Bhutan hosts 15 vulnerable, 20 endangered, and 13 critically endangered seed plants, that have been listed in the International Union for Conservation of Nature Red List of threatened species.¹

» Bhutan hosts 13 vulnerable, 11 endangered, and two critically endangered species of mammals. Additionally, Bhutan also hosts 22 vulnerable, four endangered, and four critically endangered bird species.¹

 **The total population of Bhutan is**
727,145

Bhutan is one of the least populated countries in Asia with a total population of 727,145 people in 2017, as per the population and housing census carried out in 2017.⁷

» The country has seen a population growth rate of 1.3% per annum and as a result, population density has increased from 17 persons/km² in 2005 to 19 persons/km² in 2017.¹

» Population distribution is not uniform. The capital city has the highest population density at 67 persons /km², while the northern district of Gasa has a population density of 1.3 persons/km².¹

» The nationwide literacy rate was 71.4% in 2017 with the adult (age 15 years and above) literacy rate at 66.6%. Gender disparities for the literacy rates were also present as 78.1% of the male population was literate, compared to 63.9% of the female population. The literacy rate was also significantly higher in urban areas at 84.1% than in rural areas, at 63.3%.⁸

» Life expectancy at birth has improved from 2005 to 2017, from 66.25 years to 70.2. Similar to the literacy rate, there is also a gender discrepancy for life expectancy. In 2017, life expectancy for males was 71.7 years whereas, for females, it was 68.8 years.⁸

Bhutan's economy is primarily driven by three key sectors:²⁰

- _____
- Tourism**
- _____
- Agriculture and**
- _____
- Hydropower exports**
- _____

» Tourism contributed to 9% of the GDP in 2017. The revenue generated from tourism has increased from \$2 million in the late 1980s to over \$79.81 million in 2018.⁸

» Bhutan implements a "high value, low impact" tourism policy to curtail the impact of tourism on its culture and environment.¹

» Although only 2.75% of the total land area in the country is used for agriculture as per the land cover assessment in 2016, the sector accounts for 15.82% of the GDP in 2019 and employed around 50.8% of the population in 2020.¹²

» The main cash crops for farmers in Bhutan are rice, potatoes, chilies, apples, maize, and oranges, all of which are highly sensitive to water and temperature variations.¹

» The country shares a free trade connection and cordial diplomatic relations with India.⁶

» The Gross Domestic Product (GDP) of Bhutan in 2016 was recorded at Ngultrum 164.6 billion, or \$2.4 billion. From 2013 to 2017, GDP per capita increased from \$2,464 to \$3,438.¹

- » The energy sector offers the greatest growth opportunity for the country, as the main driver of the economy. With the availability of fast-flowing rivers and other sources of renewable energy such as sunshine, biomass, and wind, there is tremendous potential for renewable energy development.²¹
- » Bhutan has one of the largest repositories of hydropower in Asia, with a theoretical potential to produce 30,000 MW. The total installed capacity of hydropower in 2018 was 1,606 MW.²⁰
- » The economy has been growing at an average rate of 7% over the past 10 years, mainly due to prolonged investment into hydropower.¹

- » **Gross National Happiness (GNH)** is the key philosophy that guides socio-economic development for the nation.⁷
- » GNH was coined by the Fourth Monarch King Jigme Singye Wangchuck. The development philosophy envisions that any economic development should be holistic and should place emphasis on the happiness and overall wellbeing of the people.⁷
- » Bhutan was categorized as a Least Developed Country (LDC) by the United Nations General Assembly in 1971 but is set to graduate from its LDC status by 2023.⁵

Climate

Bhutan has three distinctive climatic zones⁷

- | | |
|----|---------------------------|
| 1. | Subtropical belt |
| 2. | Temperate belt and |
| 3. | Alpine belt |

- » **Subtropical belt** – situated at altitudes between 200 and 2000 masl.⁴
 - › This region is characterized by high humidity and heavy precipitation, with temperatures ranging between 15°C to 30°C.¹
 - › Annually, the subtropical belt received around 1,500 meters of precipitation, the wettest region out of the three climatic zones.¹
- » **Temperate belt** – Ranging between 2000 to 4000 masl.⁴
 - › The temperate belt consists mainly of river valleys with cool winters and hot summers with moderate precipitation. Summer monsoon (June – September) temperatures range between 15°C to 26°C.⁹
 - › In the winter, temperatures can go from -4°C to -15°C. Precipitation received in the temperate belt is around 1,000 mm annually.⁹
- » **Alpine belt** – Dominated by snowcapped peaks and alpine meadows above 4000 meters experience cool summers and cold winters.⁴
 - › This zone receives around 40 mm of precipitation annually, the lowest out of the three climatic zones.¹

- » The climate in Bhutan is controlled by the following factors:⁹
 - › Topography, that varies from low elevation rolling plains in the south to the high mountains in the north and north-west.⁹
 - › Relative distance from the coast, which controls the extent of the moist monsoon penetration into the country. Eastern regions are much closer to the Bay of Bengal and therefore are influenced by the south-west monsoons.⁹
 - › The rainfall regime in Bhutan is controlled by the south-west monsoon circulation. Seasonal cycles are produced with the rainy summer season from June to September. During this period, most of the country has almost a sub-tropical climate, particularly in southern Bhutan.⁹
 - › Dry winter-time air mass from the northern high latitudes during the winter seasons cause the temperature variations, and the little rain/snowfall received during the dry winters of Bhutan.⁹
 - › Periodic impact by remnants of cycles that sometimes cross through India from the Bay of Bengal results in high rainfall events, particularly in the east of Bhutan.⁹
 - › Southern Bhutan is prone to severe thunderstorms from April to June due to strong summertime heating and the development of convective systems. These systems can also cause damaging hailstorms in northern regions of the country during Autumn and Spring.⁹

» A study in 2019 has been carried out by the National Center for Hydrology and Meteorology to determine if other global data is available to be used as proxies for Bhutan. Data sets from the Climate Research Unit (CRU) at the University of East Anglia, UK were used.⁹

› The study concluded that the data sets from the University of East Anglia showed good agreement with the surface temperature.⁹

› Rainfall at certain locations is different between the dataset and data from the climate stations, due to the coarse resolution of the data set and the inability of the dataset to properly capture terrain.⁹

» From the period of 1975 – 2005, the JJAS (June, July, August, September) and MAM (March, April, May) seasons are warmer than the rest of the seasons. Northern regions are relatively cooler than the rest of the regions. Over this period according to the CRU dataset, the mean temperature of the following seasons was 4.2°C for DJF (December, January, February), 11.1°C for MAM, 16.3°C for JJAS, 10.2°C for ON (October, November).¹

» Analysis of historical climate using the CRU dataset showed an increasing trend in surface temperature.¹

Bhutan is wettest during the Summer monsoon (JJAS) and driest during the Winter season (DJF).

Bhutan receives 70% of its precipitation during the monsoon seasons.



20% of the precipitation falls during pre-monsoon precipitation.¹⁶



» This can be seen in the CRU dataset, where mean rainfall between 1975 - 2005 was 10.2mm for DJF, 119.5mm for MAM, 367.3 mm for JJAS, 50.1 mm for ON (October, November).¹⁵

» Additionally, analysis of the historical CRU dataset revealed a decreasing trend in rainfall at mean annual scales.¹

Future Climate Change Projections

Under the RCP 4.5 (intermediate emissions scenario as per IPCC's fifth assessment report) scenario, the climate projection for surface temperature indicates an increase of about 0.8 °C – 1.6 °C during 2021-2050 and about 1.6 °C – 2.8 °C towards the end of the century (2070-2099).¹

› Overall, the climate projection of surface temperature under the RCP4.5 scenario indicated an increase in about of 0.8 °C – 2.8 °C during 2021-2100.¹⁵

› Larger warming is indicated during MAM and DJF months.¹

› The country as a whole is expected to experience an increase in temperature with a larger increase projected in the high lands.¹

› Areas in the south are likely to reach higher temperatures.¹



The average number of ice days, days when the maximum temperature is 0°C, are projected to decrease by 8.1 to 9.7 days in the country but may decrease by as many as 57 days in northern areas.¹⁶



The number of projected Summer days (temperatures above 25°C) will increase by 40-86 days and tropical nights (temperatures above 20°C) will increase by 42-73 days by the end of the century.¹⁶

› Under the RCP 8.5 (high emissions scenario as per IPCC's fifth assessment report) scenario, the climate projection for surface temperature indicated an increase of about 0.8°C – 2.0°C during 2021-2050 and, an increase of about 3.2°C towards the end of the century (2070-2099).¹⁶

The mean annual rainfall over Bhutan is likely to increase in the future.⁹

- › Under the RCP4.5 scenarios, the annual rainfall over Bhutan indicates an increase of about 10%-30% in Summer (JJAS) rainfall between 5% -15 %.⁹
- › While the increase in rainfall is likely in DJF in Bhutan, some parts of the northern and north-west are likely to experience a decrease in rainfall.¹⁶
- › During 2021-2050, Bhutan is likely to experience increasing trends in rainfall with a marginal decrease towards the end of the century (2070-2099).¹⁶
- › Under the RCP 8.5 scenario, the mean annual rainfall indicates an increase of about 10%- 20% during 2021-2050 and with more than 30% increase all over Bhutan towards the end of the century.⁹
- › While the projections suggest increasing rainfall during the JJAS, the Winter (DJF) seasons are likely to receive a decrease in rainfall in some parts of the country, in particular in the north-west region of Bhutan.⁹



Projections estimate that days with more than **50 mm** rainfall will increase by **3.34 days** by the end of the century.⁹

- › A marginal increase in rainfall trend is indicated under the RCP8.5 scenarios.⁸

For the Higher Himalayas (Alpine Belt),¹



The increase in temperature is projected to be more than 3 °C under RCP 8.5. Temperature for RCP 4.5 is projected to increase by 2 °C.¹

- › The warming is projected to be higher during the Winter months.¹
- › While there is a marginal increase in rainfall under both RCPs (RCP4.5 and RCP8.5) for this zone, the model also projects a decrease in rainfall in certain regions. In terms of the monthly average rainfall, this zone is expected to receive higher rainfall during the Summer and have a drier Winter.¹

For the Inner Himalayas (Temperate Belt),⁹

- › There is consistent warming under both the RCPs. However, warming is projected to be higher during the Winter months.⁹
- › For this elevation zone, the rainfall projection shows an increasing trend under both the RCPs. The seasonal and monthly projection shows a drier Winter and wetter Summer under both the RCPs.¹
- › However, it is projected that rainfall will increase during the Winter season under RCP 4.5 in the long term.¹⁵

For the Southern Foothills (Subtropical Belt),¹

- › An increase in temperature is consistent with the elevation zones in both the RCPs with higher warming projected for the Winter months.¹
- › The rainfall projection for this elevation zone shows an increasing trend of rainfall under both the RCPs.¹⁶
- › The Winter season is projected to get drier and wet Summer under both the RCPs. However, just as in the Inner Himalayan zone, the rainfall is projected to increase even during Winter months under RCP4.5 for 2070-2099 periods.⁹

Hydrological models were developed for the countries major river basins to project the changes to the flow under projected temperature and precipitation changes for the future.¹⁰

- › The model output indicates that average total annual flows in all major river basins are projected to increase in future periods and scenarios (across RCP4.5 and RCP8.5).¹



Under RCP4.5, all river basins in the country are projected to see the highest discharge in May, June, July. A rise in discharge is projected to range from **14%-43%**.¹

- › Under RCP 8.5, the monthly average flow is projected to increase from January to November till 2100.⁹
- › The average basin flow of December is lesser in both RCP 4.5 and 8.5 scenarios.¹⁶
- › The increases in flow are concentrated in the Summer months, while the decreases in flow are more apparent in the Winter months. In the future, wet periods are expected to become wetter, while dry periods are expected to become drier.¹

An assessment by the International Center for Integrated Mountain Development (ICIMOD) in 2019, concluded that the glaciers in the Hindu Kush Himalayan (HKH) Region are thinning and retreated, as observed since the 1970s.¹³

- › These trends are projected to persist in the future with larger increases in timing, the magnitude of glacier melt runoff, and glacial lake expansion.¹³
- › The HKH region will lose 1/3 of its ice cover by 2100, even if the average global temperature is maintained well below 1.5°C.¹³

Snow area for Bhutan between 2002 to 2010 was estimated at 9,039 km², comprising 25.5% of the total land area.¹⁸

- › The average snow area for Winter was around 14,485 km², for Spring around 7,411 km², for Summer around 4326 km², and around 7,788 km² for Autumn. Snow cover was distributed in the elevation range between 2500-6000 masl.¹⁸



Total snow cover area from 2002-2010 decreased by **-3.27 ± 1.28%**.¹⁸

Impacts of Climate Change

- » **Bhutan is highly vulnerable to the impacts of climate change and extreme weather events owing mainly to its fragile mountainous ecosystem.**²¹



Health

- » The health care system in Bhutan is mandated to provide free access to basic public health to all.¹
- » Significant improvements have been made in the healthcare system, however, all the success made could be challenged by the rise of climate-sensitive diseases and climate-induced disasters.⁷
 - › Rising temperatures, unpredictable weather patterns, unequal distribution of water supplies to communities will influence the epidemiological pattern of diseases.¹
 - › Emergency medical health requirements will also rise with rising cases of climate-induced disasters.¹

- » In 2019, Bhutan witnessed a dengue outbreak in Phuntsholing, Chukha district, and in Duksum, Tashi Yangtse district. In total, there were 3112 cases with six deaths.¹

» Under RCP4.5, the prevalence of Dengue will increase from the 16.3% probability of occurrence in 2019 to 25.3% in 2050, and 26.7% in 2070-2099, with an increase in annual mean temperature.¹

| > The malarial incidence will reach 23.9% in 2050 and 25.1% in 2070-2099, from the 2019 level of 10.4% probability of occurrence.¹

» Under RCP 8.5, the malarial incidence will reach 24.1% in 2050 and 27.0% in 2070-2099 from the current level of 10.4% in 2019.¹

| > Dengue prevalence will also increase from 16.3% in 2016 to 25.6% in 2050 and 28.6% in 2070-2099.¹



Disasters

» Due to the country precarious location, the effects of climate variability and change have highly exposed Bhutan to a diversity of hazards, including¹⁸

| > Floods and Flash floods, Glacial Lake Outburst Flooding (GLOFs), Drought, Landslides, Windstorms, Heat Waves, and Cold Waves.²⁰

» Extreme weather events have significant socio-economic consequences and adversely affect people's livelihoods and well-being, particularly marginal and poorer communities.¹⁰

» Heavy rainfall brought about by Cyclone Alia in 2009 incurred an estimated loss of \$17 million, affecting 17 districts.¹

» Over 70% of settlements, including infrastructures and fertile lands, are located along the main drainage basins, susceptible to flooding.¹⁰

» With many of the rivers confined in narrow gorges, blockage of rivers by landslides risks the formation of artificial dams that pose a threat to downstream settlements and assets such as hydropower, due to landslide dam outburst flood.⁷

» Major GLOF events were experienced in the country in 1957, 1960, 1968 and 1995.¹⁸

» The 1994 GLOF event from Luggye Tsho killed 21 people, damaged 91 houses, and destroyed 1,781 acres of land.¹⁸

» A heatwave in 2019 resulted in enhanced glacial melting, causing the eventual swelling of Lake Thorthomi, and breaching of the surrounding moraine dams.¹³

| > This resulted in the swelling of the Pho-chu river, posing a threat to communities downstream.¹³

| > An increase in the temperature and the delayed monsoons has caused the melting of huge volumes of ice and snow at Thorthormi Tsho, causing water levels to rise by almost 2 meters.¹⁸

| > Much of the warming at Thorthormi Lake took place between June 6-15 of 2019.¹⁷

| > If Thorthormi Lake and the Raphstreng Lake (located 70 meters downstream from Thorthormi) were to breach, more than 53 million cubic meters of water could be released.¹⁸

| > A GLOF event occurring at Thorthormi poses a direct threat to the economy as Bhutan's core revenue rests on hydropower. Two of the biggest hydropower projects in the country are built downstream of Thorthormi Lake, 1,200 MW Punatsangchu-I and 1,020 MW Punatsangchu-II.¹⁸

» In July 2019, the southern part of the country experienced a flash flood triggered by intense monsoon rainfall, displacing more than 100 families and damaging infrastructure.¹

» Being a landlocked nation with rugged topography, road surface transport serves as the main medium of transport in the country.⁶

» **The transport sector is highly vulnerable to the impacts of climate change and extreme weather.** Highways, particularly during the monsoon Summers are constantly damaged and destroyed by landslides, disrupting transport links between districts, and even causing loss of life.⁶



Forests and Biodiversity

Climate change affects the forest and biodiversity of the country¹

More droughts and forest fires

Loss of plants and animal species

Changes in the state of some ecosystems

» Between 2004 and 2014, about 39 incidences of bark beetle outbreaks were recorded.¹

- › Pine diebacks along the Paachu-Wangchu valley in the western valley during 1994, 1999, 2001, 2003, and 2008 are also strongly correlated with higher temperature and lower rainfall in the area.¹
- › Fire incidences of 1998/1999 were also reported to be caused due to prolonged spells of dryness in the country.¹

» These are major threats to biodiversity driven by climate change, as outlined in the State of Environment Report 2016.¹

Forest fires
Pest
Diseases
Loss of biodiversity
Invasion of alien species
Alteration in ecosystem composition

» Chir Pine forest is expected to see a significant increase in total area with suitable climate under future climate change scenarios. Other remaining forest types such as Broadleaf, mixed Conifer, Blue Pine, and Fir are likely to experience a considerable decline in the suitable area (area with favorable growing conditions for a certain species).¹⁶

» Blue Pines, found at an elevation between 1500 – 3200 masl are projected to face losses from 2050 to 2070, across both RCP 4.5 and 8.5 scenarios.¹

- › In the RCP4.5 scenario, the south-west region of Bhutan is predicted to gain a suitable area for Blue Pine forest.¹
- › In the RCP 8.5 scenario, the eastern region is predicted to have a more favorable climate for Blue Pine.¹

» Chir Pines is currently dominant in central and eastern districts of Wangdue Phodrang, Mongar, Tashigang, Punakha, and Lhuentse Dzongkhags, mainly occurring at an elevation between 700 to 2000masl.¹

- › Maximum entropy distribution (Maxent) modeling was carried out in the Third National Communication 2020, with results showing that Bhutan is likely to gain suitable climate areas for Chir Pine forests in both RCP 4.5 and 8.5 scenarios for the years 2050 and 2070.¹
- › Chir Pine range is expected to spread towards higher elevations and across the central belt, from east to west of Bhutan.¹

- › Gains in the Chir Pine forest encroach and displace Oak forests, reducing floral diversity and increased incidences of fire damage due to poor soil nutrients.¹
- » Broadleaf forests are dominant in Bhutan, occurring throughout the southern belt to inner parts of central Bhutan, up to an elevation of 3000m.¹
 - › With changing climate, broadleaf forests are likely to migrate towards higher elevation across all climate scenarios, with the highest shift in elevation predicted under RCP 8.5 for 2050 and 2070.¹
 - › Climate conditions from central to eastern Bhutan are predicted to become suitable for Broadleaf forests.¹
- » Mixed Conifer forests are the second most dominant forest type found in Bhutan, occurring at an elevation range of 2500 to 3500 masl. Mixed Conifers spread across the central belt from Tashigang in the east, all the way to Haa in the West.¹
 - › Maxent modeling suggests that area with a suitable climate for mixed Conifers is likely to reduce by 87% and 86% under RCP 4.5 and 8.5 scenarios respectively, for both the years 2050 and 2070.¹
 - › Under both scenarios, it is predicted that mixed Conifers will likely experience a range shift towards a relatively higher elevation, as the country's northern belt is predicted to have a suitable climate for the growth of mixed Conifers.¹
- » Fir forests in Bhutan occur above 3000 masl and is observed mainly in Bumthang, Wangdue Phodrang, Gasa, Tashigang, Lhuntse, and Haa.¹
 - › Maxent modeling predicts loss in suitable areas for fir up to 38% and 48% by the year 2050 and 2070 respectively across both RCP4.5 and 8.5 scenarios.¹
 - › Across all climate scenarios, Fir forests are predicted to migrate towards lower elevations.¹
 - › Additionally, Fir forests are predicted to migrate towards relatively higher elevations in RCP8.5 for the year 2070.¹
- » Shrinkage of the alpine ecosystems will threaten the existence of animals like the Himalayan field Mouse and other high-altitude animals.¹
 - › The increasing encroachment by invasive species will be expedited by climate change and will lead to further decline in native species diversity.¹
 - › Invasive species in Bhutan are particularly a threat to freshwater ecosystems and native aquatic species.¹

Energy

- » In the last decade, Bhutan has shifted its dependency on biomass to electricity due to a significant increase in electrification. In the future, dependency on electricity is predicted to further increase.⁸

Climate change poses a major threat as social and economic development is heavily reliant on energy, particularly hydropower energy.⁸

- » Hydropower is a sector that is very sensitive to climate change.²⁰
 - › The hydropower sector depends on the flow of the rivers, making it very susceptible to the impacts of climate change.¹
 - › Inter-annual variability in the timing and volume of flow, heavy and erratic rainfalls during the monsoons, drier periods in the winter cause large variations in the flow.¹
 - › An increase in flow is observed during the monsoon and a decrease in flow would be during the dry months.¹
 - › Under a warmer and more variable climate, monsoons will be erratic causing disruptions in the natural cycles, that will affect hydropower generation.¹
 - › An increase in the frequency of heavy monsoon rains, flash flooding, and landslides will damage infrastructure, power distribution, and the economy of the country.¹



» Hydrological Engineering Center Hydrologic Modelling system (HEC HMS) hydrological modeling was carried out under RCP 4.5 and 8.5 in the TNC 2020, with overall results concluding that flow will increase across all assessed basins into the future.¹

» For the Wangchu basin, under RCP4.5 flow is highest in May, June, July between 2021-2050, which is the monsoon season. During the same scenario, flow is lowest in November and December. This will negatively affect electricity generation.⁹

› Between 2070-2100, there is a huge variation in flow throughout the year with a decline in March, April, October, and December. An increase is seen in the flow percentage in November.⁹

› Under RCP 8.5 for both periods, there is a high variation in flow during monsoon, but a pronounced decrease in flow during November and December.⁹

» For the Punatsangchu basin under RCP4.5, flow is highest in May, June, and July in the year 2021-2050. A sharp drop in flow percentage is observed from August, and the flow in November and December is the lowest during this period, negatively affecting electricity generation.⁹

› Under RCP 4.5 but in 2070 – 2100, there is a huge variation in the flow percentage from May to June until September, with a decrease of flow in June. There is also an increase in the flow percentage in November, which widely varies from the patterns of flow seen today.⁹

» It has become a priority area for the country to diversify its energy sources to ensure energy security.⁸

› Bhutan is rich in natural resources from which energy can be harnessed. Fast-flowing rivers, thick forest cover, high solar radiation, and wind systems.⁸



Agriculture

» Bhutan's employment and economic output are heavily reliant on the agricultural sector, which is highly vulnerable to climate change.⁷

» The agriculture sector is vulnerable to the timings and the quantity of rainfall received during the monsoon season.²⁰

» Agricultural productivity is hindered by reduced water availability and crop loss to extreme events such as flash floods, windstorms, pests, and disease outbreaks.²⁰

» 61% of dry arable land in Bhutan is rain-fed; irrigation facilities are not adequate.¹

» The impact of climate change on the agricultural sector is further heightened, considering the low adaptive capacity of the 60% of the population, working in this sector.¹

- › Limited resource base and precarious socio-economic status.¹
- › Labor shortages and the physically demanding nature of the work.¹
- › Poor grid and road connectivity, and difficulties in accessing markets.¹
- › Unstable dryland agriculture and low-yielding seeds.¹

» By 2050 under the RCP8.5 scenario, 50% of the total area that is currently suitable for growing potatoes, will no longer be suitable for potato cultivation.⁹

 » Lower altitudes (<1,000 m) become unsuitable due to increasing temperatures, however mid-latitude areas (1,000-3,000m) experience expansion in suitable areas.⁹

» For rice suitability, Bhutan will gain rice suitability area till 2050 in both RCP 4.5 and 8.5 scenarios. After 2050 and extending till 2070 however, the country will start to lose the total area suitable for rice production.¹

» Bhutan will lose out on areas suitable for maize production under RCP4.5 and RCP8.5 till 2070, however, the loss is not significant as it ranges from only 0.04-3.43%.¹

» Soil erosion and human-wildlife conflict are other major issues to the agricultural sector that have been outlined in the Third National Communication (TNC).¹



Water

» The combined outflow of rivers in Bhutan is about 70,576 million m³, or 2,238 m³/s, corresponding to a flow of 109,000 m³ per capita, which is the highest in the Himalayan region.¹

Sources of water in Bhutan ¹
Lakes
Wetlands
Marshes
Spring
Streams
Rivers

» Despite having one of the highest per capita water availabilities, water scarcity and localized shortage is a major concern in the country.¹⁰

» Due to the rugged topography, climate variations, and settlements being located on hill-tops whereas rivers flow at the bottom of the valleys.⁸

» High altitude wetlands and glaciers also contribute to water resources.¹³

» Unseasonal and intense rainfall and hailstorms can destroy crops, thereby affecting farmers who are unprepared.¹⁸

 » The country's technical capacity in terms of weather prediction and early warning systems require immense development, to prevent widespread losses to such a vital part of the economy.¹

» According to the assessment of Potentially Dangerous Glacial Lakes (PDGL) in Bhutan in 2019, 17 glacial lakes are deemed as PDGL based on lake morphology, bathymetry conditions, condition of the feeding glacier, and the surrounding features.¹³

» Seasonal water shortages, drying up of water sources, and water-induced disasters such as Glacial Lake Outburst Flooding, are the main challenges faced by Bhutan for the water sector.¹

Mitigation and Adaptation Action

International Climate Action

- » Bhutan ratified the United Nations Framework Convention on Climate Change on the 15th of August 1995, with the National Environment Commission Secretariat (NECS) being the focal point for all the multilateral environmental agreements.¹
- » The National Environment Commission (NEC) as per the National Environment Protection Act of 2007, is entrusted with the authority to take all measures to protect the environment.⁸
- » Bhutan associated itself with the Copenhagen Accord on the 18th of December, where the country pledged to remain committed to its carbon-neutral status during COP15.³
- » Bhutan reaffirmed its pledge to remain carbon neutral through the submission of its First and Second Nationally Determined Contributions in 2015 and 2021, respectively. The NDC's outlined priority mitigation and adaptation areas and needs for Bhutan.⁸
- » Under the United Nations Framework Convention on Climate Change, Bhutan has submitted its TNC in 2020, with the second and first also being published in 2011 and 2000.¹
- » Bhutan ratified the Kigali Amendments to the Montreal Protocol on Ozone Depleting substances in 2019 and has put in place a system for licensing the import and export of hydrofluorocarbons.⁸

Greenhouse Gas Inventory



According to the national forest inventory, Bhutan's forests store **645 million tons of carbon** in the form of biomass carbon and soil organic carbon.¹

- » The NEC estimated that Bhutan's 6,309.6 Gg CO₂e carbon sink will be surpassed in the Business-as-Usual Scenario during the 2035-2040 period, putting the country's Carbon Neutral Status at risk.⁸
 - » *The business-as-usual scenario assumes that there will be no significant change in people's attitudes and priorities towards technology, economics, or policies.*⁸
- » The latest Greenhouse Gas Inventory was carried out in 2015, following the IPCC's 2006 guidelines for National Greenhouse Gas Inventories. Findings from the inventory provide insight into the trends of Greenhouse Gas emissions from the various sectors between 1994-2015.¹
 - » **The energy** sector's emissions between 1994 to 2015 had risen from 93.600 Gg CO₂e to 707.917 Gg CO₂e, an increase of 656.32%.¹
 - » Emissions from the **Industrial Processes and Product Use (IPPU)** sector from 1994 to 2015 rose from 166.931 to 769.423 Gg CO₂e, an increase of 360.92%.¹
 - » Emissions from the **Waste** sector were 55.780 Gg CO₂e in 1994 and 126.506 Gg CO₂e in 2015, an increase of 126.79%.¹
 - » **The Agriculture** sector in 1994 emitted 600.838 Gg CO₂e, and in 2015 emitted 552.875 Gg CO₂e, a decrease of 7.98%.¹
 - » The **Land Use, Land-Use Change, and Forestry (LULUCF)** sector removed 8165.342 Gg CO₂e in 1994, and 7756.220 Gg CO₂e in 2015. This equates to a decrease of 5.01%.¹
 - » Net emissions of Bhutan in 1994 was -7248.194 Gg CO₂e and in 2015, it was -5572.500 Gg CO₂e.¹

- » In 2015, the share of emissions are as follows:
 - › LULUCF (excluding removals) had the highest share, contributing to 42.75% of the total emissions in 2015.⁸
 - › The second was the IPPU sector, contributing 20.88% of total emissions in 2015.⁸
 - › The third was the Energy sector, contributing 18.56% of total emissions in 2015.⁸
 - › The fourth was the Agriculture sector, amounting to 14.50% of total emissions in 2015.⁸
 - › The sector contributing least to Bhutan's total emissions in 2015 was waste, at 3.32% of the total emissions.⁸

Relevant Mitigation Actions Taken

- » The Forest and Nature Conservation Act of 1995 ensures the protection and sustainable utilization of flora, fauna, and other natural resources of Bhutan to benefit present and future generations.¹⁹
- » The Environmental Assessment Act of 2000 establishes procedures for determining and reducing any potential effects on the environment stemming from any developmental project. The act also makes Environmental Clearance from a competent authority, a prerequisite for a project.²
- » Article 5 of the Constitution of Bhutan (2008) concerns itself with the protection of the Environment.¹¹
 - › Every citizen is entrusted to contribute to the protection and preservation of the natural environment and to prevent any form of ecological degradation.¹¹
 - › The State is mandated to ensure that 60% of the country must remain under forest cover at all times and to ensure that the nation's ecological systems and services are protected.¹¹
- » The National Environmental Protection Act 2007 outlines a wide range of environmental conservation principles and establishes a legal framework for development taking place in Bhutan. NEPA makes it a requirement for any persons benefiting from natural resources should sustainably manage and use such resources or ecosystems.²
 - › This legislation has paved the way for others such as the Waste Prevention and Management Act (2009), the Water Act (2011), and Bhutan's Climate Change Policy of 2020.²
- » Bhutan Sustainable Hydropower Policy (2008) aims to boost the position of Hydropower in Bhutan's economy, making it more attractive for investment and mobilizing the funds necessary for infrastructure development.⁸
 - › The revenue generated from Bhutan's Hydropower sector can be increased as there is a great demand for electricity export from neighboring countries. Currently, 1500MW from a potential of 30,000MW of clean energy can be harnessed from Bhutan's rivers.⁸



The Waste Prevention and Management Act of 2009 incorporates the Precautionary Principle and the Polluter Pays Principle, to avoid harm to the environment and to ensure the proper handling of waste.⁸



The Water Act of 2011 safeguards the precious of water and outlines frameworks for sustainable use and management of water sources. The Act determines the priorities for water allocation for drinking, agriculture, energy, industrial use, tourism, recreation, and other uses.⁸

- » The National Strategy and Action Plan for Low Carbon Development (2012), ensures that national emissions of greenhouse gasses will remain less than the sequestration capacity of Bhutan. Many short- and medium-term interventions are planned to achieve sustainable economic development through green growth.⁸



Transport 2040: Integrated Strategic Vision of 2013, aims to provide the entire population with a safe, reliable, affordable, convenient, cost-effective, and environmentally friendly transport system. This policy aims to sustainably integrate road transport, urban transport, and civil aviation.¹⁴

» The Economic Development Policy of 2016 and the Fiscal Incentives Act of Bhutan (2017) have provided incentives for the adoption of modern environmentally friendly technologies and tax exemptions for renewable energy machinery. Waste management and recycling industries were also provided income tax holidays and exemption of sales tax on plants and machinery.⁸



Renewable Energy Master Plan 2017-2032 was adopted as the guiding strategic plan to guide the long-term implementation of renewable technologies. This plan identified 39,462 MW of technically feasible small Hydropower, Solar, and Wind projects across the country.⁸

» Climate change has been integrated into Bhutan’s Five-Year National Development Plans. “Climate Neutrality and Disaster Resilience” has been identified as the sixth National Key Result Area (NKRA) of the 12th FYP from 2018-2023. Priority areas for mitigation and adaptation that were identified in the NDC were developed into programs to be implemented, under this NKRA.⁸

» Bhutan’s National Environment Strategy, charted the “middle path” towards development, guiding the nation’s pursuit of balanced and sustainable development. NES integrates national environmental challenges and global climate change into relevant national policy and programs.²¹

» The Climate Change Policy of the Kingdom has been adopted in 2020. The policy has the following aims,²¹

- › Providing strategic guidance to ensure carbon neutrality and protecting the people of Bhutan from the adverse impacts of climate change.²¹
- › Ensure meaningful participation of all relevant stakeholders in climate change action in a coordinated and coherent manner with clear roles and responsibilities.²¹
- › Ensure that challenges and opportunities of climate change are addressed at all appropriate levels.²¹

Sector-specific mitigation actions outlined in the TNC 2020, are listed below:

Energy	Improving energy efficiency in the iron and steel industry; action potential to reduce the maximum of 39.6 kt CO ₂ e/annum. ¹
Energy	Introduction of plug-in electric and hybrid vehicles and mass transit system; potential to reduce the maximum of 43 kt CO ₂ e/annum. ¹
IPPU	Mineral processing and metal industries utilizing coal and coke as reductants instead of fossil fuels; potential to reduce the maximum of 235 kt CO ₂ e/annum. ¹
IPPU	Waste heat recovery and electricity generation from mineral and metal processing industries; potential to reduce the maximum of 170 kt CO ₂ e/annum. ¹
IPPU	Carrying out cement blending during cement production; potential to reduce the maximum of 50 kt CO ₂ e/annum. ¹
IPPU	Replace coal by using refuse-derived fuels; potential to reduce a maximum of 170 kt CO ₂ e/annum. ¹
IPPU	Switching from diesel to electric boilers in existing small and medium-agroindustry, potential to reduce the maximum of 18 kt CO ₂ e/annum. ¹
Agriculture	Organic farming, reducing the usage of synthetic nitrogen-containing fertilizers, crop selection, improved grazing of livestock and manure management; potential to reduce around 480 kt CO ₂ e/annum. ¹

Waste

Practice of 3 R's (Reduce, Reuse, Recycle), waste segregation at source, combined composting, and biogas generation, and improving collection and transport systems; potential to reduce up to 236 kt CO₂e/annum.¹

The total mitigation potential from the actions outlined in the TNC estimated 1441 kt CO₂e/annum reductions. Implementing half of these actions would ensure that Bhutan remains carbon-neutral till 2050.¹

» In terms of mitigation, the main objective of Bhutan's NDCs is to remain carbon neutral, primarily through maintaining the constitutional mandate, of 60% forest cover. Priority areas for mitigation actions from Bhutan's 2nd NDC are outlined below:⁸

- › Forest conservation and management under the National REDD+ strategy. Approximate cost of implementation \$54.5 million.⁸
- › Low emissions development strategy for food security. The successful implementation of measures in this priority area could have a mitigation potential of up to 710 GgCO₂e. Approximate cost of implementation \$61.65 million.⁸
- › Low emissions development strategy for human settlement; mitigation potential of up to 4,122 GgCO₂e. Approximate cost of implementation \$101.84 million.⁸
- › Low emissions development strategy for Industries; mitigation potential of 9,990 – 11,370 GgCO₂ till 2030. Initial support is required for facilitating and creating an enabling environment, with an estimated cost of \$3.52 million.⁸
- › Low emissions development strategy for surface transport; mitigation potential of up to 5,283 GgCO₂e. Overall investment required is estimated to be around \$3,233 million till 2030.⁸
- › Waste management, under the National Waste Management Strategy 2019 to achieve zero waste Bhutan by 2030.⁸
- › Sustainable Hydropower development, prioritizing the development of Hydropower projects such as Punatsangchuu-I and II, Kholongchhu and Nikachhu.⁸
- › Alternative renewable energy including the promotion of Solar, Wind, mini-Hydro, and Waste to Energy technologies, to reduce deforestation and diversify energy portfolio.⁸
- › Green hydrogen roadmap, which explores the potential use of hydrogen to generate green renewable electricity. The Royal Government of Bhutan has initiated pilot projects and initial feasibility studies.⁸
- › National Energy Efficiency & Conservation Policy 2019 and Energy Efficiency Roadmap (NEECP) 2019. NEECP aims to improve energy efficiency measures and standards across the nation. Via the implementation of this action, there is a mitigation potential of 0.59 tCO₂e.⁸

» The Bhutan Electric Vehicle Roadmap (2020-2025) has been developed for a transition to zero-emission mobility with targets set for 2035, 2045, and 2050. The Bhutan Sustainable Low-Emission Urban Transport System project is being implemented to initiate the transition to EV mobility by focusing on taxis as the primary target for market transformation.⁸

Relevant Adaptation Actions

A series of National Adaptation Program of Action projects have been carried out in Bhutan.¹⁰

NAPA I	<i>Reducing Climate Change Induced Risks and Vulnerabilities from GLOF.</i> This project was implemented from 2008-2013, funded by the Least Developed Countries Fund (LDCF) and supported by the UNDP. ²⁰
NAPA II	<i>Addressing the Risk of Climate-Induced Disaster through Enhanced National and Local Capacity in Bhutan.</i> This project was initiated in 2014, funded by the LDCF and supported by the UNDP. ¹⁰
NAPA III	<i>Enhancing Sustainability and Climate Resilience of Forest and Agricultural Landscape and Community Livelihoods in Bhutan.</i> Approved in June 2017 by the LDCF. ¹⁰

- » Bhutan's first-ever National Adaptation Plan is expected to be completed and submitted in 2021, covering priority adaptation needs in the areas of water, agriculture, forests & biodiversity, and health.¹⁰
 - › The NAP builds on all of the work carried out in the country regarding climate change adaptation, including the NAPA projects and the NDCs.¹⁰
- » In terms of adaptation, the main objective of Bhutan's NDCs is to enhance the resilience of the people, economy, and society from the adverse impacts of climate change. Priority areas for adaptation actions from Bhutan's 1st NDC are outlined below:⁷
 - › Increasing resilience to the impacts of climate change on water security through Integrated Water Resource Management (IWRM) approaches.⁷
 - › Promoting climate-resilient agriculture to contribute towards achieving food and nutrition security.⁷
 - › Sustainable forest management and conservation of biodiversity to ensure sustained environmental services.⁷
 - › Strengthen the resilience to climate change-induced hazards through improving monitoring, detection, and preparedness to extreme weather events and climate risk areas (northern glacial lakes, forest fire risk assessment).⁷
 - › Minimizing climate-related health risks.⁷
 - › Climate proofing transport infrastructure against landslides and flash floods, particularly for critical roads, bridges, tunnels, and trails.⁷
 - › Promoting climate-resilient livestock farming practices to contribute towards poverty alleviation and self-sufficiency.⁷
 - › Enhancing climate information services for vulnerability and adaptation assessment planning.⁷
 - › Promotion of clean renewable and climate-resilient energy generation.⁷
 - › Integrating climate-resilient and low emissions strategies in urban and rural settlements.⁷
- » Climate adaptation has been mainstreamed into local development since 2011 under the Local Climate Adaptive Living Facility (LoCAL) program, with support from the United Nations Capital Development Fund and the European Union.⁸
 - › This program aims to support 100 gewogs (the geographic administrative unit below a district) with climate resilience grants through the 11th and 12th five-year development plans.⁸
 - › Eventually, the program is aimed to be scaled to cover all 205 gewogs in the country.⁸
- » Two projects supported by the Green Climate Fund are currently in the process of implementation in Bhutan.⁸
 - › FP107: *Supporting Climate Resilience and Transformational Change in the Agricultural Sector in Bhutan (2019-2021)*. This project aims to promote climate-resilient agricultural practices, integrate climate change data into the water and land management, and reduce the risk and impact of climate change-induced landslides during extreme events.¹⁵
 - › FP050: *Bhutan for life (2018-2032)*. This project aims to secure Bhutan's protected areas from deforestation and to protect the nation's valuable forest resources.¹⁷
- » Bhutan has started preparing the Long Term Low GHG Emission and Climate Resilient Development Strategy (LTS). LTS will guide the long-term development of a carbon-neutral Bhutan. The progress of the LTS has been hampered by the COVID-19 pandemic and is expected to be completed in 2022.⁷

The Green Finance Roadmap is being developed in line with the 21st Economic Century Roadmap, aiming to mainstream and bring about transformative changes in financing economic investments and sustainable development in Bhutan for the 21st century. The initiative aims to⁸

Make the financial systems of Bhutan more robust and resilient to external vulnerabilities in the wake of the COVID-19 pandemic.⁸

Channel lending towards products and services that can deliver both investible and environmentally positive outcomes.⁸

Ensure green investments are prioritized over business-as-usual investment.⁸

Accelerate financial sector's contribution towards transition towards a low carbon economy by leveraging on modern technologies and innovations.⁸

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